

**RESPIRATORY MANAGEMENT OF THE MECHANICALLY VENTILATED SPINAL  
CORD INJURED PATIENT IN A CRITICAL CARE UNIT**

By

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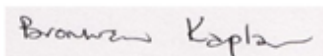
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**RESPIRATORY MANAGEMENT OF THE MECHANICALLY VENTILATED SPINAL CORD  
INJURED PATIENT IN A CRITICAL CARE UNIT**

This is to certify that I was employed by Ms Janine Love to edit the above-titled thesis for language.

A handwritten signature in black ink that reads "Bronwen Kaplan". The signature is written in a cursive style and is placed on a light-colored rectangular background.

Bronwen Kaplan

## **DEDICATION**

I dedicate this study to all mechanically ventilated spinal cord injured patients in critical care units, everywhere.

May the professional nurses caring for you provide evidence-based nursing practice and continually show compassion and advocacy for you when you are unable to speak for yourselves.

Secondly, I dedicate this study to God. Thank you for giving me the opportunity, knowledge and skill to make a difference. I pray this information will.

## **ACKNOWLEDGEMENTS**

When the world says, “Give-up”, Hope whispers, “Try it one more time”. *Anonymous*  
The success of this study would not have been possible without the love and support of my family, boyfriend, Wayne, and friends. I thank you for your continued encouragement, love, support and prayers. I thank all my colleagues and members of the multi-disciplinary team who have encouraged me and assisted me with advice on this journey.

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## **ABSTRACT**

**Background:** Spinal Cord Injuries (SCIs) are traumatic, life-changing injuries that can affect every aspect of an individual's life and can lead to death if not treated timeously and appropriately. Respiratory complications occur frequently after the SCI and are the leading cause of mortality and morbidity. Respiratory complications are predictable based on the neurological level of impairment of the spinal cord lesion; the higher the neurological injury, the more severe the respiratory complication. Changes in pulmonary function, poor cough, hypersecretion, immobility and bronchospasm all contribute to the development of respiratory complications. If the patient is unable to protect his/her airway or if respiratory failure occurs, mechanical ventilation is often required. Many patients require prolonged ventilation and subsequently need to go for tracheostomies.

The critical care nurse plays an important role in the early identification of complications and can, therefore, act to limit and prevent these complications, which may be a direct result from the injury or treatment modality such as mechanical ventilation. Respiratory management has been promoted in preventing and treating respiratory complications and is associated with better prognosis in the SCI patient.

### **Design and method:**

The research study aims to explore and describe existing literature and to make recommendations for the respiratory management of a mechanically ventilated spinal cord injured patient in a critical care unit (CCU). A systematic review was undertaken with clear inclusion and exclusion criteria. Ethical principles were maintained throughout the study. The quality of the study was ensured by critically appraising data that was utilized in the systematic review. It is envisaged that the results from this systematic review will improve the respiratory management of the SCI patient and prevent any variations in practice.

**Results:** Were presented under the following themes: priorities of care for the SCI patient in the acute phase, during the critical care phase and preventative care.

**Conclusion:** The SCI patient regardless of the neurological level or completeness of injury should be admitted to the CCU for intensive ventilatory, cardiopulmonary support and hemodynamic monitoring in order to detect and prevent respiratory complications. The use of larger tidal volumes is associated with improved comfort and less dyspnea however if a patient has acute lung injury or ARDS the use of low tidal volumes 6ml/kg is recommended. Prevention and early identification of respiratory complications is associated with improved outcomes for the SCI patient.

### **Keywords**

- Spinal cord injury
- Respiratory management
- Mechanical ventilation
- Critical care unit
- Evidence-informed nursing care

<b>TABLE OF CONTENTS</b>	<b>PAGE</b>
<b>DEDICATION.....</b>	<b>i</b>
<b>ACKNOWLEDGEMENTS.....</b>	<b>ii</b>
<b>ABSTRACT .....</b>	<b>iii</b>
<b>LIST OF TABLES .....</b>	<b>xiii</b>
<b>LIST OF FIGURES.....</b>	<b>xiv</b>
<b>LIST OF ABBREVIATIONS.....</b>	<b>xv</b>
 <b>CHAPTER ONE: INTRODUCTION AND OVERVIEW OF THE STUDY</b>	
<b>1.1 INTRODUCTION.....</b>	<b>1</b>
<b>1.2 PROBLEM STATEMENT.....</b>	<b>7</b>
<b>1.3 RESEARCH QUESTION.....</b>	<b>9</b>
<b>1.4 RESEARCH OBJECTIVES.....</b>	<b>10</b>
<b>1.5 PURPOSE OF THE STUDY.....</b>	<b>10</b>
<b>1.6 CONCEPT CLARIFICATION .....</b>	<b>10</b>
<b>1.6.1 The professional nurse .....</b>	<b>10</b>
<b>1.6.2 Critical care unit (CCU) or intensive care unit (ICU) .....</b>	<b>10</b>
<b>1.6.3 Spinal cord injuries (SCIs) .....</b>	<b>11</b>
<b>1.6.4 Critical care nursing .....</b>	<b>11</b>
<b>1.6.5 Evidence-informed clinical guidelines.....</b>	<b>11</b>
<b>1.6.6 Respiratory management.....</b>	<b>12</b>
<b>1.6.7 Mechanical ventilation .....</b>	<b>12</b>



<b>1.7 RESEARCH DESIGN AND METHOD .....</b>	<b>12</b>
<b>1.7.1 Systematic review.....</b>	<b>13</b>
<b>1.7.2 Research method.....</b>	<b>13</b>
<b>1.8 ASSESSMENT OF THE QUALITY OF STUDIES INCLUDED FOR CRITICAL APPRAISAL IN THE SYSTEMATIC REVIEW .....</b>	<b>14</b>
<b>1.9 ETHICAL CONSIDERATIONS .....</b>	<b>14</b>
<b>1.10 RESEARCH FINDINGS .....</b>	<b>14</b>
<b>1.11 DELINEATION OF THE STUDY .....</b>	<b>15</b>
<b>1.12 CONCLUSION .....</b>	<b>15</b>

## **CHAPTER TWO: RESEARCH DESIGN AND METHOD**

<b>2.1 INTRODUCTION .....</b>	<b>17</b>
<b>2.1.1 Research design .....</b>	<b>17</b>
<b>2.1.2. Systematic review.....</b>	<b>18</b>
<b>2.1.3 The purpose / rationale of performing a systematic review.....</b>	<b>18</b>
<b>2.1.4 Aims of a systematic review .....</b>	<b>20</b>
<b>2.1.5 Systematic review versus a narrative literature review .....</b>	<b>20</b>
<b>2.2 RESEARCH METHOD.....</b>	<b>21</b>
<b>2.2.1 Systematic review protocol .....</b>	<b>21</b>
<b>2.2.2. Review question .....</b>	<b>22</b>
<b>2.2.3 Search for relevant evidence .....</b>	<b>24</b>
<b>2.2.4 Critical appraisal .....</b>	<b>29</b>
<b>2.2.5 Data extraction.....</b>	<b>32</b>

<b>2.2.6 Data synthesis and presentation.....</b>	<b>33</b>
<b>2.3 ASSESSMENT OF THE QUALITY OF STUDIES INCLUDED FOR CRITICAL APPRAISAL IN THE SYSTEMATIC REVIEW .....</b>	<b>35</b>
<b>2.4 ETHICAL CONSIDERATIONS .....</b>	<b>36</b>
<b>2.4.1 Ethical review .....</b>	<b>36</b>
<b>2.4.2 Permission to conduct the research .....</b>	<b>36</b>
<b>2.4.3 Plagiarism.....</b>	<b>37</b>
<b>2.4.6 Recommendations.....</b>	<b>37</b>
<b>2.5 SUMMARY OF THE CHAPTER.....</b>	<b>39</b>

### **CHAPTER THREE: SYSTEMATIC REVIEW REPORT**

<b>3.1 INTRODUCTION .....</b>	<b>40</b>
<b>3.2. RESPIRATORY MANAGEMENT OF THE MECHANICALLY VENTILATED SPINAL CORD INJURED PATIENT.....</b>	<b>40</b>
<b>3.2.1 Method .....</b>	<b>42</b>
3.2.1.1 The review question .....	42
3.2.1.2 Searching for relevant evidence.....	43
3.2.1.3 Selection of evidence .....	44
3.2.1.3.1 Inclusion criteria .....	44
3.2.1.3.2 Exclusion criteria .....	46
3.2.1.4 Critical appraisal.....	47
3.2.1.5 Data extraction .....	47
3.2.1.6 Data analysis and synthesis.....	49
<b>3.3 Discussion and results of the systematic review .....</b>	<b>50</b>

<b>3.3.1 Description of evidence .....</b>	<b>50</b>
<b>3.3.2 Results of the systematic review .....</b>	<b>51</b>
<b>3.4 PRIORITIES OF CARE FOR THE SPINAL CORD INJURED PATIENT IN THE ACUTE PHASE.....</b>	<b>52</b>
<b>3.4.1 Admission to the critical care unit .....</b>	<b>52</b>
<b>3.4.2 Airway management.....</b>	<b>54</b>
3.4.2.1 Goals of airway management .....	55
3.4.2.2 Indications for intubation .....	55
3.4.2.3 Techniques used for intubation .....	57
<b>3.5 PRIORITIES OF RESPIRATORY CARE FOR THE SPINAL CORD INJURED PATIENT IN THE CRITICAL CARE UNIT .....</b>	<b>60</b>
<b>3.5.1 Mechanical ventilation.....</b>	<b>60</b>
<b>3.5.2 Ventilator management strategies .....</b>	<b>62</b>
3.5.2.1 Modes of ventilation .....	62
3.5.2.2 Ventilator settings.....	62
3.5.2.3 Lung protective ventilation strategies.....	64
<b>3.5.3 Weaning from the mechanical ventilator .....</b>	<b>65</b>
3.5.3.1 Criteria for weaning .....	66
3.5.3.2 Weaning strategies .....	67
<b>3.5.4 Tracheostomy care.....</b>	<b>69</b>
3.5.4.1 Indications for tracheostomy .....	69
3.5.4.2 Benefits of a tracheostomy in the spinal cord injury patient .....	71
3.5.4.3 Timing of tracheostomy .....	71

<b>3.5.5 Respiratory management in the critical care unit.....</b>	<b>73</b>
3.5.5.1 Assessment of the respiratory status of the spinal cord injured patient in a critical care unit. ....	73
<b>3.6 PRIORITIES OF PREVENTATIVE CARE.....</b>	<b>79</b>
<b>3.6.1 Incidence of respiratory complications .....</b>	<b>79</b>
<b>3.6.2 Specific respiratory complications .....</b>	<b>81</b>
3.6.2.1 Blunt chest trauma .....	81
3.6.2.2 Pulmonary venous thromboembolism .....	82
3.6.2.3 Atelectasis.....	83
3.6.2.4 Bronchospasm .....	83
3.6.2.5 Pulmonary edema .....	84
3.6.2.6 Ventilator-associated pneumonia (VAP) .....	84
3.6.2.7 Pneumonia / aspiration pneumonia.....	85
3.6.2.8 Hypersecretion .....	85
3.6.2.9 Respiratory failure .....	86
<b>3.6.3 Prevention and management of respiratory complications .....</b>	<b>87</b>
3.6.3.1 Management and prevention of atelectasis.....	87
3.6.3.2 Management and prevention of VAP .....	88
3.6.3.3 Management and prevention of pneumonia .....	89
3.6.3.4 Management and prevention of hypersecretion and retained secretions ...	90
3.6.3.5 Prevention and management of respiratory failure .....	95
3.6.3.6 Positioning .....	95
3.6.3.7 Deep breathing .....	97

3.6.3.8	Kinetic therapy .....	97
3.6.3.9	Chest physiotherapy .....	98
<b>3.7</b>	<b>SUMMARY OF THE CHAPTER.....</b>	<b>98</b>

## **CHAPTER 4: CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS**

<b>4.1</b>	<b>INTRODUCTION .....</b>	<b>99</b>
<b>4.2</b>	<b>CONCLUSION OF THE STUDY .....</b>	<b>99</b>
<b>4.3</b>	<b>Recommendations based on results from the systematic review on the respiratory management of the Mechanically ventilated SCI patient in a CCU.....</b>	<b>101</b>
<b>4.3.1.</b>	<b>Priorities of care for the SCI patient in the acute phase.....</b>	<b>101</b>
4.3.1.1	Admission to the CCU.....	101
4.3.1.2	Airway management .....	102
<b>4.3.2.</b>	<b>Priorities of respiratory care for the SCI patient in a CCU .....</b>	<b>103</b>
4.3.2.1.	Mechanical ventilation.....	103
4.3.2.2	Ventilator management strategies.....	103
4.3.2.3	Weaning from the mechanical ventilator .....	104
4.3.2.4	Tracheostomy care .....	105
<b>4.3.3</b>	<b>Respiratory management in the CCU.....</b>	<b>105</b>
4.3.3.1	Assessment of the respiratory status of the SCI patient in a CCU .....	106
4.3.3.2	Priorities of preventative care.....	107
<b>4.4</b>	<b>LIMITATIONS .....</b>	<b>109</b>
<b>4.5</b>	<b>RECOMMENDATIONS .....</b>	<b>110</b>

4.5.1 Recommendations for nursing research .....	110
4.5.2 Recommendations for education .....	111
4.5.3 Recommendations for nursing practice .....	112
4.6 SUMMARY OF THE CHAPTER.....	113
REFERENCE LIST A.....	115
REFERENCE LIST B.....	124
ANNEXURE A: LETTER TO HOSPITAL .....	130
ANNEXURE B: LETTER TO UNIT MANAGER .....	131
ANNEXURE C: SYSTEMATIC REVIEW PROTOCOL: RESPIRATORY MANAGEMENT OF THE MECHANICALLY VENTILATED, SPINAL CORD INJURED PATIENT IN A CRITICAL CARE UNIT .....	132
ANNEXURE D: LIST OF HAND-SEARCHED JOURNALS .....	137
ANNEXURE E: SEARCH TERMS: RESPIRATORY MANAGEMENT OF THE MECHANICALLY VENTILATED SPINAL CORD INJURED PATIENT IN A CRITICAL CARE UNIT .....	138
ANNEXURE F: COPY OF THE AGREE II INSTRUMENT .....	140
ANNEXURE G: JBI CRITICAL APPRAISAL TOOL FOR EXPERIMENTAL STUDIES (MAStARI).....	144
ANNEXURE H: JBI CRITICAL APPRAISAL TOOL FOR COHORT STUDIES (MAStARI) .....	145
ANNEXURE I: JBI CRITICAL APPRAISAL TOOL FOR OBSERVATIONAL STUDIES (MAStARI).....	146
ANNEXURE J: JBI CRITICAL APPRAISAL TOOL FOR NARRATIVE, TEXTUAL OR OPINION PAPERS (NOTARI).....	147

<b>ANNEXURE K: CRITICAL APPRAISAL TOOL FOR SYSTEMATIC REVIEW (ADAPTED FROM THE JBI APPRAISAL TOOLS) .....</b>	<b>148</b>
<b>ANNEXURE L: JBI MASTARI DATA EXTRACTION TOOL.....</b>	<b>149</b>
<b>ANNEXURE M: JBI NOTARI DATA EXTRACTION TOOL.....</b>	<b>150</b>
<b>ANNEXURE N: Characteristics of excluded studies for review on the respiratory management of the mechanically ventilated SCI in a CCU.....</b>	<b>151</b>

## LIST OF TABLES

Table 2. 1: Search Strategy .....	25
Table 2. 2: Levels of evidence hierarchy .....	28
Table 2. 3: Evidence hierarchy & software packages used for critical appraisal.....	31
Table 2. 4: Grades of recommendation (USPSTF).....	38
Table 3. 1: Items for discussion on the systematic review report on the respiratory management of the mechanically ventilated SCI patient in a CCU	42
Table 3. 2: Papers included for the critical appraisal on the respiratory management of the mechanically ventilated patient in a CCU (Adapted from Lobiondo-Wood and Haber, 2010:6) .....	45
Table 3. 3: Summary of the synthesized data .....	52



## LIST OF FIGURES

Figure 3. 1: Results of papers found and included in the systematic review of the respiratory management of the mechanically ventilated SCI patient in a CCU ..... 51

## **LIST OF ABBREVIATIONS**

ABC's = airway, breathing and circulation

ABG = Arterial blood gases

ALI = Acute lung injury

ARDS = Acute respiratory distress syndrome

CCU = critical care unit

CRP = C-reactive protein

CSCI = cervical spinal cord injury

DARE = Database of Abstracts and Reviews

ETT = endotracheal tube

FIO<sub>2</sub> = fraction of inspired oxygen or percentage of oxygen

HDU = high dependency unit

ICU = Intensive Care Unit

ICP = Intracranial pressure

JBIC = Joanna Briggs Institute

JBIC-ACTUARI = Joanna Briggs Institute Analysis of Cost, Technology and Utilisation Assessment and Review Instrument

JBIC-MAStARI = Joanna Briggs Institute Meta Analysis of Statistics Assessment and Review Instrument

JBIC-NOTARI = Joanna Briggs Institute Narrative, Opinion and Text Assessment and Review Instrument

JBIC-QARI = The Joanna Briggs Institute Qualitative Assessment and Review Instrument

JBIC - SUMARI = System for Unified Management, Assessment and Review of Information

MV = mechanical ventilation

MeSH = medical subject headings

M-IE = mechanical insufflator-exsufflator

MODS = Multiple Organ Dysfunction Score (MODS)

PaO<sub>2</sub> = Arterial oxygen tension

PEEP = positive end expiratory pressure

RCT = randomized control trial

SCI = spinal cord injury

Spinal Cord Injury Rehabilitation Evidence = (SCIRE)

SIMV – synchronized intermittent mandatory ventilation

SPICE = mnemonic, referring to the Setting, Perspective, Intervention, Comparison and method of Evaluation

SOFA = Sequential Organ Failure Assessment

USPSTF = United States Preventive Services Task Force

## 1.1 INTRODUCTION

The worldwide incidence of spinal cord injuries (SCIs) is approximately 10.4 – 83 per 1 million people annually (Aarabi, Harrop, Tator, Alexander, Dettori, Grossman, Dettori, Grossman, Fehlings, Mirvis, Shanmuganathan, Zacherl, Burau, Frankowski, Toups, Shaffrey, Guest, Harkema, Habashi, Andrews, Johnson and Rosner, 2012:38). McKinley, Santos, Meade and Brooke (2007:215) state that the incidence in the United States is close to 40 cases per million per year, and the National Spinal Cord Injury Statistical Centre of Alabama (2012:1) states that in the US, there are approximately 12 000 new SCI cases per year. According to Elliot, Aitken and Chaboyer (2007:343), there are about 11 000 Australians living with SCIs, which is 13.6 per million of the population, whilst New Zealand has an incidence rate of 27 per million of the population. No statistics of the incidence of SCIs were found in South Africa and according to Wyndaele and Wyndaele, (2006:525) no data has been found on the prevalence of SCIs in developing countries, including Africa.

SCIs are traumatic injuries to the spinal cord caused by the dislocation of bones, rupture of ligaments, vessels, or vertebral discs, stretching of neural tissue, or impairment in blood supply (Comer, 2005:183). Traumatic SCIs are often caused by motor vehicle accidents, falls, gunshot wounds, violent attacks and sport injuries. Acute SCIs are often traumatic but can occur as a result of degenerative spinal disease, tumour compression, infection, myelitis, vascular factors, spina bifida, syringomyelia and spinal stenosis (Ones, Yilmaz, Beydogan, Gultekin and Caglar (2007:1187). According to Draulans, Kiekens, Roels and Peers (2011:1148) the most common causes of traumatic SCIs in Sub-Saharan Africa are related to motor vehicle accidents, falling from heights and violence, whereas causes of non-traumatic SCIs included tuberculosis and malignant illness. SCIs can be classified as complete or incomplete, irrespective of the level of the lesion, depending on how the injury affects motor and sensory function. Injuries to spinal nerves may occur along the spinal column and can occur in the cervical region, where there are eight cervical nerves (C1-C8), the thoracic region, where there are 12 thoracic nerves (T1-T12), the lumbar region, where there are five lumbar nerves (L1-L5) and the sacral region,

where there are five sacral nerves (S1-S5). The level of injury will determine the extent of the motor disability (Gibson, 2003:39).

Masri (2006:30) suggests that the sudden paralysis related to SCIs, as well as the devastating medical, emotional, psychological, financial and economical consequences, usually affect not only the patient, but also their partner, family, friends, employer and the community in general. SCIs are devastating as they result in a total disruption of the life of the person affected by them, changing an individual's life abruptly and permanently, as the patient moves from independence to dependence (Lohne, 2009:67). The extent and enduring effects of SCI depends on the level of injury, the care rendered to the patient and the education given to the patient and care-givers, as well as how regularly the patient is monitored to assess that their needs are being met.

SCIs have an extensive effect on the physiological function of the body as nearly all body systems are innervated by the spinal cord and, as a result, the injury may directly or indirectly affect every system. Systemic effects include cardiovascular, respiratory, endocrine, gastrointestinal, renal, reproductive, integumentary and musculoskeletal ones (Gibson, 2003:36). Individuals with SCIs are at risk of developing secondary complications resulting from their injury. These include pain, spasticity, shoulder pain, urinary-tract infections, respiratory complications, pressure ulcers, cognitive impairments and major depressive disorders. Respiratory complications are the most common of the systematic complications following a SCI and might add to an increase in mortality, morbidity and length of hospital stay amongst these patients (Aarabi *et al.*, 2012:38). Secondary complications are complications that occur as a result of the SCI and can contribute considerably to morbidity, medical costs, and readmission to hospital within the first year following the injury (Matter, Feinberg, Schomer, Harniss, Brown and Johnson, 2008:545).

According to Kearns and Shimabukuro (2012:220), respiratory complications are the main cause of death amongst patients who survive the initial injury. Reid, Brown, Konnyu, Rurak, Sakakibara and the Spinal Cord Injury Rehabilitation Evidence (SCIRE) Research Team (2010:353) agree that respiratory complications are the

main cause of mortality and morbidity in the SCI patient and are more pronounced in complete and higher neurological injuries. Harvey (2008:205) suggests that respiratory complications are the main cause for hospitalisation of these patients, and that respiratory complications were reported to be the second cause of death. However the latest findings by the National Spinal Cord Injury Statistics centre in the United States, (2012:2) stated that pneumonia and septicaemia are the leading cause of death. According to Wong, Shem and Crew (2012:283), respiratory complications include hypoventilation, hypercapnia reduction in surfactant production, mucous plugging, atelectasis and pneumonia. Respiratory complications can arise within hours to days post injury and the consequence of the paralysis of the respiratory muscles places these patients at risk of respiratory failure. Kearns and Shimabukuro (2012:220) agree that SCI patients are at risk of developing respiratory complications and specify atelectasis, pneumonia and ventilatory failure which can occur secondary to spinal shock and paralysis. Other possible respiratory complications not listed above include acute lung injury, acute respiratory distress syndrome, pulmonary embolus, pleural effusion, pneumothorax and hemothorax (Grossman, Frankowski, Burau, Toups, Crommett, Johnson, Fehlings, Tator, Shaffrey, Harkema, Hodes, Aarabi, Rosner, Guest and Harrop, 2012:121).

Furthermore, respiratory complications are directly related to the level of injury sustained in the spinal cord. SCIs at different levels have the ability to affect different respiratory muscles. Injuries occurring higher up on the spinal cord are associated with a higher risk of respiratory complications (Harvey, 2008:205). Respiratory dysfunction was found to be the cause of 80% of deaths in patients with cervical SCI in hospital followed by pneumonia. Flint, Meredith, Schwab, Trunkey, Rue and Taheri (2008:294) agree that respiratory complications occur more frequently in the cervical injuries but can also affect lower levels with an incidence of 51% in T1-T6 and 34.5% in T7-T12.

Neurological level and completeness of the injury will contribute to the need for artificial ventilation and respiratory complications (Aarabi *et al.*, 2012:38). Patients requiring ventilation to assist with respiration include those with complete injuries to the cervical spine at levels C1–C4, whereas injuries occurring to the lower cervical

region as well as high thoracic injuries (C5–C8 and T1–T5) may also have complications with respiration due to weak or paralysed respiratory muscles. When the diaphragm and intercostal muscles are affected, the result is reduced chest expansion and decreased inspiratory volume. Expiratory effectiveness is reduced when the abdominal and internal intercostal muscles are affected, and the patient will have difficulty coughing and clearing secretions from the respiratory tract (Gibson, 2003:38). The work of breathing can become laborious and if the patient fatigues or deteriorates, intubation and mechanical ventilation are often required, regardless of the level of the injury (McQuillan, Makic and Whalen, 2009:590).

Acute Respiratory Failure occurs when the respiratory system is unable to maintain gaseous exchange. According to Urden, Stacy and Lough (2010:602), the respiratory system is the most common organ failure seen in SCI patients in a critical care unit (CCU), with a mortality rate ranging from 22 – 75%. Mortality rates will vary if the patients' conditions are compounded with additional organ dysfunction. The treatment goals for acute respiratory failure include maintaining a patent airway, optimising oxygen delivery, minimizing oxygen demand, treating the cause of the acute respiratory failure and preventing complications (Sole, Klein and Moseley, 2009:443). The ability to maintain a patent airway and keep the airway free from secretions is extremely important for survival of the SCI patient. Injuries to the spinal cord can affect the respiratory muscles and coupled with bronchoconstriction and increased mucous production predisposes the SCI patient to respiratory complications (McQuillan *et al.*, 2009:589). According to Cheng, Chen, Wang and Chung (2006:32), the retention of secretions is the main cause of atelectasis and respiratory failure. Respiratory management should involve interventions to enhance and improve the patient's coughing and clearance of secretions in the airway during the acute phase. The respiratory management of an SCI patient differs considerably when compared to a patient who still has voluntary respiratory muscle control. When individuals are unable to clear their airway of secretions, they are at an increased risk of respiratory infections including pneumonia as well as atelectasis and respiratory failure, which may result in the need for intubation and mechanical ventilation (Jelic, Cunningham and Factor, 2008:209).

On admission to the CCU, attention must be focussed on the airway, breathing and circulation (ABCs) of the SCI patient. Respiratory assessment is essential to the patient's survival and prognosis. First, the airway must be evaluated for clearance and patients who can not maintain an open airway, an artificial airway must be inserted before hypoxia occurs which can further exacerbate the SCI. Assessment of the breathing patterns must be made after the airway has been secured and the level of injury indicates the degree of altered breathing patterns and gaseous exchange. Complete injuries above C3 results in the paralysis of the diaphragm requiring full ventilatory support. Assessment of cardiac output and tissue perfusion is essential to prevent life threatening injuries and cardiac monitoring is essential to detect cardiac dysrhythmias and bradycardia which can be a result of vagus activity, hypoxia and hyperthermia (Urden *et al.*, 2010:952-953).

Mechanical ventilation is a lifesaving intervention that supports the respiratory system until the cause of the acute respiratory failure has been resolved (Sole *et al.*, 2009:201). According to Marani and Perri (2010:16), the majority of patients in CCUs survive because of mechanical ventilation. The goal in ventilator management of the SCI patient is to prevent respiratory complications and transfer them to a spinal cord rehabilitation centre (Kearns and Shimabukuro, 2012:220).

Although mechanical ventilation may be essential to maintain ventilation and oxygenation in SCI patients in CCUs, it may cause adverse effects. In a study done by Estaban, Anzueto and Frutos (2002:351), it was noted that the survival rate in patients with respiratory failure, who required mechanical ventilation for more than 12 hours, was 69%, and depended not only on factors present when initiating mechanical ventilation, but mainly on the development of complications and patient management during the subsequent course of care. Complications associated with mechanical ventilation include ventilator-associated lung injury, volutrauma, atelectrauma and biotrauma, pneumothorax, ventilator-associated pneumonia, eye-care complications and oral hygiene insufficiency.

Specialized respiratory management is necessary when treating the SCI patient to prevent respiratory complications (Wong *et al.*, 2012:283). Higginson and Jones



(2009:456) state that nurses should also be able to apply respiratory management strategies to ensure that patients receive appropriate respiratory care quickly, efficiently and effectively. McQuillan *et al.*, (2009:590) state that aggressive pulmonary hygiene is essential to prevent and treat respiratory complications.

The respiratory assessment of the critically ill patients in CCUs differs to the assessment of patients in general wards due to the presence of an artificial airway and mechanical ventilation. The CCU nurse caring for a mechanically ventilated patient needs to incorporate the ventilator and ventilator alarms as part of the respiratory assessment and assess the patient for patient – ventilator synchrony and signs of respiratory distress, including nasal flaring, excessive use of intercostal and accessory muscles, uncoordinated movement of the chest and abdomen as well as shortness of breath (Smeltzer, Bare, Hinkle and Cheever, 2008:576). Respiratory management should include the monitoring of the respiratory function and performing respiratory assessments. According to Jevon and Ewens (2002:36), monitoring respiratory function requires assessing the efficacy of breathing, work of breathing and ventilation together with a complete patient assessment.

Furthermore, in order to reduce cost, decrease hospital stay, decrease mechanical ventilator days and stay in the CCU, decrease mortality and morbidity due to respiratory complications, and improve quality care and patient outcomes, it will be imperative to use evidence-based practice in order to guide clinical decision making in caring for the mechanically ventilated SCI patient. Significant variations in healthcare practices and the lack of implementing best care practices might be the leading cause of inadequate patient care, increased healthcare costs and an increased risk of adverse effects to patients. The incorporation of quality improvement tools, such as evidence-informed clinical guidelines, have been shown to reduce practice variations and improve the use of best practices, thus improving the processes of and outcomes for patient care (Carnett, 2002:60). .

A vast amount of literature has been published on various aspects of mechanical ventilation and respiratory management. However, a paucity of literature is available on the respiratory management of the mechanically ventilated SCI in a CCU. In South Africa, there is no evidence of a national evidence-informed clinical guideline;

therefore, there is a need to develop one. A guideline of this nature will thus contribute to the unique body of research and nursing practice. Evidence-based guidelines are based on results from systematic reviews. The development of a guideline is beyond the scope of this research study but a literature search will be done which can serve for the development of an evidence-based practice guideline in a future research study.

## **1.2 PROBLEM STATEMENT**

There are currently no formal statistics on the incidence of SCI patients or the respiratory complications that they develop in local CCU in the Nelson Mandela Metropole. Approximately two acute SCI patients are admitted to the CCU every month (Unpublished Institutional Statistics, 2012). Although this does not seem like a large number, the researcher has observed that these patients remain ventilated for a lengthy period of time from weeks to months and pose a challenge to the multidisciplinary team due to the severity of the injury and the complications they develop. Increased length on mechanical ventilation is associated with increased costs. In the public healthcare sector, there is always a shortage of beds in the CCUs, as well as human and financial resources, so the sooner the patients can breathe independently without mechanical ventilation, provided they are stable, they can be transferred to a high dependency unit or ward for further management and in so doing, allow other critically ill patients admission to the CCU contributing to cost effective and quality patient care. Ideally these patients should be treated in a specialised spinal unit so rehabilitation can start as soon as possible, however there are currently no specialised spinal units in the Eastern Cape resulting in SCI patients being treated in local CCUs.

Mechanical ventilation is a lifesaving therapy but is not without complications. The presence of an endotracheal tube places the patient at risk for ventilator associated pneumonia and/or acute lung injury which can further complicate their management. The researcher has also noted that SCI patients have copious secretions and a weak cough and need to be suctioned frequently. They are prone to recurrent lung collapse and frequently require bronchoscopies (sometimes daily). Due to the

prolonged period of mechanical ventilation these patients frequently require a tracheostomy. In the public healthcare sector, these patients are seen daily and sometimes twice a day by physiotherapists for respiratory management in the CCUs but unfortunately, this is not possible after hours or on weekends.

In the local CCU where the researcher works as a critical care nurse, there are no evidence-based guidelines/ protocols/ algorithms guiding clinicians in the respiratory management of SCIs. The protocol file within the local CCU includes a short description on the classification of these patients that was produced by the Physiotherapy Department within the hospital in 2006 however this makes no reference to the medical or nursing management of the SCI and the respiratory system is not mentioned at all. The researcher and fellow nurses are unaware of the best nursing care practices related to the respiratory management of mechanically ventilated SCI patients. International guidelines, which are not contextualised to South Africa, are available which offer guidance on how to care for the patient systematically, and are related to the acute management of the SCI patient. The researcher was unable to find any national guidelines on the management of Spinal Cord Injuries. The critical care nurse looking after the critically ill SCI patient has a responsibility to ensure that the patient is managed according to the best evidence available that will ensure the best outcome for the SCI patient and prevent further complications occurring.

SCI patients form part of a unique population and have special needs. These patients will be treated by various members of the multidisciplinary team who will treat the different needs of these patients throughout their stay in hospital. The focus of the research study will be to explore and describe the respiratory management of the mechanically ventilated SCI patient in a CCU. Management of these patients in the CCU differs considerably from management in other areas due to the presence of cardiac monitors, ventilators and trained and experienced critical care nursing staff.

The researcher has observed that nurses fail to perform thorough systematic respiratory assessments, and even when these are done, they are not always

documented as thoroughly as they should be, for example, noting inspection, palpation, percussion and auscultation. Furthermore, the researcher noted that no reference in the documentation is made to investigations such as chest X-rays and arterial blood gas analysis. Inspection is used frequently but palpation, percussion and auscultation are rarely, if ever, done. The researcher has observed that nurses lack the confidence and knowledge to act on the physical data, laboratory data and ventilator graphics to make decisions about the management of the SCI patient. The mechanical ventilator appears to complicate the management of these patients especially when novice nurses lack training and experience.

Informal discussions were held with a senior medical doctor and several senior nurses working in a CCU in the public healthcare sector who agree that the respiratory management of these patients can be challenging depending on the neurological level of injury and the associated injuries and management should be based upon the latest evidence available. It was agreed that these patients remain ventilated for a prolonged period of time, weaning is often slow and these patients have copious secretions requiring frequent suctioning.

Critical care nurses must be knowledgeable and skilled with regard to the respiratory management of the mechanically ventilated SCI patient to prevent complications and promote rehabilitation as soon as possible. The aim of the research is to explore and describe the literature regarding the respiratory management of the mechanically ventilated SCI patients and to make recommendations for practice based on the literature found.

### **1.3 RESEARCH QUESTION**

The research question is:

- What is the latest, best evidence that should inform the respiratory management of the mechanically ventilated spinal cord injured patient in a critical care unit?

## **1.4 RESEARCH OBJECTIVES**

The objectives of the study are:

- To explore and describe existing literature regarding the respiratory management of the mechanically ventilated spinal cord injured patient in a critical care unit.
- To make recommendations based on the latest evidence to enhance the respiratory management of the mechanically ventilated spinal cord injured patient in a critical care unit.

## **1.5 PURPOSE OF THE STUDY**

To explore and describe existing literature and to make recommendations for the respiratory management of a mechanically ventilated spinal cord injured patient in a critical care unit.

## **1.6 CONCEPT CLARIFICATION**

The following concepts utilised throughout the study are clarified below to ensure understanding.

### **1.6.1 The professional nurse**

A professional nurse is an individual who is registered with the South African Nursing Council as a nurse or a midwife and is competent to render nursing care (Nursing Act 33 of 2005). For the purpose of this study, a professional nurse refers to a nurse who is working in the critical care unit and who may hold an additional qualification in intensive care or have work experience in the field.

### **1.6.2 Critical care unit (CCU) or intensive care unit (ICU)**

According to Urden *et al.*, (2010:1) a critical care unit (CCU) is a specialised unit in a hospital, which provides care for severely ill patients with potentially reversible conditions. It also provides care for patients who require close observation and/or specialised treatments that cannot be provided in a general ward (Adam and Osborne, 2005:8). In this research study, a CCU comprises of critically ill adult

patients who have been admitted to a specialised unit with any condition or disease process that requires mechanical ventilation following SCI.

### **1.6.3 Spinal cord injuries (SCIs)**

A spinal cord injury (SCI) has been defined as an injury caused by trauma to the spinal cord, vertebral column, supporting soft tissue, or intervertebral discs (Smeltzer *et al.*, 2008:2233). According to Urden *et al.*, (2010:951) damage to the spinal cord may be classified as complete or incomplete depending on the degree of sensory and motor function below the level of the injury. For purpose of this research, SCIs will refer to all patients admitted to a CCU with any injury affecting the spinal cord, be it complete or incomplete.

### **1.6.4 Critical care nursing**

Critical care nursing is concerned with human responses to life-threatening problems, such as trauma, major surgery, or complications of illness. The human response can be physiological or psychological phenomena. The focus of the critical care nurse includes both the patient's and the family's response to illness and involves both prevention as well as cure (Sole *et al.*, 2009:3). Critical care nursing is practiced whenever care is rendered to a critically ill patient (Urden *et al.*, 2010: 951). In this research study, critical care nursing will refer to the nursing care rendered to a critically ill, mechanically ventilated SCI patient in a CCU.

### **1.6.5 Evidence-informed clinical guidelines**

Guidelines have been defined as systematically developed statements to assist practitioner and patient decisions about appropriate healthcare for specific clinical circumstances (Rees and Booth, 2005:315). According to Pearson, Field and Jordan (2007:103), clinical guidelines can be defined as sources of summarised information on specific practices related to patient care in order to guide healthcare professionals in their clinical decision-making. Evidence-informed clinical guidelines are systematic, developed statements based on the best available evidence in order to inform clinical decision-making (Swinglehurst, 2005:308). The development of

evidence informed guidelines was beyond the scope of this research. Recommendations will be made based on the latest evidence available from literature which will inform nursing care practice and will allow guidelines to be developed later as part of a future research study.

### **1.6.6 Respiratory management**

The respiratory system is sometimes referred to as the pulmonary system and includes the anatomical structures that allow gasses to move between the external and internal environment. The principal function of the respiratory system is gas exchange; other functions include regulating acid-base balance, metabolism of compounds and filtering of unwanted materials (Morton and Fontaine, 2009:525). For purposes of this research, respiratory or pulmonary refer to the respiratory system and the process of ventilation (movement of air into and out of the airways) and respiration (movement of gases across the alveolar capillary membrane). Management focuses on the respiratory interventions the nurse undertakes to ensure adequate ventilation and respiration of a mechanically ventilated SCI patient in a CCU.

### **1.6.7 Mechanical ventilation**

Mechanical ventilation has been defined by Urden *et al.*, (2010: 653) as a process of using an apparatus to facilitate the movement of oxygen and carbon dioxide between the atmosphere and the alveoli for the purpose of enhancing gaseous exchange. The research study focuses on the SCI patient who requires mechanical ventilation.

## **1.7 RESEARCH DESIGN AND METHOD**

The research design of a study has been referred to as the blueprint for conducting research and it offers control over factors that may threaten the validity of one's research findings. A research design assists the researcher in preparing and applying the study to attain the desired objective. A strong design makes it more likely that the study will contribute to the evidence base for practice (Burns and Grove, 2009:218). The research study will comprise of a systematic review. The

research design and method is described more comprehensively in Chapter Two of the study.

### **1.7.1 Systematic review**

A systematic review has been defined by Petticrew and Roberts (2010:9) as a literature review that adheres closely to a set of scientific methods that explicitly aim to limit systematic error (bias), mainly by attempting to identify, appraise and synthesise all relevant studies (of whatever design) in order to answer a particular question (or set of questions). Systematic reviews can be used to summarise and share the results from critically appraised research. The methods used in a systematic review are clearly indicated and examinable. Systematic reviews use inclusion and exclusion criteria and all available evidence on a topic and articles that are not included are put in table form and reasons for not including the research are clearly stated, reducing the risk of bias (Torgerson, 2003:6). All methods involved in the systematic review must be open and easy to replicate and the readers must clearly be able to assess the reliability, validity, and relevance of the review (Parahoo, 2006:134). Systematic reviews are an important part of clinical practice as they provide evidence-based information to support and develop practice as well as to support professional development as they highlight gaps in knowledge (Petticrew and Roberts, 2010:13).

A systematic review will, therefore, be undertaken in this study to identify the latest, evidence available regarding respiratory management of the mechanically ventilated SCI patient in a CCU with the intention of improving the management of these patients and preventing complications.

### **1.7.2 Research method**

Performing a systematic review requires a technique and plan in collecting and analysing data. This method, as applied when conducting the systematic review, includes developing a systematic review protocol, generation of a clear review question, searching for relevant evidence, data appraisal, extraction, synthesis and



data presentation. A copy of the systematic review protocol is provided in Annexure C.

### **1.8 ASSESSMENT OF THE QUALITY OF STUDIES INCLUDED FOR CRITICAL APPRAISAL IN THE SYSTEMATIC REVIEW**

Burns and Grove (2009:218) suggest that it is important to be able to recognise the design of the study and possible flaws that may threaten the validity of the findings. The Joanna Briggs Institute (JBI) (2001:3) suggests that all studies included in a systematic review need to be assessed for methodological rigour, which can be assessed by performing a critical appraisal.

A critical appraisal has been defined by Aveyard (2010:159) as a process by which the quality of evidence is assessed. A critical appraisal tool makes use of a checklist to assist in determining the quality of the evidence. The purpose of critical appraisal is to include studies providing good quality evidence and exclude studies offering poor quality evidence. All papers that met the requirements for inclusion in the systematic review must be appraised by two researchers independently of each other. The aim of critically appraising the evidence is to establish the validity. Validity refers to the strength of the research and how trustworthy and believable the evidence is (Pearson *et al.*, 2007:74).

### **1.9 ETHICAL CONSIDERATIONS**

Although this is a systematic review and the traditional method of data collection was not followed, it is noted that the following ethical principles have to be adhered to in conducting the research study. These ethical principles include ethical review, permission to conduct the study and plagiarism which will be comprehensively discussed in Chapter Two.

### **1.10 RESEARCH FINDINGS**

Results of the research need to be disseminated. According to Holloway and Wheeler (2002:37), research findings can be disseminated through journal articles,

books, or other media such as conferences, video and audiotapes. It is envisaged that a peer-reviewed article will be published in a scientific journal and a copy of the research findings will be disseminated to the unit manager of the CCU where the researcher works. The researcher will also be glad to share research findings at future nursing conferences and will make recommendations for future research when the need is identified.

### **1.11 DELINEATION OF THE STUDY**

The research is divided into the following chapters:

#### **Chapter One: Overview of the study**

This chapter involves introducing the reader to the research study including orientating the reader to the problem statement and describing the research design and method utilised in it.

#### **Chapter Two: Research design and method**

This chapter discusses the research design and method as it applies to the research study.

#### **Chapter Three: systematic review report**

Data collected from the systematic review will be presented in this chapter.

#### **Chapter Four: Conclusion, limitations and recommendations**

In this chapter the researcher makes concluding remarks, highlights limitations of this research study and makes recommendations with regard to the nursing care of the mechanically ventilated patient.

### **1.12 CONCLUSION**

The study aims to explore and describe the latest best evidence available regarding the respiratory management of the mechanically ventilated spinal SCI patient in a CCU. As mentioned earlier, nursing is dynamic, and practices are constantly changing as a result of developments in nursing research. The principle of incorporating evidence-based practice into nursing care has been highlighted and is

of fundamental importance when providing care for a mechanically ventilated SCI patient in a CCU. Respiratory complications are the leading cause of mortality in SCI patients and, where possible, these complications need to be prevented. The consequences of SCIs can result in paralysis of some or all the respiratory muscles resulting in the need for mechanical ventilation. Mechanical ventilation is a life-saving intervention but is also associated with several complications. If respiratory complications can be prevented or reduced, this will result in decreased mortality rates, decreased lengths of time on mechanical ventilation, decreased time spent in CCUs and decreased medical costs. Based on the results from the systematic review, evidence based recommendations will be made to improve the respiratory management of the mechanically ventilated SCI patient in a CCU. This chapter provided an overview of the study, while the next chapter will discuss the research design and method.

## CHAPTER TWO: RESEARCH DESIGN AND METHOD

In Chapter One, an overview of the study was given. Chapter Two provides a detailed discussion of the research design, method and measurement of the quality of the study, namely the systematic review, a description of the methods used to ensure the quality of the research as well as the ethical principles as applied throughout the study.

### 2.1 INTRODUCTION

The success of any research will depend upon identification of a research problem, developing a research plan, and the appropriate application of methods to the specific type of research. Along with the research design, the research method is vital as it describes the plan of how the research will be achieved. The researcher follows a predetermined plan as set out in the protocol (see Annexure C).

The purpose of this chapter is to provide a detailed description of the research design and method used to achieve the objectives of the study which are:

- To explore and describe existing literature regarding the respiratory management of the mechanically ventilated spinal cord injured (SCI) patient in a critical care unit (CCU).
- To make recommendations based on the latest evidence to enhance the respiratory management of the mechanically ventilated SCI patient in a CCU.

#### 2.1.1 Research design

Research has been defined by Pearson *et al.*, (2007:37) as the systematic search for truth or knowledge. The research design is the overall plan for addressing a research question, including strategies for enhancing the study's integrity (Polit and Beck, 2010:567). Aveyard (2010:19) suggests that doing a literature review systematically has a research methodology in its own right.

### **2.1.2. Systematic review**

According to Pearson *et al.*, (2007:101) the systematic review is a central part of evidence-based practice. Several approaches are available for identifying the best evidence but systematic reviews that are well conducted are regarded as the most influential form of evidence as they involve a rigorous review of the literature (Hargrove and Lund, 2005:226). Healthcare is an ever-changing environment which requires nurses to be aware of how to implement evidence-based practice to ensure that their patients receive the best treatment possible. Systematic reviews are highly recommended for the busy clinicians as they provide the latest evidence whilst saving time (Scanlon, 2007:8).

A systematic review has been defined by Hargrove and Lund, (2005:226) as a formal review where the researchers search, analyze and synthesize the literature relative to the topic using specific predetermined methods to answer a question. Sutherland (2004:48) defines a systematic review as “a summary of world literature on a specific topic that uses explicit methods to systematically search, critically appraise and synthesize the evidence from clinical research.” The researchers who will review the literature must adhere to inclusion and exclusion criteria set out before the research is conducted as well as maintain the standards for evaluating the search results. Systematic reviews summarise all past research on a given subject (JBI, 2001:2). According to Petticrew and Roberts (2010:9), systematic reviews maintain a set of scientific methods that explicitly intend to minimise bias, and in the process identify, appraise and synthesize all relevant studies of whatever design for the purpose of answering a research question.

### **2.1.3 The purpose / rationale of performing a systematic review**

According to LoBiondo-Wood and Haber (2010:210), the purpose of a systematic review is to describe the latest, compelling and applicable research on knowledge and intervention, which would inform evidence-based decision making in clinical practice. Systematic reviews are essential to the development of nursing skill and knowledge and publishing the research findings is an important way to improve evidence-based nursing practice (Rew, 2011:68). Evidence-based practice has

become the new buzzword of the decade (Egerod, 2006:107), and healthcare decisions need to be based on the best available evidence. There is an ever-expanding volume of literature, and systematic reviews are now considered the most reliable way by which this volume of research can be managed. The body of knowledge on which healthcare is based is changing rapidly and keeping updated with the volume of healthcare literature is difficult. Reviews of research are a way to become familiar with what is known about a topic in a single document, but only recently has it become necessary to describe the methods used to appraise the quality of the document. The systematic review uses rigorous methods to identify, critically appraise and synthesize relevant studies (Evans, 2001:51). Therefore, systematic reviews provide the best quality of evidence and should be chosen over other reviews.

Decisions on how to treat a patient need to be based on the best available evidence and not only on personal experience or case studies (Clarke, 2000:239-240). Nurses must learn to combine best available evidence, own expertise and judgement, as well as patient preferences and values when making clinical decisions that will effect the patient (O'Mathuna, Fineout-Overholt and Kent, 2008:107). Systematic reviews that are well-executed render the greatest level of evidence to base medical decisions on (Wieseler and McGauran, 2010:1240).

The researcher chose to do a systematic review as it is the most powerful form of research and forms the basis for evidence-based practice. A systematic review was chosen as it summarises all available literature on the topic and will assist the critical care nurse in making decisions about patient care that are based on the latest evidence to ensure patient safety and promote quality care. The researcher noted that no recent guidelines or protocols are available for the respiratory management of the mechanically ventilated SCI patient, and the researcher was uninformed of the latest evidence for the respiratory management of the mechanically ventilated SCI patient. Since systematic reviews are linked to evidence-based practice this was the approach chosen. The objective of the research is to explore and describe existing literature regarding respiratory management of the mechanically ventilated SCI

patient in a CCU and to make recommendations to enhance respiratory management of these patients.

#### **2.1.4 Aims of a systematic review**

According to Torgerson (2003:7) the aims of a systematic review include: focusing on a relevant research question, searching for data in a systematic way, diminishing bias at all stages of the review, appraising the quality in relation to the research question in order to synthesize the results of the review in an explicit way, to make the knowledge base more accessible, to recognise gaps and make suggestions in existing knowledge, to make recommendations for future research and to present all stages of the review in the final report so that they can be easily replicated and critically appraised. Systematic reviews are an important part of clinical practice as they provide evidence-based information to support and develop practice as well as to support professional development as they highlight gaps in knowledge (Petticrew and Roberts, 2010:13).

#### **2.1.5 Systematic review versus a narrative literature review**

A systematic review should not be confused with a narrative literature review. Both narrative literature reviews and systematic literature reviews provide summaries on the available literature on a topic; however, they fulfil very different needs. Narrative literature reviews give important summaries by experts and are usually an overview but are prone to bias as they do not follow a scientific review methodology (Bettany-Saltikov, 2012:9). Despite the fact that non-systematic literature reviews are prone to bias, they can be valuable as they may be written by experts in the field who have knowledge and expertise and offer a general summary of the topic area, but they may not include all the literature on the topic (Petticrew and Roberts, 2010:10).

A traditional or narrative literature review differs considerably from a systematic review in that it has no focused research question or search strategy, the methods of data appraisal and synthesis are not clear and the review is not easily repeatable. Narrative literature reviews are not recommended for academic studies. There is also a risk of personal bias from the author as well as selection bias in choosing

which studies to include. The methodology is unclear which makes the study difficult to be reproduced, so results cannot be easily confirmed and may, in fact, be false (Aveyard, 2010:18).

The systematic review uses a rigorous research methodology to minimise bias throughout every step of the review (Bettany-Saltikov, 2012:9). The systematic review, in contrast, has a clear methodology, a focused research question, a focused search strategy with comprehensive and specific methods, rigorous methods of data appraisal and synthesis, the method of undertaking the review is precise and results can be duplicated. Detailed reviews are a rigorous and demanding process (Aveyard, 2010:19). A systematic review identifies all available evidence pertaining to an identified theme and allows the readers to judge for themselves if the evidence supports or rejects the hypotheses. All evidence regarding a certain topic is collected and rejected and evidence is recorded, as well as the reasons for not including the research (Torgerson, 2003:6). Due to the paucity of clinical practice guidelines on the respiratory management of spinal cord injured patients in CCUs, it was decided to perform a systematic review on the topic. The data obtained in the systematic review can serve as a basis for guideline development.

## **2.2 RESEARCH METHOD**

The research method is the process used by researchers when forming a study to collect and examine information relative to the research question in a systematic way (Polit and Beck, 2010:16). The systematic review is sometimes referred to as secondary research (Pearson *et al.*, 2007:54); however, conducting a systematic review also requires a plan for obtaining and examining data. The research method will include: systematic review protocol, the review question, searching for relevant evidence, data appraisal, data extraction, data synthesis and presentation.

### **2.2.1 Systematic review protocol**

The development of a systematic review protocol is the first step in the research process and provides a predetermined plan to ensure scientific rigour and limit bias. (Pearson *et al.*, 2007:54-55). Another important consideration is to have a plan that



one can show one's colleagues at work and/or one's supervisor who can then assist with additional suggestions before one begins the research. The systematic review protocol is essential to the research process as it states the objectives and methods of the systematic review. The systematic review protocol allows the reader to see how the recommendations were arrived at. The protocol specifies the inclusion and exclusion criteria for studies to be included in the review. Any differences between the protocol and systematic review report should be discussed in the systematic review report (JBI Reviewers Manual, 2011:13).

The protocol includes the research question, the aims and methods that will be utilized to identify applicable information that will be used. The protocol is developed before the literature search with the reasoning that the research question as well as the inclusion and exclusion criteria for the literature search will not be subjected to bias before conducting the literature search (Torgerson, 2003:26).

The protocol includes the method for reviewing the research and, therefore, can be subject to peer review. The protocol distinguishes systematic reviews from traditional literature reviews due to the fact that the review is as careful and thorough as the research project (Evans, 2001:53). Torgerson (2003:27-29) suggests that the protocol be developed by researchers with experience in the area of concern and research synthesis. The inclusion and exclusion criteria are clearly set out in the protocol and specify the time frame for publications, the type of research to be reviewed, how the literature applies to the research question and will include criteria for determining the quality of the included studies. (See Annexure C for the systematic review protocol for the nursing care of the mechanically ventilated SCI patient in a CCU.) The inclusion and exclusion criteria will be more comprehensively discussed in Chapter Three.

### **2.2.2. Review question**

The first step in performing a systematic review begins with developing a clear research question (Yoshii, Plaut, McGraw, Anderson and Wellik, 2009:21). Bettany-Saltikov (2010:49) suggests that the review question is the most essential and difficult part of the research design. When performing a systematic review, it is

essential to have a clear question (Pearson, *et al.*, 2007:54). Whiting (2009:36) states, furthermore, a well-focused question gives structure to the review process and offers the reader insight into a chosen topic. According to Katapodi and Northouse (2011:193), a good research question will specify dependent variables, independent variables and interventions of interest as well as the population being investigated. The research question may examine the efficacy of treatments, identify subgroups and identify outcomes of specific interventions. A clear question will save time and money (Torgerson, 2003:26).

Clinical questions often arise from clinical situations. According the JBI Reviewers Manual (2011:12-13), a number of mnemonics are available to help researchers structure research questions. The PICO mnemonic is the most common and refers to Population, Intervention being investigated, Comparator, Outcome(s) of interest. Another mnemonic is the PICo which addresses the Population, the phenomena of Interest and the Context. Another that can be used across quantitative and qualitative reviews is the SPICE mnemonic, which describes the Setting, Perspective, Intervention, Comparison and method of Evaluation. Clinical questions have four components which can be easily remembered by the following acronym PICO (Population, Intervention, Comparison and Outcome) (LoBiondo-Wood and Haber, 2010:47).

In this research study, the PICo mnemonic has been used where the population refers to the adult mechanically ventilated SCI patient, the phenomena of interest refers to the respiratory management and the context refers to the CCU as it is the most applicable to the research study.

The research question thus formulated was based on the PICo mnemonic.

- What is the latest, best evidence that should inform the respiratory management of the mechanically ventilated spinal cord injury patient in a critical care unit?

### 2.2.3 Search for relevant evidence

The purpose of a literature search is to gather as many primary studies, published and unpublished, which aim to possibly answer the research question. According to Pearson *et al.*, (2007:60) a poorly designed search strategy can negatively affect the quality of the systematic review. The search strategy should be included in the research protocol. The methodology used to identify literature relevant to a systematic review is a key component when assessing the rigour of the review (Barker, 2010:95).

According to Katapodi and Northouse (2011:193), identifying and obtaining studies relevant to the systematic review takes the most time. It is advisable to seek assistance from a librarian or an information specialist who will know how to access the most relevant databases. Searching electronic databases, hand searching of key journals and searching reference list of other systematic reviews is the method least likely to cause selection bias (Torgerson, 2003:34-35).

The search process will result in many articles for possible inclusion in the systematic review. These articles then need to be sorted for relevance to the topic of discussion. Potentially relevant articles and abstracts should be included for consideration. It is very possible that duplicate studies may be included. It is important to be aware that duplicate studies or publications from the same study are a potential source of bias. Details of studies excluded should be recorded as well as reasons for exclusion (Katapodi and Northouse, 2011:195).

According to the JBI Reviewers Manual (2011:53-54), the search strategy of a systematic review can be done in different stages which were applied to the research study and are illustrated in Table 2.1.

**Table 2. 1: Search Strategy**

SEARCH STRATEGY		
Phase One	Initial search of the literature	<ul style="list-style-type: none"> <li>• Searched Cochrane Library for existing reviews</li> <li>• Searched the JBI systematic review library for existing reviews</li> <li>• Determined the databases that should be searched</li> <li>• Become familiar with the topic</li> <li>• Identified key search terms for each database</li> <li>• Developed and documented a search strategy</li> </ul>
Phase Two	Conduct search	<ul style="list-style-type: none"> <li>• Searched all databases using the identified search terms</li> <li>• Used inclusion criteria to determine which papers should be retrieved (as explained in the protocol and Chapter 3)</li> </ul>
Phase Three	Bibliography search	<ul style="list-style-type: none"> <li>• Searched the reference lists and bibliographies of all papers for additional studies</li> </ul>

Phase one included an initial electronic search of all major available databases including CINAHL, MEDLINE, PUBMED, the JBI Systematic Review Library, the National Guidelines Clearinghouse, the Cochrane Library and Google Scholar using broad search terms applicable to the title.

Google Scholar was a good place to begin searching for key terms. However, access to subject-specific data bases or retrieval of full text academic articles was limited. The JBIs best practice information sheets as well as systematic reviews were accessed online via the JBI site. EBSCOhost (Business, Social Sciences, Humanities, Medical and Health Education) database was also accessed via the NMMU website. EBSCOhost provided access to several other sites including, Academic search complete, CINAHL with full text (Cumulative Index to Nursing and Allied Health Literature), Health Source: Nursing/Academic Edition, MEDLINE (a medical literature analysis and retrieval system online) and MEDLINE with Full Text. Additional databases available on the NMMU library site that were searched include PubMed Central, ScienceDirect and Biomed Central. Within Biomed Central, the

Annals of Intensive Care, BMC Nursing and BMC Musculoskeletal Disorders journals were of particular interest.

The Cochrane Library consists of six databases, including the Cochrane Database of Systematic Reviews, the Cochrane Controlled Trials Register and Database of Abstracts and Reviews (DARE) and these were also searched although Wiley Online made complete access difficult.

The initial search both familiarised the author with the topic, and revealed how much information was available. This process assisted the author to gain a greater understanding of SCI patients. Databases did not all grant free access, some required subscription or purchase of an article which was not taken into account when determining the budget for the research.

The initial search allowed the researcher to become familiar with how the different databases work. Each database uses its own language or terminology that helps the researcher find information more easily. Searching tools are words or symbols used to assist the researcher in conducting an optimum search. Searching tools included Boolean logic, truncation, wildcard, thesaurus, index terms and MeSH headings. Different databases have different requirements and search tools are explained on the individual databases and were adjusted accordingly. (See Annexure E for a copy of the search terms used for the different databases.)

In step two of the search process, the researcher searched all databases using the identified search terms as well as the inclusion and exclusion criteria related to the nursing care of the mechanically ventilated patient. The researcher followed the inclusion and exclusion criteria which were decided before undertaking the literature review to limit potential bias in the systematic review. Characteristics of excluded studies have been documented in Annexure N.

In step three, all the reference lists as well as bibliographies of relevant studies were searched for additional studies. This process is called pearl-growing and is performed to discover if any other potential studies have been missed previously. Grey literature must also be included in step three; however, grey literature was

difficult to locate and obtain and, unfortunately, not found. Other databases that were found during the searching process included Highwire, the British Medical Journal, Evidence-Based Nursing – British Medical Journals Open Edition and the New England Journal of Medicine.

Abstracts as well as full text articles were used. The librarian at Nelson Mandela Metropolitan University assisted in obtaining full text articles of relevant abstracts when these were not available. Articles were obtained either electronically or via interlibrary loan. The researcher also asked the librarian to assist with searching the databases available to ensure that no evidence was overlooked. Journals were searched either online or in hard-copy form. Manual searching takes time but the researcher was able to retrieve literature that was unobtainable via electronic search due to access problems. The resource centres at the local government hospital library had a variety of academic articles which were not able to be accessed electronically, so these were searched manually. See Annexure D for a list of hand-searched journals.

After a researcher has collected the data that answered the research question, the researcher then must be able to distinguish between the different types of information encountered and the importance and relevance of the information. There is a general agreement that a hierarchy of evidence exists and that certain forms of research evidence are stronger than others (Aveyard, 2010:43-61). Hargrove and Lund (2005:226) suggest that a framework or hierarchy of evidence is needed so that individual clinicians can appraise and classify the information according to the strength of evidence. According to LoBiondo-Wood and Haber (2010:17), there exists a hierarchy of evidence for judging the strength of a study's design, which is just one level of assessment able to influence the confidence one has in the conclusions the researcher has made. Various hierarchies exist in literature but for purposes of this research, the model, as described in LoBiondo-Wood and Haber (2010:16), will be used in the research study (see Table 2.2). The reason for using the level of hierarchy of evidence is based on the fact that the study's objective is evidence informed, thus drawing on a wider variety of evidence. This model provides inclusion of different types of evidence.

Due to the fact that numerous literature papers were found on the topic of research, the level of evidence hierarchy was adapted by adding the literature papers to Level VII on the hierarchy. The decision was also based on the fact that the critical appraisal tool for the opinion papers would make provision for the appraisal of literature papers. Once the search process was completed, all papers found were read and re-read to assess if the data obtained was relevant to the review question. The papers were then re-read to assess the study methods used in each paper. Once the study design was identified, the papers were categorized according to the hierarchy of evidence levels. As mentioned earlier, if abstracts were relevant, then the librarian was contacted to try and obtain full-text articles. The amount of studies, according to the evidence hierarchy found, will be presented in Chapter Three of this study.

**Table 2. 2: Levels of evidence hierarchy**

LEVELS OF EVIDENCE HIERARCHY (LoBiondo-Wood and Haber, 2010:16)	
Level I	Systematic review or meta-analysis of randomized control trials (RCTs) Evidence-based clinical practice guidelines based on systematic reviews
Level II	A well-designed randomized controlled trial or randomized cross over studies
Level III	Controlled trial without randomization (quasi-experimental study)
Level IV	Single non-experimental study: <ul style="list-style-type: none"> <li>• Cohort studies, correlation, case control</li> <li>• Descriptive, survey and/or observational</li> <li>• Case reports</li> <li>• Retrospective</li> <li>• Single-group repeated measure</li> </ul>
Level V	Systematic reviews of descriptive and qualitative studies
Level VI	Single descriptive or qualitative study
Level VII	Opinion of authorities and/or reports of expert committees/ conference papers, Literature review papers or best practice information sheets or guidelines (added by the researcher for the purpose of this study)

### 2.2.4 Critical appraisal

Critical appraisal is the process by which the quality of the evidence is assessed. Once the papers found were categorized according to the hierarchy of evidence levels, the papers were again analysed with the intention of using the correct critical appraisal tool for the type of study. A critical appraisal tool is a checklist used to assess the quality of the evidence (Aveyard, 2010:159).

According to Pearson *et al.*, (2007:98) various critical appraisal tools are available on single studies without performing a meta analysis including CATmaker, RAPid, RevMan and SUMARI. For the purpose of this research study, the SUMARI (System for Unified Management, Assessment and Review of Information) Version 5.0 software package, developed by the Joanna Briggs Institute, was used ([www.joannabriggs.edu.au](http://www.joannabriggs.edu.au)). The research study is based on the JBI theoretical framework and, therefore, it was decided to use SUMARI as it assists the reviewers in all components of the systematic review process. SUMARI or the JBI-SUMARI is a software package designed to aid health and other researchers, scientists and practitioners conduct systematic reviews (Pearson *et al.*, 2007:96).

The JBI-SUMARI has various modules or components that can be used:

- The Joanna Briggs Institute Qualitative Assessment and Review Instrument (JBI-QARI) which is designed to facilitate critical appraisal, data extraction and meta-aggregation of findings of qualitative studies.
- Joanna Briggs Institute Meta Analysis of Statistics Assessment and Review Instrument (JBI-MASARI) which is designed to conduct the meta-analysis of the results of comparable cohort, time series, descriptive studies, case reports or review papers using a number of statistical approaches.
- Joanna Briggs Institute Narrative, Opinion and Text Assessment and Review Instrument (JBI-NOTARI) which is designed to facilitate critical appraisal, data extraction and synthesis of expert opinion texts and reports.
- Joanna Briggs Institute Analysis of Cost, Technology and Utilisation Assessment and Review Instrument (JBI-ACTUARI). This module which is designed to facilitate critical appraisal, data extraction and synthesis of economic data (SUMARI suite accessed via [www.joannabriggs.edu.au](http://www.joannabriggs.edu.au).)



After all the papers have been categorized and grouped according to the evidence found, the systematic review can then be registered on the JBI SUMARI suite. According to the evidence found, the critical appraisal tools in the MASTARI and the NOTARI modules were used to appraise the evidence. The JBI MASTARI was designed to enable reviewers to systematically review and combine the results of quantitative healthcare research. The critical appraisal tools in the JBI NOTARI module in the software package were used to appraise the Level VII evidence found, including opinion of expert, conference, committee and literature review papers.

The SUMARI software does not allow for the critical appraisal of clinical guidelines found; therefore, the Appraisal of Guidelines Research and Evaluation was used which is an international collaboration which aims to improve the quality and effectiveness of guidelines by promoting a common approach to development. The appraisal tool was been updated from the AGREE tool to the AGREE II appraisal tool. The AGREE instrument was developed to evaluate the methodological rigour and transparency in which a guideline was developed. According to the AGREE II instrument (2009:1), the purpose includes: assess the quality of guidelines, provide a methodological strategy for the development of guidelines and inform what information and how the information ought to be reported in guidelines. The Agree II instrument includes 23 items under six domains followed by two global rating items and each domain evaluates a unique dimension of guideline quality which needs to be appraised. A minimum of two and a maximum of four appraisers are needed to appraise the guideline. Each of the AGREE II items and the two global rating items are rated on a 7-point scale (1 - strongly disagree to 7 - strongly agree). The overall assessment includes the rating of the overall quality of the guideline and whether the guideline should be recommended for use in practice. In this research study, the AGREE II instrument was used to critically appraise the clinical practice guidelines found. (See Annexure F.) The SUMARI software does not allow appraisal of systematic reviews and a critical appraisal tool that was adapted from JBI tool was used (See Annexure K.)

Due to the different levels of evidence found, various critical appraisal tools were used which made provision for assessment of different types of evidence that can be found. Each tool is designed to check assess the validity of the specific study design

and the methods used. Copies of the critical appraisal tools used are illustrated in the Annexures G, H, I and J.

The SUMARI software package made provision for the different types of critical appraisal tools to be used and is indicated in Table 2.3.

**Table 2. 3: Evidence hierarchy & software packages used for critical appraisal.**

EVIDENCE HIERARCHY & SOFTWARE PACKAGES USED FOR CRITICAL APPRAISAL		
Level I	Systematic review or meta-analysis of randomized control trials Clinical practice guidelines based on systematic reviews	Joanna Briggs Institute Meta Analysis of Statistics Assessment and Review Instrument (JBI-MASARI) Appraisal of Guidelines Research and Evaluation II (AGREE II) instrument <b>[Note: this appraisal tool is not part of SUMARI as discussed before]</b>
Level II	A well-designed randomized controlled trial	JBI-MASARI software
Level III	Controlled trial without randomization (Quasi-experimental study)	JBI-MASARI software
Level IV	Single non-experimental study <ul style="list-style-type: none"> <li>• Cohort, correlation, case control</li> <li>• Descriptive, survey and/or observational</li> <li>• Case reports</li> </ul>	JBI-MASARI software
Level V	Systematic reviews of descriptive and qualitative studies	Joanna Briggs Institute Qualitative Assessment and Review Instrument (JBI-QARI). Not used as no evidence related to the topic found

Level VI	Single descriptive or qualitative study	JBI-QARI. Not used as no evidence related to the topic found
Level VII	Opinion of experts and/or reports or expert committees, conference papers Literature review papers or best practice information sheets or guidelines (added)	Joanna Briggs Institute Narrative , opinion and Text Assessment and Review Instrument (JBI-NOTARI) software

Once the study design and method of each paper to be critically appraised was assessed, two reviewers independently performed the critical appraisal using the SUMARI software packages. When discrepancies occurred, the reviewers would meet and discuss the issue and reach a consensus. After consensus was reached, the primary reviewer, namely the researcher, concluded the assessment process in order to move on to the next phase, namely data extraction.

### 2.2.5 Data extraction

According to Whiting (2009:39), data extraction can be defined as the process by which the information needed for data synthesis is obtained. Furthermore, the method of data extraction must be indicated in the protocol. Data extraction can be a challenging process and entails reviewing the primary studies and accessing the relevant information that will answer the research question (Bettany-Saltikov, 2010:52). In this research study, the researcher used the JBI-MAStARI and JBI-NOTARI software Version 5.0, which respectively allow for data extraction once the studies and/or papers found were critically appraised.

The JBI MAStARI extraction page lists a range of aspects which describe the study and include: method, setting, participants, number of participants, interventions, author and reviewers conclusions, (See Annexure L) (JBI – SUMARI Manual 5:128). The data extraction tool for the JBI NOTARI (Annexure M) differs from the MAStARI and has ten fields for data extraction which include: the type of text, those represented, stated position, setting, geographical context, cultural context, logic of

the argument, authors conclusions and the reviews comments (JBI – SUMARI Manual 5:176).

No extraction tool was available when using the AGREE II instrument for the clinical guidelines. As the number of clinical guidelines is limited, the researcher felt that it was not necessary to develop and pilot a data extraction tool. On completion of critically appraising the clinical guidelines, data was presented in a summarized manner.

### **2.2.6 Data synthesis and presentation**

Data analysis and synthesis in systematic reviews is concerned with pooling similar results together. According to Holopainen, Hakuline-Viitanen and Tossavainen (2008:80), results of a systematic review can occur as conclusions, analysis or synthesis. Bettany-Saltikov (2010:53) state that synthesis is the summary of the current state of knowledge, related to the research question. Systematic reviews can synthesize evidence from qualitative, non-experimental studies as well as experimental and quasi-experimental studies. The aim of a systematic review is to summarize the data and present it in a significant manner (Katapodi and Northouse, 2011:201). A quantitative combination of research results is commonly referred to as a meta-analysis whilst a qualitative combination of results is referred to as a meta-synthesis. Meta-analysis and meta-synthesis are important to evidence-based practice as they provide the option of assessing a larger set of data than is generally achievable as compared to a single study (Pearson *et al.*, 2007:92).

Meta-analysis has been defined by Torgerson (2003:8) as the statistical synthesis of data from separate but similar, for example comparable studies, leading to a quantitative summary of pooled results. Polit and Beck (2010:559) agree that a meta-analysis is a research technique for quantitatively combining results from various studies aimed at addressing a similar or the same research question. A meta-analysis of different sets of results can be undertaken only if studies are similar to each other so that the combination of the results is meaningful. The drawback to using a meta-analysis is that it is a complex process and can only be used on a similar type of quantitative data (Aveyard, 2010:126). When results from individual

studies are combined as is the case with a meta-analysis, the statistical power increases ensuring more accurate effect estimates (Noordzij, Hooft, Dekker, Zoccali and Jager, 2009:1130).

Meta-synthesis has been defined by Polit and Beck (2010:559) as the interpretive translations produced from the integration or comparison of findings from qualitative research. According to Barker (2010:97), if it is not possible or applicable to pool data in the form of a meta-analysis, then a narrative integration or a written summary of the findings will be provided. Barker (2010) further suggests that meta-analysis has two parts: calculating a measure of treatment effect and confidence level of each study as well as calculating the overall treatment effect. The researcher then assesses heterogeneity, how diverse the effects are across the different studies which are usually represented on forest plot graphs (also referred to as blobbograms). Meta-analysis or meta-synthesis can be used to analyse and present data (in the form of a forest plot, where possible).

However, in assessing the various studies, it was noted that the outcomes were not similar. Additionally, not all studies gave an account of their statistical analysis used, for instance, reports on the standard deviations and other inferential statistics. Due to the heterogeneity of the studies, it was thus not possible to perform a meta-analysis in this systematic review and to present the data in the form of a forest plot. No qualitative evidence was found that could be related to the systematic review questions, therefore, meta-synthesis was not used.

After the data extraction was completed on the JBI NOTARI software package, conclusions or recommendations were drawn from the studies reviewed. The process of categorising the conclusions or recommendations and synthesising these categories is called meta-aggregation of data and is specific to the JBI NOTARI module in the SUMARI. Included papers were read and re-read by the primary reviewer. Identified conclusions or recommendations for each paper were entered into the conclusion field. After all conclusions were drawn for the various papers reviewed, categories were assigned to various conclusions.

Categories are groups of conclusions that reflect similar relationships between similar phenomena, variables or circumstances that may inform practice. The categories were formulated based on the items that were repeated in the conclusions or recommendations. Synthesis of data involved the aggregation of categories to summarise the findings of the individual study into a final recommendation(s).

According to Wieseler and McGauran (2010:1244), the main purposes of a discussion of the results in a systematic review report are to explain how the research findings solve the research question and how the results differ from prior relevant research. This step can be particularly difficult to write and frequent problems encountered include long-windedness and repetition of results. The data as reported by categories will be discussed in Chapter Three as part of the systematic review report.

### **2.3 ASSESSMENT OF THE QUALITY OF STUDIES INCLUDED FOR CRITICAL APPRAISAL IN THE SYSTEMATIC REVIEW**

The quality of the studies included in the systematic review were reviewed by the researcher who evaluated if the data obtained answered the research question, whether the research design was correct, how the data was collected, the size of the sample as well as limitations of the study evaluate the research design, sample size, how data was collected, results and limitation of studies (Rew, 2011:64).

Critical appraisal is important for assessing the quality of studies. The researcher should be aware that pooling results of poor quality evidence may lead to outcomes that are less desirable for patients (Pearson *et al.*, 2007:74). All studies included have therefore gone through a process of critical appraisal with the intention of only including studies with a high quality of evidence and thus exclude those with poor quality evidence.

According to Scanlon (2007:9), there are three phases to critical appraisal of a systematic review. The first phase includes how the topic and search is accomplished, the second phase includes the validity and appraisal of the studies

that are included and excluded, and the third phase includes the interpretation of the studies. The main aim of critical appraisal of any type of evidence is to establish the validity of the evidence. Validity of the evidence refers to how trustworthy or believable it is and, in research, it is about the ability it has to convince us that it is acceptable. Validity is directly linked to the rigour of the research and the rigour differs according to the different research process (Pearson *et al.*, 2007:74). The validity of evidence from opinions as in a literature review was assessed not only on its logic and ability to convince, but also on the influence of the source and the quality of the opinion that makes it supportable. Critical appraisal was done using validated critical appraisal tools developed by the JBI (See Annexures G, H, I, J).

## **2.4 ETHICAL CONSIDERATIONS**

Although this is a systematic review and the traditional method of data collection will not be followed, it is noted that the following ethical principles have to be adhered to in conducting the research study. Ethical principles need to be maintained during all stages of the research process.

### **2.4.1 Ethical review**

An ethical review is necessary before data collection can commence. According to Terre Blanche, Durrheim and Painter (2007:61), an independent, accredited research ethics committee must approve all research. The research proposal was submitted and approved by the Research Committee in the Department of Nursing Science and the Faculty of Health Science Research, Technology and Innovation (FRTI) Committee at Nelson Mandela Metropolitan University where the study is registered. FRTI committee reference number is H11-HEA-NUR-003.

### **2.4.2 Permission to conduct the research**

Although no structured data collection method was pursued to collect data from the research population, written permission to review the documents (protocols, policy files, unit guidelines) regarding the respiratory management of the mechanically ventilated SCI patients in the CCU was requested from the unit manager and hospital manager at the local hospital (See Annexures A and B).

### 2.4.3 Plagiarism

According to Carver, Dellva, Emmanuel and Parchure (2011:124), plagiarism is the frequent form of scientific misconduct and has been defined as taking of another individuals ideas, processes, results or words without giving them credit for their work. A systematic review is sometimes referred to as secondary research as a systematic review makes use of previous completed research which is otherwise referred to as primary research (Pearson *et al.*, 2007:54). The researcher undertaking a systematic review is aware that the information provided by other authors must be credited and referenced appropriately. This researcher appropriately referenced and credited the work of the different authors used in the study.

### 2.4.6 Recommendations

According to Pearson *et al.*, (2007:108) evidence obtained from the research question should be utilised to develop recommendations to benefit the patient. Levels of evidence can be used to determine the quality of evidence for inclusion in the systematic review, on the one hand, when deciding whether or not to incorporate into practice an intervention or activity, on the other hand, grades of recommendation can be used. The grades signify the strength of recommendations to be used in practice. According to Pearson *et al.*, (2007:111) there are numerous examples of how recommendations can be graded. The United States Preventive Services Task Force (USPSTF) grading system, accessed via the link [www.ahcpr.gov/clinic/usptfix.ht](http://www.ahcpr.gov/clinic/usptfix.ht), has been utilised to rank recommendations for practice in this research study. Grade A includes level I and II types of evidence, Grade B indicates a level III evidence including quasi-experimental, non-randomised controlled trial, Grade C indicates level IV evidence including observation, descriptive and cohort studies and Grade D recommendations can be assigned to level VII evidence including case studies and expert opinion. Allocation of the grades depends on the quality of the study as assessed in performing the critical appraisal. See Table 2.4 for an explanation of the grades.



The researcher will apply these grading systems when making recommendations to enhance the respiratory management of the mechanically ventilated SCI patient in a CCU. These recommendations will be based on the data derived from the systematic review.

**Table 2. 4: Grades of recommendation (USPSTF)**

GRADES OF RECOMMENDATION (USPSTF)		
Grade	Definition	Suggestions for Practice
A	The USPSTF recommends the service and/or conclusion. There is high certainty that the net benefit is substantial.	Offer or provide this service
B	The USPSTF recommends the service and /or conclusion. There is high certainty that the net benefit is moderate to substantial.	Offer or provide this service
C	(Note this statement is under revision). Clinicians may provide this service and/or conclusion to selected patients or individual circumstances. However, for the most individuals without signs or symptoms there is likely to be only a small benefit from this service and/or conclusion.	Offer or provide this service only if other considerations support the offering or providing the service is an individual patient
D	The USPSTF recommends against the service and/or conclusion. There is moderate or high certainty that the service has no net benefit or that harms outweigh the benefits.	Discourage the use of this service
I	The USPSTF concludes that the current evidence is insufficient to assess the balance of benefits and harms of the service. Evidence is lacking, of poor quality, or conflicting, and the balance of benefits	Read the clinical considerations section of the USPSTF Recommendation Statement. If the service is offered, patients should

	and harms cannot be determined.	understand the uncertainty about the balance of benefits and harms
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## 2.5 SUMMARY OF THE CHAPTER

This chapter discussed the research design and method which are essential when planning and performing the research study. The next chapter will describe the systematic review report with regard to the respiratory management of the mechanically ventilated patient with an SCI.

## **CHAPTER THREE: SYSTEMATIC REVIEW REPORT**

Chapter One introduced the reader to the study. Chapter Two described the research design and method of the study. This chapter will discuss the systematic review report on literature found in addressing the respiratory management of the mechanically ventilated spinal cord injured (SCI) patient in a critical care unit (CCU).

### **3.1 INTRODUCTION**

Systematic reviews are considered the highest level of evidence and are essential to evidence-based practice (Hamunen, 2012:68). According to Pearson *et al.*, (2007:102) systematic review reports form the foundation for clinical practice guidelines. The review report should include a broad background that gives a good reason for conducting the review, an explanation of the objectives of the review, the method used for considering which studies to include in the review, the search strategy, methods used for critical appraisal, extraction and synthesis of the data. When reviewing the results, there must be a description of the studies including the type and number of papers identified. Furthermore, a description of the number of studies included and excluded, as well as a summary of the overall quality of the literature identified should be included in the systematic review report.

The systematic review report should include an overview of the results as obtained from the articles appraised and data extraction. Conclusions based on results and where there is adequate evidence, suitable recommendations for practice should be made. The final review report must contain references and appendices including critical appraisal forms, data extraction forms, table of included and excluded studies with the reason of exclusion next to it (Pearson *et al.*, 2007:102).

### **3.2. RESPIRATORY MANAGEMENT OF THE MECHANICALLY VENTILATED SPINAL CORD INJURED PATIENT**

Spinal cord injuries have an extensive effect on the physiological function of the body as nearly all body systems are innervated by the spinal cord and, as a result, the injury may directly or indirectly affect every system (Gibson, 2003:36). Individuals

with SCIs are at risk of developing secondary complications resulting from their injury. These complications include pain, spasticity, shoulder pain, urinary-tract infections, respiratory complications, pressure ulcers, cognitive impairments and major depressive disorders. Secondary complications are complications that occur as a result of the SCI and contribute considerably to morbidity, medical costs, and readmission to hospital within the first year following the injury (Matter *et al.*, 2008: 545). Respiratory complications are the most common of the systematic complications and might include pneumonia, atelectasis, aspiration, ventilator associated pneumonia, pulmonary edema and emboli. Furthermore, these complications can increase the mortality and morbidity rate and increase the length of hospital stay amongst these patients (Aarabi *et al.*, 2012:38). Considering the complications related to respiratory system, it is thus cardinal for the professional nurse caring for these patients to be knowledgeable and skilled in the management of such a patient. Respiratory management to avoid the above stated complications is thus an essential part of caring for the mechanically ventilated SCI patient.

In order to enhance care and decision making that is based on the best available evidence, clinical practice guideline use, which is based on a systematic review, is recommended. Due to the paucity of literature and, specifically, a systematic review on this topic, it was thus decided to undertake this systematic review. The systematic review in this research study was undertaken for the following reasons:

- To enhance the nursing care practices of the mechanically ventilated SCI patient in a CCU by making recommendations for practice that focuses on the respiratory management.
- To provide a systematic review report that is contextualised to the care of a mechanically ventilated patient in a CCU in the Nelson Mandela Metropolitan area.
- To provide a baseline for an evidence-informed clinical guideline to be developed as part of future research studies.

The items that will be discussed in the systematic review report are indicated in Table 3.1.

**Table 3. 1: Items for discussion on the systematic review report on the respiratory management of the mechanically ventilated SCI patient in a CCU**

ITEMS FOR DISCUSSION ON THE SYSTEMATIC REVIEW REPORT ON THE RESPIRATORY MANAGEMENT OF THE MECHANICALLY VENTILATED SCI PATIENT IN A CCU	
<b>3.2.1</b>	<b>Method</b>
3.2.1.1	The review question
3.2.1.2	Searching for evidence
3.2.1.3	Selection of evidence
3.2.1.4	Critical appraisal
3.2.1.5	Data extraction
3.2.1.6	Data analysis and synthesis
<b>3.3.</b>	<b>Discussion and Results of the systematic review</b>
3.3.1	Description of the evidence
3.3.2	Results of the systematic review

**3.2.1 Method**

The following section of the research study aims to describe the method used in conducting the systematic review on the respiratory management of the mechanically ventilated SCI patient.

**3.2.1.1 The review question**

The review question was structured on the PICO format. The population of interest (P) refers to the intubated, mechanically ventilated SCI adult. The phenomenon of Interest (I) relates to the respiratory management and the context (Co) refers to the critical care unit. The critical care unit will comprise both private and public sector. Based on the above principle, the following review question was structured: What is the latest, best evidence that should inform the respiratory management of the mechanically ventilated spinal cord injury patient in a critical care unit?

### 3.2.1.2 Searching for relevant evidence

A search strategy was initially formulated before the commencement of the literature searching process. A three-step approach, as described in Chapter Two, was followed in searching for the relevant evidence. Step One included an initial electronic search of all major available databases including CINAHL, MEDLINE, PubMed Central, the JBI Systematic Review Library, the National Guidelines Clearinghouse, the Cochrane Library, Google Scholar, BioMed Central, EBSCOhost and ScienceDirect using broad terms such as “mechanical ventilation” and “spinal cord injuries”. Apart from the electronic searching, a manual search of evidence was done in order to ensure that all possible evidence was included in this systematic review.

Step Two of the searching process involved searching all the databases using the identified search terms as well as the inclusion and exclusion criteria related to the respiratory management of the mechanically ventilated SCI patient in a CCU. Search terms used for identifying potential literature included “mechanical ventilation” OR “respiratory management” OR “pulmonary management” OR “respiratory assessment” OR “acute respiratory care” OR “respiratory complications” OR “respiratory failure”. AND “spinal cord injuries” OR “SCI” OR “acute spinal cord injuries” AND “critical care unit” OR “CCU” OR high dependency unit” OR “HDU” OR “intensive care unit” OR “ICU” OR critical care nursing” AND “evidence-based practice” OR “evidence-informed clinical guideline” The search terms related to the various databases are reflected in Annexure E.

Step Three involved searching the reference lists and bibliographies of research articles to assess if any potential articles had been missed as well as additional databases which were then accessed. The Critical Care Society of Southern Africa also has a database and this was searched to assess if any evidence or guidelines on the respiratory management of the SCI were available. Furthermore, hand searching for articles in critical care, emergency medicine, spinal cord journals and respiratory care journals was done to ensure that all possible evidence was included. The local health institutions library was used to access these journals. The librarian

at the university assisted in obtaining full text articles where abstracts proved to be relevant to the topic. The librarian and the interlibrary loan facility assisted in obtaining articles that could not be accessed via the local university. A search for unpublished dissertations and theses was done.

### 3.2.1.3 Selection of evidence

The inclusion and exclusion criteria as stated in the systematic review protocol (Annexure C) were used to identify which evidence to include and exclude in the review. The inclusion criteria considered the types of studies, types of participants, interventions and outcome measures, language of publications, and the time period the studies were conducted and published. The inclusion and exclusion criteria are discussed below.

#### 3.2.1.3.1 *Inclusion criteria*

The papers selected for inclusion in the review had to adhere to the criteria as set out below.

### **Types of evidence**

All types of research evidence that described the respiratory management of the mechanically ventilated SCI patient in a CCU, including best practice information sheets, clinical practice guidelines, randomised controlled trials, quasi-experimental, cohort studies, observational and descriptive studies, expert opinion and literature review papers were included in the systematic review. Papers were assessed against the evidence hierarchy for rating levels of evidence as stated in LoBiondo-Wood and Haber (2010:16). Due to the paucity of randomised control trials, systematic reviews and meta-analysis on the topic and the amount of literature papers found, it was decided to add literature review papers as Level VII evidence to the hierarchy of evidence.

The number of papers (according to the hierarchy of evidence) initially located is displayed in Table 3.2. A description of the total amount of papers found is reflected in Figure 3. 1.

**Table 3. 2: Papers included for the critical appraisal on the respiratory management of the mechanically ventilated patient in a CCU (Adapted from Lobiondo-Wood and Haber, 2010:6)**

TABLE 3.2 PAPERS INCLUDED FOR THE CRITICAL APPRAISAL ON THE RESPIRATORY MANAGEMENT OF THE MECHANICALLY VENTILATED PATIENT IN A CCU (ADAPTED FROM LOBIONDO-WOOD AND HABER, 2010:6)		
Level	Types of evidence	No. of papers allocated
I	Systematic review or meta-analysis of randomised control trials	3 (+3)
	Clinical practice guidelines based on systematic reviews	3 (+3)
II	A well-designed randomised controlled trail Randomised cross-over studies	1 (+1)
III	Controlled trial without randomization (quasi-experimental study)	(+1)
IV	Single non-experimental study: <ul style="list-style-type: none"> <li>• Observational</li> <li>• Case reports</li> <li>• Retrospective study</li> </ul>	9 (+6)
V	Systematic reviews of descriptive and qualitative studies	(+1)
VI	Single descriptive or qualitative study	0
VII	Opinion of experts and/or reports or expert committees Conference papers Literature review papers (added by the researcher) Best practice information sheets/guidelines	19 (+13)
Total number of papers		35 (+28) = 63

**Note, the papers indicated in brackets (28) were excluded after the critical appraisal.**



**Types of participants**

All studies that included human, adult patients, aged 18 years and older, who have sustained an injury to the spinal cord and who required mechanical ventilation were considered in the review.

**Types of interventions or activities**

Interventions of interest include those related to the respiratory management of the mechanically ventilated SCI patient. Specific interventions included respiratory assessment, intubation, airway management, suctioning, mechanical ventilator settings, tracheostomy, respiratory complications and weaning the patient from the mechanical ventilator.

**Types of outcomes measured**

The primary outcome measured would be a reduction in the amount of respiratory complications that occur during the acute phase of an SCI. Secondary outcomes would include a reduction in the length of days on mechanical ventilation in patients who are able to be weaned and therefore, a reduction in complications that arise from mechanical ventilation, as well as reduction in the days in the CCU, increased patient safety, decreased cost and better quality of life for these patients.

**Language of publications**

No language restrictions were applied and no non-English articles were found.

**Time period**

To ensure a thorough, broad search, all evidence that was available from the year 2000 was considered. However in cases where there was a paucity of literature, the researcher did consider using older data.

**3.2.1.3.2 Exclusion criteria**

All studies that included paediatric patients, neonates or animals were excluded due to anatomical and physiological differences.

#### 3.2.1.4 Critical appraisal

The JBI NOTARI tools were used to critically appraise literature review papers (See Annexure J for a copy of the critical appraisal tool used). The JBI MASTARI tools were used to appraise higher levels of evidence including Levels II, III and IV evidence found. Different critical appraisal tools for the specific design are available (See Annexures G, H, and I for copies of the critical appraisal tools used). The AGREE II appraisal tool (See Annexure F) was used to assess the quality of the clinical practice guidelines and/or best practice guidelines available on the nursing care of the mechanically ventilated SCI patient. The AGREE II instrument was discussed in Chapter 2 of this study. The adapted JBI appraisal tool was used for systematic reviews (See Annexure N).

Two reviewers independently appraised the papers found. The primary reviewer (the researcher) collected the results in order to make the final appraisal. When discrepancies were detected between the appraisal results of the two reviewers, consensus discussions were held to establish the reason for a discrepancy. Once a consensus was reached by the two reviewers, the final selection of papers was done for inclusion in the systematic review.

#### 3.2.1.5 Data extraction

Data from each study was extracted using the specific data extraction tools in the JBI SUMARI software packages. After the critical appraisal process, the details of each study and paper were entered into the respective data extraction tools available within the MASTARI and NOTARI modules (see Annexure L and M respectively).

NOTARI was used to capture each of the papers that were appraised in Level VII. Each paper was carefully read and re-read in order to capture all the details needed for extraction. Special attention was given to the conclusions and recommendations made in the papers to understand the core concepts and ideas. According to the JBI SUMARI – JBI version 5.0 (175-176), extraction details for Level VII opinion, conference and literature review papers included the following:

- The type of text refers to the type of opinion being reported, for example, an expert opinion, a guideline, a newspaper article or Best Practice Information Sheet or a literature review paper.
- Those who are represented in the paper, refers to those who the paper refers or relates to.
- The stated allegiance/position is a short statement summarizing the main points of the publication.
- The setting is important and gives information about the location from which the opinion has come from or where the research was conducted, for example, a CCU.
- The geographical context refers to the location of the author, including the country and whether the setting is rural or metropolitan.
- The cultural context refers to the features of the publication setting, for example, employment, lifestyle, ethnicity, age, gender, socioeconomic class, location and time period.
- The logic of the argument refers to how clearly the author describes assumptions and conclusions and whether evidence is available to back up these assumptions and conclusions.
- The author's conclusions reveal the core results of the publication.
- The reviewers' comments, which aided in describing the strengths and weaknesses of each paper ([www.joannabriggs.edu.au](http://www.joannabriggs.edu.au)).

The SUMARI software package includes a data extraction tool in the MASTARI module which is used to extract data from Level II, III and IV evidence. The extraction details' page lists a range of fields including: method, setting, participants, number of participants, interventions, authors' and reviewers conclusions. No data extraction tools are available for the AGREE II tool; therefore, data was summarized using the different headings as stated in the AGREE II appraisal tool. No data extraction tool was available for systematic reviews; therefore, data was also summarised and added to the themes.

### 3.2.1.6 Data analysis and synthesis

After completing the data extraction process, data analyses and syntheses were done using the SUMARI software packages. The next step on the JBI NOTARI software package allows for conclusions and categories to be formulated and saved. Conclusions are the main results reached by a reviewer after examining the data. Categories are groups of conclusions that reflect comparable relationships between similar phenomena, variables or circumstances that may inform/advance practice. (JBI-SUMARI:180).

After critically appraising each Level VII paper, summaries were made to provide a description. The main findings of each paper were then summarized in a table format, stating the author and the publication details, the aim of the paper, the type of study or paper, the main findings, its strengths and limitations. A code(s) was then allocated to the main finding(s) of the paper, for instance, if it focussed on assessment of respiratory system, the code assigned was 'assessment'. Once each paper was coded, the codes were grouped to develop a conclusion on the paper. The conclusions were then used to formulate categories. The synthesized data are illustrated in Table 3.3.

The MASTARI module in the SUMARI allowed for the synthesis of data appraised. Meta-analysis or meta-synthesis can be used to analyse and present data (in the form of a forest plot, where possible). However, in assessing the various studies, it was noted that the outcomes were not similar. Additionally, not all studies gave an account of their statistical analysis used, for instance, reports on the standard deviations and other inferential statistics. Due to the heterogeneity of the studies, it was thus not possible to perform a meta-analysis and to present the data in the form of a forest plot.

After critically appraising each paper, summaries were made and, where possible, the main findings were coded and linked to the categories that were developed. The thematic analysis allowed for data to be analysed and presented under themes and subthemes.

### 3.3 DISCUSSION AND RESULTS OF THE SYSTEMATIC REVIEW

The results of the systematic review will be discussed in this section of the study and this section as classified according to the categories and conclusions as set out in Table 3.3.

#### 3.3.1 Description of evidence

The initial literature search identified 220 possible papers for inclusion in the systematic review. However, after preparing the papers for the critical appraisal process 157 papers were excluded for the following reasons.

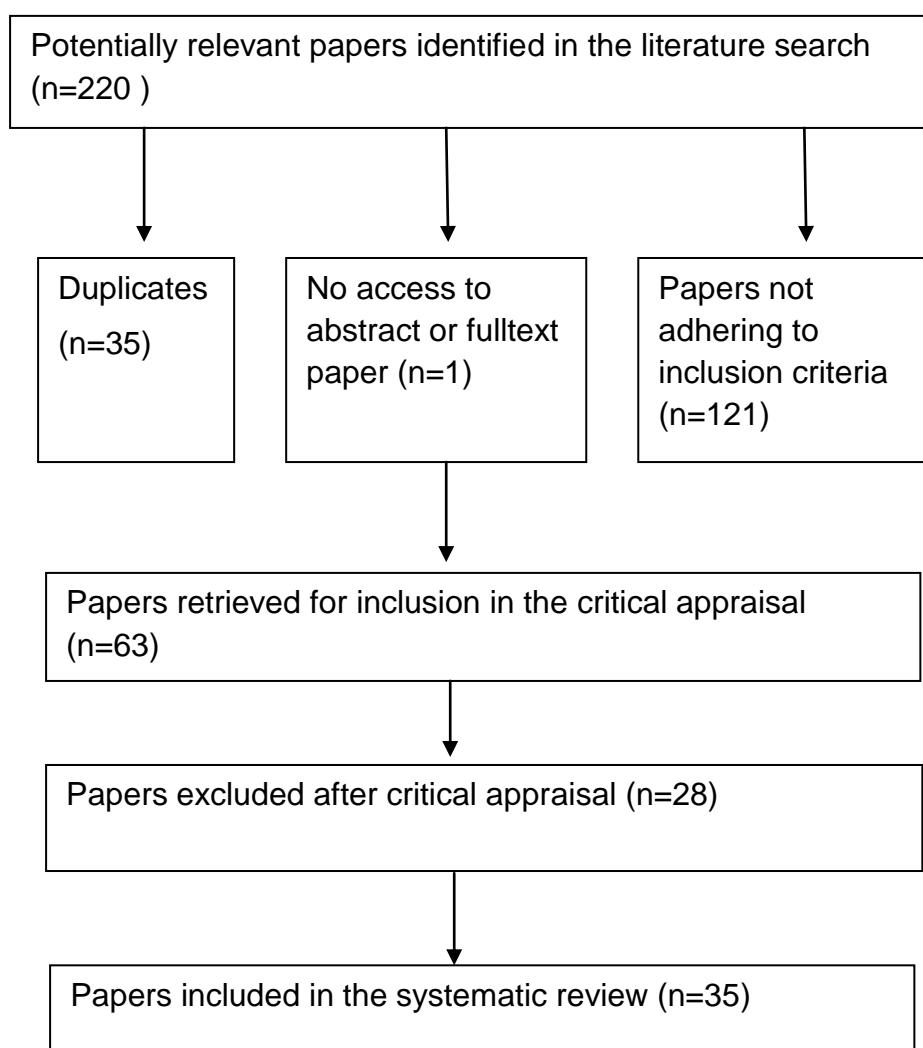
- Duplicate papers (n=35)
- No access to abstract/full text paper (n=1)
- Papers not adhering to inclusion criteria (n=121)

The papers (n=121) that were not adhering to the inclusion criteria comprised of the following:

- Abstracts (n=11)
- Fulltext (n=110 - of which animal studies (n=3), paediatrics (n=1) and the remaining articles not answering the review question (n=106)

Please see Annexure N for a list of excluded studies.

Total number of (63) papers were thus included for critical appraisal. Following the critical appraisal process, 28 papers were excluded from inclusion in the systematic review, thus a total of 35 papers were included. Figure 3.1 reflects the search results.



**Figure 3. 1: Results of papers found and included in the systematic review of the respiratory management of the mechanically ventilated SCI patient in a CCU**

### 3.3.2 Results of the systematic review

The results of the systematic review on nursing the mechanically ventilated patient with an SCI in a CCU will be discussed under the following headings as set out in Table 3.3.

**Table 3. 3: Summary of the synthesized data**

<b>Categories (Themes)</b>	<b>Subcategories (sub-themes) related to the respiratory management of the mechanically ventilated spinal cord injured patient.</b>
Priorities of care for the spinal cord injured patient in the acute phase	<ul style="list-style-type: none"> <li>• Admission to the critical care unit</li> <li>• Airway Management</li> </ul>
Priorities of respiratory care for the spinal cord injured patient in the critical care unit	<ul style="list-style-type: none"> <li>• Mechanical Ventilation</li> <li>• Weaning from the mechanical ventilator</li> <li>• Tracheostomy care</li> <li>• Respiratory management</li> </ul>
Priorities of Preventative Care	<ul style="list-style-type: none"> <li>• Specific respiratory complications</li> <li>• Prevention and management of respiratory complications</li> </ul>

### **3.4 PRIORITIES OF CARE FOR THE SPINAL CORD INJURED PATIENT IN THE ACUTE PHASE**

Patients that sustain trauma, irrespective of the types of injuries, are managed on the scene as part of the pre-hospital management. However, when admitted to a trauma unit, these patients are triaged according to the severity of the injury sustained. Patients with SCIs are managed in the same way. This section will discuss the priorities of care for the SCI patient in the acute phase once received in the hospital.

#### **3.4.1 Admission to the critical care unit**

Patients who are admitted to the trauma unit following a suspected SCI are triaged according to the type and severity of injury sustained. The SCI patient is at risk of multisystem complications; however the adverse effect on the respiratory system often results in these patients being admitted to the CCU.

According to a guideline for the management of acute cervical spine and SCIs by Hadley, Walters, Grabb, Oyesiku, Przybylski, Resnick, Ryken and Mielke (2002:420-

421), patients with acute SCIs, especially cervical injuries, frequently experience hypoxemia, pulmonary dysfunction and cardiovascular instability. Alterations in the respiratory function may occur in the early stages of SCI and can have detrimental effects if not recognised or managed promptly. Monitoring of these patients, especially respiratory and hemodynamic monitoring, is thus essential as is admission to the CCU. Monitoring these patients in a CCU allows for early identification of changes in the hemodynamic status of the patient including pulmonary dysfunction and hypoxemia. Early identification and treatment of these life-threatening events leads to a reduction in mortality and morbidity. Optimal length of stay in the CCU to provide optimal management is unknown, but it is recommended for the first seven to 14 days as this is when these patients are at the greatest risk of cardiac and pulmonary complications. Ball (2001:S27) agrees, in a literature paper stating that cardiopulmonary function is often affected as a consequence of acute SCI resulting in the management in a CCU. Due to the complications and intensity of monitoring of the SCI patient, the critical care nurse must have adequate knowledge regarding the pathophysiology as well as the management of these patients to promote health and prevent complications.

A systematic review on the intensive cardiopulmonary management after SCI done by Casha and Christie (2011:1492) recommends that the SCI patients should be managed in a special care unit with intensive ventilatory and cardiopulmonary support capability. Respiratory insufficiency tends to be prolonged when assisted ventilation is needed and often occurs within the first few days, but may last for weeks. Delayed pulmonary complications must be anticipated. The period at risk for an SCI patient starts early, if not immediately, following the injury but may extend beyond a month due to prolonged ventilatory requirements that are frequently encountered.

Other studies did not explicitly state the duration of admission of an SCI patient to the CCU but stated the importance of admitting these patients to one. In a literature paper by Jia, Kowalski, Sciubba and Geocadin (2011:4), the admission and management of the SCI patient in the CCU is highlighted as an important cornerstone of care in the acute treatment of these patients. Patients who have



sustained injuries to the cervical and thoracic spine were of particular concern as their injuries are associated with respiratory and cardiovascular complications which are serious concerns for the physician. Isolated and multiple organ failures may occur from the spinal injury and can be assessed by the Multiple Organ Dysfunction Score (MODS) and Sequential Organ Failure Assessment (SOFA), which can be used from the initial admission in the trauma unit. Management in the CCU is further important as SCI patients are at higher risk from systemic inflammation which may precipitate organ damage.

A literature review by Markandaya, Stein and Menaker (2012:175-177) recommends that all patients with an SCI or hemodynamic instability as well as other injuries warrant admission to the CCU. Other indications for critical care admission include: respiratory/ventilatory insufficiency secondary to weakness of respiratory muscles, neurogenic shock requiring intensive volume resuscitation and vasopressors/inotropes therapy.

A literature review paper by Tollefsen and Fonden (2012:1112) states that admission and management in the CCU is important as 75-80% of tetraplegic SCI patients may require intubation and mechanical ventilation during the acute phase of the injury. Respiratory management forms a crucial part of care for these patients. A retrospective study done by Hassid, Schinco, Tepas, Griffen, Murphy, Frykberg, Kerwin (2008:1328), in contrast, states that despite the type of SCI sustained, whether complete or incomplete, airway protection and respiratory management are essential in the care of these patients. Admission to the CCU, despite the type of SCI, is recommended in order to maintain and sustain the airway and respiratory effort.

### **3.4.2 Airway management**

Airway management has been recognised as part of the initial priorities of care once a patient with an SCI is admitted to the acute health care setting. In this section, airway management will include (1) goals of airway management, (2) indications for intubation and (3) techniques for airway management.

#### 3.4.2.1 Goals of airway management

Acute management of the SCI patient involves rapid restoration of the airway, breathing and circulation. Securing the airway and supporting the respiratory status is a priority in airway management (Consortium for Spinal Cord Medicine, 2008:433). According to a prospective observational study done by Berney, Gordon, Opdam and Denehy (2011:247), well thought-out airway management decisions are essential for the treatment of SCI patients in the CCU. Delayed or failed efforts to maintain and sustain spontaneous breathing efforts can result in increased risk for complications, for instance, ventilator-associated pneumonia, higher mortality and morbidity rates, prolonged length of stay in the CCU and increased cost.

A literature review paper by Berlly and Shem (2007:314) states that in SCI patients' tracheal intubation and ventilation should be commenced quickly to prevent secondary hypoxic central nervous system damage. Stevens, Bhardwaj, Kirsch and Mirski (2003:220) agree in their literature review in stating that the goal of airway management in the SCI patient is to ensure rapid control of the airway while incurring minimal neurologic risk and complications. Two literature papers concur that the goals for intubation include maintenance of adequate oxygenation and ventilation and ensuring adequate spinal cord perfusion pressure. Preserving the patients' airway is the main concern throughout the acute phase of care for SCI patients. Airway patency and respiratory management should be a care priority in preventing and managing respiratory complications (Royster, Barboi and Peruzzi, 2004:14 and Sheerin, 2005:27-30).

#### 3.4.2.2 Indications for intubation

If the SCI patient is unable to maintain spontaneous breathing efforts, an attempt by means of intubating and ventilating the patient should be made in order to assist with breathing efforts, thus ensuring airway management.

It is recommended in a literature review done by Berlly and Shem (2007:314) that non-invasive ventilator techniques should be attempted first in order to ensure a patent airway for the SCI patient. However, if despite the non-invasive techniques,

intubation is required, it should be based on the following criteria: vital capacities trending downwards and less than 15 mL/kg ideal body weight, increasing oxygen requirements, increasing respiratory rate with low tidal volumes, rising PCO<sub>2</sub>, and diminished breath sounds. According to the guideline by the Consortium for Spinal Cord Medicine (2005:5), indications for intubation include intractable respiratory failure when continuous positive airway pressure (CPAP) and bi-level positive airway pressure (BiPAP) or non-invasive ventilation have failed. If the SCI patient is at risk for respiratory compromise or at a high risk for aspiration or aspiration pneumonia, the patient should be intubated.

Berney, Bragge, Granger, Opdam and Denehy (2011:22) conducted a systematic review on the management of cervical SCIs and reported that approximately 74-90% of patients with complete cervical injuries would require intubation. A retrospective study done by Como, Sutton, McCunn, Dutton, Johnson, Aarabi and Scalea (2005:912) on cervical SCI patients who were admitted to a level 1 trauma centre revealed a high probability for intubation in patients with a complete cervical SCI even in the absence of respiratory failure. Findings of the study revealed that 92% of cervical SCI patients will require intubation and airway management and that all complete injuries above C5 will require intubation. 79% of cervical injuries at C6 and below need intubation, while only 35% of incomplete injuries require it. Based on the results of their study, authors recommend early semi-elective intubation of complete cervical SCI patients with levels above C5 to avoid emergency intubation which is associated with risk factors. Another retrospective study by Hassid *et al.*, (2008:1331) agrees that early intubation is mandatory for complete SCI patients. However, patients with incomplete SCI who have signs of respiratory failure must have immediate airway intervention, which will include intubation and mechanical ventilation.

The above statement is supported by a literature review paper of Royster *et al.*, (2004:16) stating that respiratory difficulty, regardless of the level of injury, frequently requires intubation and full ventilatory assistance. The indications for an endotracheal airway include: reduced or absent airway protective mechanisms (due to coexisting intracranial injury or other pathology); evidence of an obstructed airway;

acute respiratory failure in patients with injuries at or above C4 who lack diaphragmatic function and in patients with coexisting thoracic-abdominal trauma. Furthermore, patients who have an inability to cough, or ability to clear secretions and participate in bronchial hygiene, due to a decrease in forced vital capacity and forced expiratory volume as a result of a loss of intercostal and abdominal muscle activity must be intubated.

Six literature review papers agree upon the indications and the importance of endotracheal intubation. Endotracheal intubation is indicated in presence of apnea, respiratory distress and depressed levels of consciousness to protect the patients' airway (Walker, 2009:52). According to Stevens *et al.*, (2003:219), intubation is indicated in SCI patient with a compromised airway (coma, edema, retropharyngeal hematoma, high risk of aspiration), respiratory failure (significant decline in FVC or  $FVC < 15$  ml/kg, increased work of breathing,  $PaO_2 < 60$  mmHg or substantial reduction since supplemental  $O_2$ ,  $PaCO_2 > 60$  mmHg) as well as associated traumatic brain injury,  $GCS < 8$ , intracranial hypertension and risk for herniation. Cervical SCIs are seen as a high risk factor for intubation. Injuries to the cervical spine C1-C4 will definitely require intubation, while injuries above C5 are likely to result in apnea and will need immediate ventilatory support (McLeod, 2004: 1045). Three literature reviews agree that injuries to C5 and below may have impaired spontaneous ventilatory parameters and often present with a forced vital capacity and maximal inspiratory force that are acutely decreased by 70% (El-Said, 2011:103; Ball, 2001:S27; Denton and McKinlay, 2009:83).

#### 3.4.2.3 Techniques used for intubation

SCI patients are at a high risk for intubation-associated complications and special care should thus be taken when managing the airways of this population of patients. A literature review paper by Sheerin (2005:27) indicates that intubation should be done carefully and practitioners need to be aware as they may trigger bradyarrhythmias or cardiac arrest in patients who may already have neurogenic shock-induced bradycardia. Another literature review by Stevens *et al.*, (2003:219) states that intubation of an unstable SCI can result in severe injury and death. Bradycardia,

hypotension and even a cardiac arrest can occur during intubation of the tetraplegic patient, which might be due to hypoxia or manipulation of the larynx or trachea. A guideline recommends that atropine pre-treatment may be appropriate if the patient had bradycardia prior to airway management (Consortium for Spinal Cord Medicine, 2008:448).

Due to the intubation-related complications, a literature review by Royster *et al.*, (2004:14-15) recommend that bag-mask ventilation be used initially for ventilatory failure in the SCI, but is not a long-term solution as air may be introduced into the stomach and cause gastric distension and increase the risk of aspiration of gastric contents. The chin lift and jaw-thrust methods should be avoided if the patient has an unstable spine as it may result in a more than 5 mm widening of the disc space with C5-6 instability that is not diminished by a rigid collar. In addition, two literature review papers (Sheerin, 2005:27; Walker, 2009:52) favour the jaw-thrust approach rather than the chin-lift approach for airway management. The chin-lift approach can cause extension of the neck whilst the jaw-thrust method shows minimal spinal hyperextension.

In patients where securing an airway is suspected to be difficult or if coexisting facial trauma is present, a cricothyroidotomy can be performed. However, this procedure is difficult if the spine is immobile and no studies have shown the neurological outcome of these patients. Other options include blind nasotracheal intubation, light wand and retrograde intubation (Royster *et al.*, 2004:15). However, it is noted in a literature review paper by Stevens *et al.*, (2003:220) that varying degrees of displacement might occur with nearly all airway interventions including: chin lift, jaw thrust, cricoid pressure, mask ventilation, laryngeal mask airway placement, combi-tube placement, laryngoscopy and orotracheal tube placement. Therefore, manual in-line stabilization where two people (one to hold the head in a neutral position while the other one to cannulate the trachea) has been shown to decrease but not abolish cervical spine movement and is thought to be safer option while intubating the SCI patient. The method is supported in the literature papers by Ball (2001:S27) and El-Said (2011:104) stating that orotracheal intubation with manual in-line traction is safe

in acute cervical SCI. They agree that a two-person oral intubation with in-line cervical traction should be done in a controlled as opposed to emergency situation.

However, Berlly and Shem (2007:314) and Royster *et al.*, (2004:14) in their literature review papers agree that orotracheal intubation in acute SCI is safe but emphasize that awake fiberoptic intubation is preferred. According to a guideline by the Consortium for Spinal Cord Medicine (2008:433), the technique for intubating a patient with a suspected or confirmed cervical SCI in an emergency situation is rapid sequence induction with cricoid pressure and manual inline stabilization. If a difficult intubation is anticipated, and the patient is awake and co-operative, an awake fiberoptic intubation is the method of choice for securing the airway in patients who have impending respiratory failure. Fiberoptic intubation is beneficial as it can be performed without any movement of the cervical spine. Several other authors in three literature papers (Berlly and Shem, 2007:314; Stevens *et al.*, 2003:220; and Royster *et al.*, 2004:15) and one retrospective study (Como *et al.*, 2005:912) agreed that fiberoptic intubation is preferred whilst the patient is awake under controlled circumstances. Royster *et al.*, (2004:15) state the advantages of fiberoptic intubation include: the patient is able to breathe instinctively, reduced risk of aspiration, enhanced vision of the larynx, easier procedure to complete than direct rigid laryngoscopy. However, assistance from the patient is required as well as an unobstructed airway from blood and secretions, minimal pharyngeal edema and sufficient supra and infraglottic anaesthesia. However, there is minimal evidence to suggest a decrease in neck movement and success rate and time to intubation is comparable to direct rigid laryngoscopy.

Apart from the technique to be used for intubation and thus securing the airway in the SCI patient, recommendations have been made with regard to the induction agents of choice when intubating.

According to a guideline by the Consortium for Spinal Cord Medicine, (2008:433) succinylcholine remains the agent of choice for rapid sequence intubation in SCI patients within the first 48 hours of injury, thereafter, a non-depolarizing neuromuscular blocking agent should be used instead. Data obtained from two

literature papers (El-Said, 2011:106; Denton and McKinlay, 2009: 83) agree that suxamethonium is safe for use within the first 48 hours post SCI. However, a literature review by Berlly and Shem, (2007: 314) suggest the safety of Succinylcholine is restricted to the first 24 hours post SCI due to the increased risk of precipitating hyperkalemia. In another literature review paper by Ball (2001:S27) it was suggested that Succinylcholine is safe to use up to four days post SCI.

According to a guideline by the Consortium for Spinal Cord Medicine (2008:433), propofol and thiopental are frequently used in hemodynamically stable patients, as both can aggravate hypotension. Ketamine and etomidate are alternatives induction agents that can be used during intubation. However, ketamine can result in hypertension and is controversial in patients with head injury as it can cause an increase in intracranial pressure. Etomidate provides stable hemodynamics during induction, but there is a concern about safety of use in critically ill patients as etomidate inhibits adrenal steroid synthesis and has been associated with hypotension however the significance of this remains controversial as sicker patients were reportedly used.

### **3.5 PRIORITIES OF RESPIRATORY CARE FOR THE SPINAL CORD INJURED PATIENT IN THE CRITICAL CARE UNIT**

Once the SCI patient has been stabilised and intubated in the acute phase of management, it is essential to maintain breathing efforts by means of a mechanical ventilator. This section focuses on priorities of care in the CCU, which include mechanical ventilation, tracheostomy care, respiratory management and weaning from the mechanical ventilator.

#### **3.5.1 Mechanical ventilation**

Mechanical ventilation is a treatment modality that can assist to reverse hypoxemia and hypercapnia, reduce the work of breathing, re-expand collapsed lungs, and aid in pulmonary toileting all of which are essential in the SCI patient (Stevens *et al.*, 2003:221).



A retrospective study by Como *et al.*, (2005:915) indicated that the level of neurological injury and completeness were associated with need for airway control and mechanical ventilation. All patients with complete injuries at C5 and above needed definitive airway and ventilatory support.

According to a literature review by Stevens *et al.*, (2003:221) respiratory dysfunction is directly related to the level and completeness of neurological injury in the SCI patient. Complete injuries above C3 might result in apneac arrest and death, except if ventilatory assistance is given immediately. Survivors have the highest mortality rate compared to other SCIs and are at a high risk of respiratory complications and will need long-term ventilatory support or diaphragmatic pacing. C3-C5 injuries are associated with differing degrees of respiratory failure with reduced lung volumes and need for mechanical ventilation. However, considerable numbers of these patients may be liberated from the mechanical ventilator (Stevens *et al.*, 2003:221). Another two literature reviews by Royster *et al.*, (2004:16) as well Markandaya *et al.*, (2012:178) agrees that high cervical SCI patients with injuries above C5 will need to be intubated and be placed on mechanical ventilation.

Three literature papers highlighted the need for mechanical ventilation in the SCI patient: Tollefsen and Fondenes (2012:1112) agree that tetraplegic patients (75-80%) may need mechanical ventilation during the acute phase and injuries higher than C6 will need intensive observation. McLeod (2004:1045-1046) states that high cervical SCI injuries at (C1-C4) will require intubation and mechanical ventilation but the SCI patient with injuries to C5-C7 may develop respiratory insufficiency as spinal cord edema increases and, therefore, also need mechanical ventilation later. An additional literature review agrees that injuries above C3-C5 result in apnea and the need for immediate ventilatory support. Injuries to C5 and below may have impaired spontaneous ventilatory parameters which need to be monitored in case mechanical ventilation is indicated (El-Said, 2011:103).

According to a prospective study done by Gutierrez, Harrow and Haines (2003:100) and a literature review (Jia *et al.*, 2011:4), the mortality and morbidity rates are strongly associated with the dependence on mechanical ventilator. Furthermore, it



was recorded that the survival rate for ventilator-dependent SCI patients is 33 % compared to 84% in those patients with similar injuries who were able to discontinue mechanical ventilation.

### **3.5.2 Ventilator management strategies**

Once the patient is intubated and connected to the mechanical ventilator, strategies have to be applied to ensure optimal ventilation and to avoid ventilator-related complications. In managing the mechanical ventilator, the modes of ventilation, tidal volume, PEEP and other settings have to be considered. The following section aims to discuss the ventilator strategies that are optimal for the SCI mechanically ventilated patient.

#### **3.5.2.1 Modes of ventilation**

A literature review by Stevens *et al.*, (2003:221) states that patients with complete SCIs to C3 and above require ventilatory support with modes such as controlled mandatory ventilation or assist-control. However, patients with incomplete injuries at this level require ventilator modes that incorporate spontaneous breathing, for instance, pressure-support ventilation and synchronised intermittent mandatory ventilation, which might limit respiratory muscle deconditioning and atrophy and promote weaning. A literature review by Tollefsen and Fondenæs (2012:1113) recommends controlled ventilation as opposed to assist ventilation when respiratory muscles are not equally affected on both sides of the diaphragm. Assisted mechanical ventilation results in less lung expansion and increased atelectasis in the poorly functioning hemi-thorax.

#### **3.5.2.2 Ventilator settings**

A guideline by the Consortium for Spinal Cord Medicine (2008:454) reports that higher tidal volumes (20ml/kg or greater) showed favourable outcomes for atelectasis, and the time to ventilator weaning in the SCI patient. Another spinal cord guideline from the Consortium for Spinal Cord Medicine (2005:6) states that management of the SCI patients with intractable atelectasis needing mechanical

ventilation should include using a protocol that consists of increasing ventilator tidal volumes to resolve and/or avoid atelectasis. The ventilator should also be set so that the patient does not override the ventilator settings. However, a protocol for ventilation should be used.

A literature review by Tollefsen and Fonden (2012:1112-1113) recommends the use of larger tidal volumes (15 ml/kg of ideal body weight) during the acute phase as this lowers the risk of atelectasis and pneumonia. In the event of evident atelectasis, tidal volumes can be temporarily increased by 100ml/day and up to 20 ml/kg. Peak airway pressures must be kept below 40 cmH<sub>2</sub>O in order to prevent barotrauma. The use of higher tidal volumes is confirmed by a literature review by Wallbom, Naran and Thomas (2005:3) who recommend the use of higher tidal volumes (TV) 10-15cc/kg and working up to 20 cc/kg, if needed to treat atelectasis. Another literature review paper by Royster *et al.*, (2004:16) suggests ventilator strategies with low respiratory rates in addition to high tidal volumes (15-20 cc/kg) resulted in lower respiratory complication rates and shortened time on the ventilator as well as improved patient comfort and less dyspnea.

Two literature reviews (El-Said, 2011:107 and Denton and McKinlay, 2009:84) agree that when respiratory failure is due to ventilatory failure, for example, a low fraction of inspired oxygen (FIO<sub>2</sub>), large tidal volumes >20 ml/kg have been recommended as there is evidence that this reduces atelectasis and hastens weaning. Authors Winslow and Rozovsky (2003:810) confirm in a literature review that ventilation strategies utilizing larger tidal volumes have been suggested for the SCI patient and are commonly used among those treating ventilatory failure after SCI, but there are no reference range for tidal volume. A literature review by Stevens *et al.*, (2003:221) states many clinicians promote larger tidal volumes (10-15ml/kg), intermittent sighs, or positive end expiratory pressure to assist in recruiting of atelectatic lungs.

According to Berly and Shem (2007:315-317), who conducted a literature review, significant debate regarding low-volume and high-volume ventilation exists. Barotrauma results from high-volume ventilation and it is recommended that tidal volumes of 6-8 ml/kg be used. However, no trials involved the SCI patient. Low tidal

volumes pose a risk to SCI patients as they can lead to atelectasis, mucous plugging, decreased surfactant, thus increasing the work to expand the lungs. The use of higher tidal volumes in the management of the SCI patient is recommended.

An additional literature review suggests that mechanically ventilated SCI patients prefer larger tidal volumes; however, the rationale is not well-known but it is thought that dyspnea occurs with the use of smaller tidal volumes. Large breaths have the advantage of preventing small-airway narrowing or closure by stretching airway smooth muscle, and by reducing surface tension by expanding the surface area of the surfactant. Large breaths up to 1,0L (often with PEEP of 5 cmH<sub>2</sub>O) are common and are not responsible for ventilator-associated lung damage, however large breathes are associated with a low PaCO<sub>2</sub> but no identified harmful long-term consequences (Brown, DiMarco, Hoit, Garshick, 2006:865).

A literature review by Cook (2003:149), on the management of an SCI patient with associated traumatic brain injury, recommended that tidal volumes and PEEP values are sufficient to hyperinflate alveoli and to maintain surfactant release and prevent atelectasis. In patients with SCI and associated traumatic brain injury, PEEP values as high as 10-12 cmH<sub>2</sub>O should be avoided as it can produce a 3-5cm increase in cerebrospinal fluid pressure.

### 3.5.2.3 Lung protective ventilation strategies

According to the Guideline by the Consortium for Spinal Cord Medicine (2008:454), SCI patients who develop ARDS should receive low tidal volume ventilation until their pulmonary disease resolves. Low tidal volume ventilation of 6 ml/kg is recommended to be used in all SCI patients with acute lung injury (ALI) or Acute Respiratory Distress Syndrome (ARDS) as it is the only method of mechanical ventilation that up until now has been shown to improve survival.

However, five literature reviews (El-Said, 2011:107; Tollefsen and Fondenes, 2012:1112; Denton and McKinlay, 2009:84; Royster *et al.*, 2004:16 and Stevens *et al.*, 2003:221) agree higher tidal volumes should only be used in the absence of lung

injury. If lung injury is present in the form of acute lung injury, contusion, infection, and ARDS, then only lung protective ventilation should be used for SCIs.

### **3.5.3 Weaning from the mechanical ventilator**

Weaning the SCI patient from the mechanical ventilator timeously is important in minimising or preventing respiratory complications. The neurological level and completeness of the injury are independent predictors of that ability to wean.

Two retrospective studies done by Call, Kutcher, Izenberg, Singh and Cohen (2011:1673) and Como *et al.*, (2005:914) reveal that higher levels of SCI correlated with failure to wean and to extubate the patient. Como *et al.*, (2005:914) further state that in a patient aged above 50, who presents with other associated injuries in addition to high cervical SCI, the weaning process might be compromised. A literature review by Winslow and Rozovsky (2003:811) suggests that completeness of the SCI is a factor in weaning patients from the mechanical ventilator. The rate of weaning SCI patients with complete injuries at level C5-C8 was not affected, but patients with incomplete injuries at level C4 were more likely to be weaned than complete injuries at this level. A retrospective study by Seidl, Wolf, Nusser-Muller-Busch, and Niedeggen (2010:1077) states that an attempt to extubate the patient should be made in all trauma patients, especially those who present with SCIs below C7-C8. A literature review by Denton and McKinlay (2009:84) states that SCI injuries at and below C4 are potentially weanable once the active pulmonary pathology has resolved and chronic changes to pulmonary mechanics have commenced.

Failed attempts to wean the SCI patient may prolong endotracheal intubation, increase tracheal and laryngeal trauma, infection and prolong the stay in the CCU (Berlly and Shem, 2007:315). Findings from a retrospective study by Call *et al.*, (2011:1673) revealed that unsuccessful extubation was associated with pulmonary insufficiency (80%), inadequate pulmonary hygiene (22%) or due to sedation or neurological issues (5%). Weaning attempts should thus be initiated as soon as possible to avoid respiratory-related complications and reduce length of stay in the CCU.

### 3.5.3.1 Criteria for weaning

A literature review by Berly and Shem (2007:316) suggests the following criteria for weaning: patient should be afebrile, have stable vital signs, a vital capacity at least 15mL/kg ideal body weight, inspiratory force > -24cmH<sub>2</sub>O, respiratory stable for at least 24 hours, PaO<sub>2</sub> >75, PCO<sub>2</sub> = 35-45, no PEEP, FIO<sub>2</sub> no more than 25%, manageable secretions, medically stable for at least 24 hours, clear chest x-ray, psychologically willing and ready to participate.

Another literature review by Tollefsen and Fondenes (2012:1113) states in order for the patient to be weaned by ventilator-free intervals, the patient must have spontaneous respiration, have stable vital signs, no current infection, no sedation, appropriate nutrition and must be able to co-operate on the training. The patient must not be dependent on oxygen greater than 25%. Transition to non-invasive ventilation will depend on adequate swallowing function, minimal risk of aspiration and effective mobilisation of secretions. A vital capacity less than 15ml/kg ideal body weight, reduced cough power, previous pulmonary disease, smoking and age >45 years are adverse factors that affect weaning.

A literature review by Wallbom, *et al.*, (2005:2-4) suggests the following criteria for weaning include: spontaneous respiratory efforts, initial vital capacity of at least 15ml/kg body weight (approximately 1000ml), inspiratory force > -24cmH<sub>2</sub>O pressure (NIF), maximum FIO<sub>2</sub> (fraction of inspired oxygen) of 25% on the ventilator. The patient should be respiratory and medically stable for at least 24 hours with a arterial blood gas of PaO<sub>2</sub>>75, PCO<sub>2</sub> 35 - 45, pH 7.35- 7.45, no positive end expiratory pressure, clear chest X ray with manageable secretions as well as stable vital signs. The patient must be assessed for any adverse effects from medications such as narcotics which can affect muscle activity and vital capacity, and psychologically the patient must be able to participate in the weaning process and, if anxious, relaxation techniques can be applied.

### 3.5.3.2 Weaning strategies

A guideline by the Consortium for Spinal Cord Medicine (2005:7) recommends using progressive ventilator-free breathing (PVFB) over synchronized intermittent mandatory ventilation when weaning an SCI patient from the mechanical ventilator.

A literature review by Ball (2001:S28) states that a variety of ventilatory strategies may be used in the weaning process, including T-piece trials, continuous positive airway support, and pressure support, but it is not clear which one is superior or allows more rapid ventilator independence. Pressure support ventilation has become more common, allowing for slow titration of ventilatory support. According to a literature review by Berlly and Shem (2007:312), post-operative SCI patients who had no problems with breathing before surgery are often weaned from the ventilator with the expectation that they will be able to breathe on their own. However, these patients often require emergent re-intubation. It is recommended that post-operative patients should be weaned slowly if their vital capacity is less than 15mL/kg of ideal body weight; their cough is poor, they have had a previous co-morbid disease, are older than 45 and have a history of smoking.

Once the patient does not need mandatory ventilation and is on pressure support ventilation, two common weaning strategies can be used: pressure support weaning, where pressure support is reduced until the patient is CPAP or high flow and T-piece weaning (progressive ventilator-free breathing) or “sprint weaning”. Once pressure support levels reach 12-15cmH<sub>2</sub>O, instead of decreasing pressure support further, patients breathe without pressure support on a high flow circuit (with or without CPAP) or simply through a heat moisture exchange device (HME) for a preset time every hour. The length of time without pressure support is slowly increased (sometimes only in increments of a few minutes per hour) until the patient can achieve full or partial independence from mechanical assistance. It is to be noted that patients need to be rested at night in order to prevent exhaustion (Denton and McKinlay, 2009:84). According to the literature paper by Tollefsen and Fondenes (2012:1113), the weaning process should occur gradually by increasing the length of 2 ventilator-free intervals per day. Arterial blood gas analysis or pulse oximetry and

end tidal capnometry are recommended. This method has proved better than synchronised intermittent mandatory ventilation (SIMV) which is also a mode of ventilation.

A literature review by Wallbom *et al.*, (2005:4) states that a selection of weaning methods can be used including pressure support ventilation (PSV), intermittent mandatory ventilation (IMV), progressive ventilator free breathing (PVFB) and that protocols may differ between institutions. PVFB is most commonly used for SCI patients as other methods are associated with fatigue. The weaning method includes physically removing the patient from the ventilator using a T-piece or trach collar and trials of spontaneous breathing initiated with an  $\text{FIO}_2$  of 10% above the  $\text{FIO}_2$  of the ventilator. Rest periods are encouraged in order to give the deconditioned diaphragm a chance to recover before the next trial. Patients should be closely monitored and initial stages must be performed in the supine position which offers advantages as a larger vital capacity may be obtained. If the vital capacity decreases by 25% from the initial vital capacity, the patient needs to be placed back on the ventilator. Increasing trials are encouraged based on the patient's tolerance. During T-tubing periods, IPPB is used to deliver bronchodilator and mucolytic medications. T-tubing starts on a twice daily schedule with a 3-4 hour rest between trials. T-tubing can be increased by an hour twice a day as long as post-session VC is not less than 25% on the initial VC,  $\text{O}_2$  saturation is above 93% and the patient does not have shortness of breath and endures continued weaning. After the patient has been T-tubed for six hours twice daily and the vital capacity continues to improve or be maintained, T-tubing times may be combined for 10-12 hours with the goal of increasing the patient's tolerance within parameters (that is, pre and post t-tubing VCs) up to 24 hours. The ventilator can be discontinued after the patient has been off the ventilator for 48 hours.

A prospective case series done by Gutierrez *et al.*, (2003:105) used a resistance and endurance protocol (REP) to wean seven patients with incomplete cervical SCIs. Patients were preoptimised, where respiratory optimisation was done by tracheal suctioning in the Trendelenberg position, use of bronchodilators and hyperinflation of the lungs. For inspiratory resistance training, patients breathed through a fixed



inspiratory resistor applied to the mouth for 10 seconds, four times a day. Thereafter, expiratory muscle training was done by breathing through an expiratory resistor. Endurance training was initially done on a ventilator by gradually decreasing the support, once the patients were able to cope, ventilator free breathing and time off the ventilator was gradually increased. Following this approach, both high cervical (C2, N=2) and low cervical patients (C4-C7, n=5) gained muscle strength. C4-C7 patients were weaned within 2 months. C2 tetraplegic patients were able to cope off the ventilator for a short period.

Furthermore, a randomised trial with cross-over experimental design by Gutierrez, Stevens, Merrit, Pope, Tanesescu and Curtiss (2010:270) revealed that ventilator dependent patients who were clinically prepared with the Trendelenburg chest optimization had a significant improvement in their spontaneous breathing trial that lasted 53 minutes longer as compared to patients who were prepared with supine chest optimization. Therefore, clinical progress in weaning may be associated with the ability to progressively increase the length of ventilator-dependent patients that a CSCI can perform a spontaneous breathing trial.

### **3.5.4 Tracheostomy care**

Derived from the various levels of evidence, various themes evolved under tracheostomy including indications for it, its benefits, complications associated with it, timing and indications for an early tracheostomy.

#### **3.5.4.1 Indications for tracheostomy**

A guideline from the Consortium for Spinal Cord Medicine (2005:7) suggests a cuffed tracheostomy for patients who are aspirating. According to a guideline by the Consortium for Spinal Cord Medicine (2008:453), age (older), a higher neurological level of injury, pre-existing medical conditions (lung disease or pneumonia) are indications for performing a tracheostomy in the SCI patient. A systematic review by Berney *et al.*, (2011:26) states the completeness and the level of the injury above or below C5 influence the need for a tracheostomy in the SCI patient. The frequency of



tracheostomy for complete injuries above C5 level is 81-83%, compared with 49-60% for complete injuries at C5 and below.

A retrospective study by Como *et al.*, (2005:916) agrees that identifiable differences were noted in the respiratory management between complete and incomplete injuries in their study and conclude that completeness of the injury and the level of neurological injury are predictive of the need for tracheostomy. Three literature papers agree that tracheostomies are common in complete cervical injuries. In addition to complete high cervical injuries, other risk factors include age older than 45 years, previous pulmonary impairment, smoking history, pre-existing comorbid medical problems and pneumonia (Berlly and Shem, 2007:315; McLeod, 2004: 1045-1046; Markandaya *et al.*, 2012:183-184).

A literature review by McLeod (2004:1045-1046) agrees that early tracheostomy should be considered in SCI patients with injuries at C1-C4 as they may require permanent ventilation. A literature review by Markandaya *et al.*, (2012:183-184) agrees that tracheostomies are commonly performed on patients with high spinal cord injuries who have respiratory compromise. A literature review by Royster *et al.*, (2004:17) suggests the need for long-term mechanical ventilation and pulmonary hygiene as indications for a tracheostomy. In a retrospective study by Seidl *et al.*, (2010:1077) early tracheostomy is recommended for SCIs with C4-C6 injuries. After failed extubation, early tracheostomy should be carried out, depending on the severity and paralysis and presence of thoracic trauma. Berlly and Shem (2007:314) suggest tracheostomy cannot be done within two weeks of an anterior cervical stabilization and the practitioner must decide which procedure is more important first.

A retrospective review by Ganuza, Forcada, Gambarrutta, De La Lastra Buigues, Gonzalez, Fuentes and Luciani (2011:81) states that percutaneous and surgical tracheostomies can be carried out safely in the CCU at the bedside. The advantages associated with percutaneous tracheostomy include: limited dissection resulting in less tissue damage, decreased risk of bleeding and infection as well as no risks associated with transporting the critically ill patient to the operating theatre. No differences were found in the complication rates after surgical as opposed to

percutaneous tracheostomy. However the research study revealed that the duration of CCU stay was lower with the percutaneous dilation technique but both groups showed no difference in the duration of mechanical ventilation. Percutaneous tracheostomies were also associated with a lower incidence of pneumonia. No differences were found in terms of mortality and perioperative complications. Percutaneous tracheostomy should thus be considered as the first method of choice.

#### 3.5.4.2 Benefits of a tracheostomy in the spinal cord injury patient

Prolonged nasotracheal and endotracheal intubation has been associated with complications such as subglottic stenosis and sinusitis, and patients are not as easy to rehabilitate as they are less able to mobilise out of bed with endotracheal and nasopharyngeal tubes. The placement of tracheostomy does eliminate these risk factors. Various benefits have been reported regarding tracheostomy mainly from lower levels of evidence from literature reviews and confirmed by two retrospective reviews.

In a retrospective study done by Romero, Vari, Gambarrutta and Oliveriero (2009:1455), the benefits associated with a tracheostomy in the SCI include the following: improved respiration, facilitated weaning by reducing airway resistance, reduced mortality rate and prevention of complications of prolonged orotracheal intubation such as laryngeal and tracheal stenosis or fistula. Other benefits are included in several literature papers (Royster, *et al.*, 2004:17; Markandaya *et al.*, 2012:183-184; Denton and McKinlay, 2009:84; Stevens *et al.*, 2003:221 and Jia *et al.*, 2011:4). These benefits include reduced dead space, improved mobility, ability to eat and drink which is associated with improved psychological status, assists weaning, allows easy suctioning of secretions from bronchi, limited laryngeal damage from prolonged intubation associated with a decreased incidence of fevers and respiratory tract infections.

#### 3.5.4.3 Timing of tracheostomy

Two literature reviews by Jia *et al.*, (2011:4) and Royster *et al.*, (2004:17), as well as a retrospective study by Romero *et al.*, (2009:1452) agree that performing an early

tracheostomy (<7 days) is beneficial in the SCI patient. The authors reported that early tracheostomy was associated with reduction in the duration of mechanical ventilation and stay in the CCU. In contrast, a single-centre retrospective study by Seidl *et al.*, (2010:1077) found that early tracheostomy did not influence the number of days in the CCU, duration of mechanical ventilation, or duration of treatment. Markandaya *et al.*, (2012:183-184) recommends that early tracheostomy in patients with high cervical spinal cord lesions above C5 may reduce the number of days on MV.

According to a guideline by the Consortium for Spinal Cord Medicine (2008:453), early tracheostomy is recommended for ventilator-dependant patients or for patients who will need to be weaned slowly from mechanical ventilation unless the treating centre specialises in non-invasive ventilation. Royster *et al.*, (2004:17) recommends early tracheostomy for patients with irreversible neurological injury. A literature review by Stevens *et al.*, (2003:221) agrees that early tracheostomy should be considered if the need for ventilatory support is expected to be prolonged (lasting for 2-3 weeks).

Como *et al.*, (2005:916) published the need for early tracheostomy amongst complete cervical SCIs including lower cervical ones. However, a retrospective study by Hassid *et al.*, (2008:1331) suggests tracheostomy is only one component of airway management and just as important is the early intubation of these patients at the first sign of respiratory failure to avoid complications.

Retrospective studies done by Ganuza *et al.*, (2011:81) and Romero *et al.*, (2010:1456) could not find proof that tracheostomy timing lowers the risk of ventilator-associated pneumonia. Jia *et al.*, (2011:4) in their literature review paper agree that there are no proven studies that tracheostomy helps prevent ventilator-associated pneumonia or decreases mortality. However this technique is still advocated in traumatic SCI patients who will need prolonged mechanical ventilation. However, two literature reviews by Markandaya *et al.*, (2012:183-184) and Berlly and Shem (2007:314) suggest that early tracheostomy may reduce the incidence of ventilator-associated pneumonia.

### 3.5.5 Respiratory management in the critical care unit

Ventilatory function in the CSCI usually worsens in two to five days, post injury, but with optimal care, progressively improves; however it never returns to baseline function (Stevens *et al.*, 2003:221).

According to a literature review paper by Walker (2009:53), the aim of respiratory management is to prevent respiratory complications, promote oxygenation and optimise spinal cord perfusion to reduce the incidence of secondary damage to the spinal cord. Respiratory management interventions improve air entry, resulting in more effective breathing and decrease the risk of respiratory complications (Walker, 2009:53). Sheerin (2005:27) states in a literature review paper that the goals of respiratory management in acute care remains to prevent deterioration of the current condition while optimising rehabilitation potential through the multidisciplinary team. Effective use of anticipation and planning is essential when caring for patients during the acute phase of SCI, particularly focussing on airway, breathing and circulation.

The goals of initial management include: immobilize the cervical spine, protect the airway and ensure adequate oxygenation and ventilation (El-Said, 2011:103).

#### 3.5.5.1 Assessment of the respiratory status of the spinal cord injured patient in a critical care unit.

The Consortium for Spinal Cord Medicine (2008:453) recommends that initial assessment includes obtaining baseline respiratory parameters including vital capacity, forced expiratory volume, and arterial blood gas. Continue the assessment at regular intervals until stable, in particular, monitoring for respiratory failure especially in the first five days post-SCI. A retrospective study by Hassid *et al.*, (2008:1330) reiterates the importance of a comprehensive assessment of pulmonary status in all low cervical SCIs as well as continuous monitoring for signs of respiratory dysfunction which is essential, especially in incomplete SCI patients as they can suddenly lose airway control.

According to the guideline by the Consortium for Spinal Cord Medicine (2005:8), assessments of the respiratory status in the SCI patient include taking an initial health history, and performing initial laboratory assessment as well as respiratory function and respiratory monitoring. Initial assessment must include the following: obtaining the patient's relevant health history, if possible, including significant past medical history, previous lung disease, neurological impairment, recent use of medication and substance abuse. Initial laboratory assessment includes arterial blood gas (ABG), routine laboratory studies (complete blood count, chemistry profile, coagulation profile, cardiac enzyme profile, urinalysis and toxicology screen), chest x-ray and electrocardiogram. Assessments of the respiratory function include respiratory complaints, physical examination of the respiratory system including respiratory rate and pattern, chest auscultation and percussion, chest imaging as indicated, continuous pulse oximetry, performance of respiratory muscles by measuring vital capacity (VC) and maximal negative inspiratory pressure, forced expiratory volume in 1 second (FEV1) or peak cough flow as well as neurological level and extent of impairment. Assessment also includes monitoring oxygen saturation and end tidal CO<sub>2</sub> to measure the quality of gaseous exchange in the following few days and comparing this data with the patient's level of respiratory distress.

According to a literature review by Wallbom *et al.*, (2005:3), information that affects the respiratory system needs to be noted. The information includes medical history, associated co-morbidities, clinical examinations of the respiratory function as well as ongoing respiratory monitoring in order to help anticipate and prevent any respiratory complications. Respiratory function monitoring includes vital capacity (VC) and negative inspiratory force (NIF) monitoring. If the patient is uncooperative or is unable to generate a vital capacity, end tidal CO<sub>2</sub> may be used to monitor the respiratory status and trends.

Stevens *et al.*, (2003:217) discuss in a literature review paper that clinical assessment should begin with evaluating airway, breathing and circulation. The literature review highlights the importance of performing a physical examination in the first few days, which should also include the neurological findings. According to a

literature review by Walker (2009:52), respiratory assessment should be performed frequently during the acute phase of SCI. Assessment includes monitoring, observation and chest auscultation as well as monitoring the patients' respiratory rate, depth, rhythm and bilateral chest movements.

According to a literature review by Tollefsen and Fonden (2012:1112), respiratory observation is important with all levels of SCI injuries. Respiratory monitoring includes that measuring vital capacity and analysis of arterial blood gas be performed in the early stages and remain requisite at regular intervals until the patient has been stabilised.

According to a literature review by Berly and Shem (2007:313), a complete health history and both physical and neurologic examinations are necessary to determine the level of injury as accurately as possible. Knowledge of the patient's neurologic injury will assist in the assessment of ventilatory dysfunction. This relevant health history should include a review of previous lung disease, substance abuse and the patient's history of smoking. Physical assessment includes an evaluation of breathing patterns (including paradoxical breathing), and coughing and obtaining the patient's height, vital capacity, and respiratory rate. The vital capacity should be monitored every nursing shift during the first several days. If the patient's vital capacity approaches 10mL/kg of ideal body weight, it implies that the patient is fatigued and immediate intubation should be considered. Chest radiography should be obtained and followed serially to assess for atelectasis, pulmonary edema, chest trauma and aspiration. The need for intubation may be urgent if the chest radiograph shows atelectasis, desaturating oximetry readings or if the patients has the following co-morbidities such as anemia, obesity, lung disease, history of smoking, chest trauma or copious secretions.

Monitoring for signs of respiratory failure includes tachypnea, progressive desaturation and a decrease in vital capacity to less than 15ml/kg ideal body weight. ABG is used to evaluate the overall impact of pulmonary dysfunction. Arterial oxygen tension ( $\text{PaO}_2$ ) is considered to be the most effective tool for the evaluation of atelectasis, and arterial carbon dioxide tension ( $\text{PaCO}_2$ ) is considered an indication

of ventilation abnormalities. Berly and Shem (2007:313) recommend end-tidal CO<sub>2</sub> monitoring and continuous pulse oximetry, as well as forced vital capacity monitoring which may substitute for frequent ABGs.

In a literature review by El-Said (2011:107), it is stated that the work of breathing of the SCI patient needs to be constantly monitored. The patient's level of comfort, changes in the ability to speak in non-ventilated patient as well as trends in respiratory rate, monitoring of PaCO<sub>2</sub>, X-ray evidence of worsening volume loss, lobular collapse and infection (monitor white cell count (WCC), C-reactive protein (CRP), temperature and sputum culture) require more aggressive treatment. The patient should be monitored for rapid shallow breathing. This kind of breathing is inefficient as there is still the need to move air into the dead space of the trachea and bronchi and because a large percentage of each breath does not participate in gaseous exchange, this can promote atelectasis. Spirometry is an objective measure of respiratory reserve with FVC < 12-15ml/kg being an indicator for mechanical ventilation.

Neurological deficits can be worsened by hypoxic insults to the injured cord. Many patients with cervical spine injuries may initially be able to maintain adequate ventilation but may require elective intubation as their respiratory function deteriorates. Careful assessment to note signs of fatigue are useful in the decision to intubate the patient. Measurements of vital capacity can be done at the bedside and if this value progressively declines or is at <1 L, and if there is a rising respiratory rate and (PCO<sub>2</sub>), this should cause concern. Serial ABGs are recommended to assess ventilation and oxygenation (El-Said, 2011:104).

A literature review by Denton and McKinlay (2009:83) states the importance of monitoring the work of breathing in the SCI patient. The comfort level of the patient, trends in respiratory rate and changes in the ability and quality of speech should be noted. Monitoring for increasing PaCO<sub>2</sub> levels, X-ray evidence of worsening volume loss, lobar collapse, and infection (WCC, CRP, temperature and sputum culture) will indicate the need for more aggressive treatment.



A literature review by Cook (2003:146) discusses the importance of respiratory care in the SCI patient with a traumatic brain injury. It is important to do an initial respiratory assessment, followed by regular assessments in the following five to seven days as the nature of the SCI may change. Vital points to include in the respiratory assessment include relevant past medical history affecting the pulmonary system as well as a neurological assessment to identify the extent and level of the SCI. The assessment can provide information of the possible respiratory muscle groups that may be affected as a result of the SCI. Additionally, the physical assessment should include the following: the patient's respiratory rate, rhythm and effort, the alignment of the trachea to identify the presence of laryngeal injury or mediastinal shift, the shape of the thorax and the symmetry of the chest wall as well as the patient's pallor. Other factors to be noted, when auscultating the lungs, include noting breath sounds to assess air entry, obstructed flow and the presence of retained secretions. A swallow assessment should be obtained to assess patients at risk for aspiration. To assess the patient's cough, physiotherapists should be consulted to note problems with pulmonary mechanics. Additionally, investigations, for example, chest X-rays, should be performed preferably in the supine position and should be examined and compared with previous findings. Arterial blood gas must be monitored closely to identify a rise in PaCO<sub>2</sub> and a drop in PO<sub>2</sub> and close attention must be paid to the patient's ventilatory requirements, particularly increasing or decreasing ventilatory needs.

Respiratory monitoring and assessment is important to anticipate and prevent respiratory complications (Sheerin 2005:29, Wallbom *et al.*, 2005:3 and Royster *et al.*, 2004:16). Performing a respiratory assessment is important in order to identify the patient's needs, recognize preventative and curative treatments to treat possible and current pulmonary complications as well as to highlight potential secondary neural damage (Cook, 2003:146). A literature review by Sheerin (2005:29) indicates that nurses can help in the prevention, early identification and management of respiratory complications by performing respiratory assessments, observing for signs of infection, pulmonary edema and noting culture and sensitivity of sputum and assessing effectiveness of antimicrobial therapy. Another literature review by March (2005:22) highlights that nurses are in a favourable position to perform respiratory



assessments as they are with the patient for 24 hours a day, allowing for early detection of potential problems. Nurses must observe for signs of respiratory muscle fatigue and failure as well as assess for signs of sensory and motor function noting for signs of developing cord edema, which could result in a stable patient suddenly developing respiratory muscle fatigue. Should this occur, they can then act appropriately.

In a literature review by Ball (2001:S27), assessment and monitoring for signs of fatigue are important and can assist with airway management decisions and deciding when to intubate the patient. Vital capacity needs to be regularly monitored at the bedside and if the value is below 1L and accompanied by a rising respiratory rate or PaCO<sub>2</sub>, intubation should be considered. A literature review highlights the importance of spirometry measures that give an objective measure of respiratory reserve with FVC < 12-15ml/kg an indicator for assisted ventilation (Denton and McKinlay, 2009:83). An additional literature review by Winslow and Rozovsky (2003:811) states that monitoring respiratory function may be a better predictor of respiratory function than level of injury.

According to a literature review by McLeod, (2004:1046) poor respiratory function can result in chest infection and lobar collapse and needs to be avoided as this will negatively affect gaseous exchange. Assessments for clinical signs of chest infection including respiratory rate, oxygen saturation and chest auscultation must be done. Monitoring patients' vital capacity gives an indication of respiratory muscle strength and will often start to deteriorate before changes in arterial blood gas.

In a literature paper by El-Said (2011:104), it is stated that neurological deficits can be worsened by hypoxic insults to the injured cord. Many patients with cervical spine injuries may initially be able to maintain adequate ventilation but may require elective intubation as their respiratory function deteriorates. Careful assessment to note signs of fatigue are useful in the decision regarding intubation. Measurements of vital capacity can be done at the bedside and if this value progressively declines or is at

<1 L, this should cause concern as should a rising respiratory rate or PaCO<sub>2</sub>. Serial ABGs are recommended to assess ventilation and oxygenation.

### **3.6 PRIORITIES OF PREVENTATIVE CARE**

Respiratory complications are quite common in the SCI patient. In order to minimise and/or prevent respiratory complications, it is important to identify, prevent and manage as well as know the implication for nursing practice.

#### **3.6.1 Incidence of respiratory complications**

A literature review by Winslow and Rozovsky (2003:812) states that respiratory complications occur in 50–67% of patient who sustains an SCI. Over the last 25 years, the frequency of respiratory complications has decreased. This could be due to improvements in detection, prevention and treatment of respiratory complications as well as improvements in intensive care medicine and utilisation of multidisciplinary team to treat these patients. Studies of alterations in respiratory mechanics caused by SCIs have led to improvements in the care of these patients and have expanded the understanding of normal physiology. However, despite significant advances in prevention, diagnosis and treatment of respiratory complications, they continue to significantly affect SCI patients.

According to a retrospective study by Cotton, Pryor, Chinwalla, Wiebe, Reilly, Schwah (2005:1400), pulmonary complications are the most common cause of death in SCIs. Due to a high rate of respiratory complications, mortality rates range from 20–50% in patients sustaining cervical SCI. The study compared patients with low thoracic SCI to patients with high thoracic SCI and found that patients with high thoracic SCI have a higher risk for pneumonia and death. These findings suggest that high thoracic SCI should receive intensive monitoring and aggressive pulmonary care similar to cervical SCI. Two literature papers (Denton and McKinlay, 2009:82; and Tollefsen and Fondenes, 2012:1111) agree that respiratory complications are the main cause for morbidity and mortality in the SCI patient during the short and long term.

According to a retrospective study by Hassid *et al.*, (2008:1330), ineffective coughing, pooling of secretions, tendency to develop atelectasis, as well as increased respiratory infections are factors that affect mortality and morbidity in the SCI patient. A literature review by Wallbom *et al.*, (2005:2) states that respiratory complications during the acute phase can prolong the length of stay in the CCU by 27 days. A literature review by Denton and McKinlay (2009:82) suggests that respiratory complications are the leading cause of death during the short and long term. SCIs can cause various pulmonary complications but appropriate respiratory management can reduce morbidity, length of stay in the CCU and mortality.

According to a literature paper by Royster *et al.*, (2004:16), the level of neurological impairment, age and presence of co-existing medical problems all contribute to the mortality associated with SCI and pulmonary dysfunction. Injuries to the lumbar cord are associated with little or no effect on ventilation or cough. Injuries to the thoracic cord can impair coughing but have little effect on normal breathing. Injuries to the cervical spinal cord at or above C5 can affect diaphragmatic function, and complete injuries at or above C3 produce bilateral paralysis of the diaphragm which is incompatible with life in the absence of mechanical ventilation. Lesions to C4-5 are associated with varying degrees of diaphragmatic dysfunction. Lesions from C6- T12 are characterized by an intact diaphragm that can provide up to 90% of tidal volume and non-functional intercostals that cannot stabilize the ribcage.

A literature review by Wuermser, Ho, Chiodo, Priebe, Kirshblum, Scelza (2007:S57) agree that pulmonary complication rates during acute hospitalisation are common and occur in 84% C1-C4 injuries, 60% C5-C8 injuries and 65% for thoracic levels showing that all levels of injury are at risk. Pulmonary complications are the leading cause of SCI-related deaths. Major causes of pulmonary dysfunction after SCI include difficulty handling secretions, atelectasis and hypoventilation; therefore, these should be handled efficiently.

Respiratory insufficiency and pulmonary dysfunction occur frequently after SCI especially with cervical injuries. SCI patients show reductions in expected vital capacity, inspiratory capacity and may experience relative hypoxemia which can add

to overall hypoxemia which can intensify SCI. Cardiac and/or ventilatory/pulmonary dysfunction makes early detection of life-threatening complications possible and treatment can be targeted correctly (Hadley *et al.*, 2002:411-412).

SCI does not exist in isolation, and other traumatic and medical complications must be taken into account when deciding on the correct management strategy. The acute management of a patient with an SCI requires rapid restoration of airway, breathing and circulation (Consortium for Spinal Cord Medicine, 2008:433). The acute SCI patient provides the acute care/critical care medical practitioner with a serious challenge and the injuries of the SCI present unique difficulties that make resuscitation and care of these patients intricate. The patient needs to be frequently assessed to identify the pattern and extent of the injury. Supportive and therapeutic interventions may need to be constantly adjusted to ensure favourable patient outcomes (Royster *et al.*, 2004:27). Therefore, the literature paper by Tollefsen and Fondenes (2012:1111) suggests that the prevention of respiratory complications needs to begin immediately irrespective of the level of injury and the degree of motor impairment.

From the above mentioned literature, it is clear that respiratory complications are the main cause of death in the acute SCI patient regardless of the level of the injury identification. Assessment and management of the respiratory complications are thus important.

### **3.6.2 Specific respiratory complications**

Common respiratory complications seen in the SCI include those caused by chest trauma, pulmonary thromboembolism, atelectasis, bronchospasm, pulmonary edema, pneumonia (aspiration and/or ventilator-associated), hypersecretion and respiratory failure.

#### **3.6.2.1 Blunt chest trauma**

According to the literature review by Berlly and Shem (2007:312), blunt chest trauma is common in individuals who have sustained an SCI from motor vehicle accidents.

Normal chest X-ray and ABG assessment on the initial evaluation does not exclude the presence of associated injuries and a high degree of vigilance must be obtained. Associated injuries may include rib fractures with flail chest, pulmonary contusions or laceration, avulsion of a bronchus, rupture of the diaphragm, or oesophagus, pneumothorax, hemothorax, or hemopericardium. An additional literature review paper by Winslow and Rozovsky (2003:811) suggests that pleural effusions, pneumothorax and hemothorax are less common respiratory complications and occur more frequently in patients with thoracic injuries as opposed to cervical injuries (70% vs 16%), suggesting these complications are more likely due to concurrent thoracic trauma. Chest trauma may impair movement of the chest wall and subsequently affect the ability of the patient to breathe deeply, cough and clear secretions (March, 2005:21).

The critical care nurse must be aware that certain injuries may have been overlooked initially and pay particular attention especially during assessment and monitoring and report any abnormalities at once.

#### 3.6.2.2 Pulmonary venous thromboembolism

Two literature papers by (Ball, 2001:S29 and Stevens *et al.*, 2003:222) stated that acute SCI has the highest risk of venous thromboembolism with a threefold risk compared to trauma patients without cord injury. The period of time that the SCI is at greatest risk for an emboli is 72 hours following injury. In the absence of prophylaxis, 50% of patients with acute SCI may develop venous thromboembolism. According to the guideline by the Consortium for Spinal Cord Medicine, 2008:452), risk factors for venous thromboembolism include ethnicity (African American had the highest rate), co-morbidities, gender (males have a higher rate than females) and intubation .

According to the guideline by the Consortium for Spinal Cord Medicine (2005:7) and a literature paper by Ball (2001:S29), ventilated patients should be closely monitored for the occurrence of pulmonary embolism. Mechanical compression devices such as external pneumatic compression devices or compression stockings should be applied early after the injury. Low molecular weight heparin or unfractionated heparin

plus intermittent pneumatic compression should be commenced. Winslow and Rozovsky (2003:812) in a literature review also highlight that the combination of low molecular weight heparin as well as compressive stockings or external pneumatic devices can contribute to the reduction in the incidence of thromboembolism. The combination of these treatments has been shown to be effective even in patients undergoing elective spinal surgery. Two literature review papers agree that there has been a significant reduction in thromboembolism over the last decade, probably due to use of low molecular weight heparin, which is superior to standard heparin, and sequential compression devices (Berlly and Shem, 2007:312 and Winslow and Rozovsky, 2003:812).

Once the treatment modalities are prescribed, the nurses are involved in the execution of the prescription as well as monitoring the patient for side-effects related to the treatment, for instance, to monitor for bleeding when the patient receives heparin.

#### 3.6.2.3 Atelectasis

Atelectasis is the most common respiratory complication and can lead to pneumonia and respiratory failure which may worsen during the first few days as respiratory muscles fatigue, secretions accumulate and lung compliance decreases. Atelectasis and pneumonia in the SCI are commonly seen during the first few weeks following SCI with a 4:1 prevalence occurring on the left-side of the chest.. This is thought to be due to the bronchial anatomy and the fact that suction catheters do not pass into the left main-stem bronchus. Atelectasis results from diminished lung expansion from weak respiratory muscles, abdominal contents being pushed cephalad, retained secretions and weak cough. Atelectasis and pneumonia occur in the first five to seven days and are usually focussed to the left lower lobe (Consortium for Spinal Cord Medicine 2008:454 and Royster *et al.*, 2004:17).

#### 3.6.2.4 Bronchospasm

According to a literature review, bronchospasm (with no history of asthma) are prevalent in cervical SCIs due to autonomic changes. Resting airway tone is

potentially increased in tetraplegic patients and although no studies using anticholinergics in the treatment of acute patients were found, a therapeutic trial of an anticholinergic agent may be indicated with the hope of decreasing the incidence of mucous retention and respiratory complications. Bronchospasms necessitate the use of bronchodilators every four hours (Berlly and Shem, 2007:311-313). Therefore, nurses can give bronchodilators as ordered for bronchospasm and must be vigilant and note when bronchospasm occurs.

#### 3.6.2.5 Pulmonary edema

Two literature papers by Sheerin (2005:29) and Royster *et al.*, (2004:16) state that pulmonary edema in the SCI patient may result from aggressive fluid therapy secondary to neurogenic shock-related hypotension. Another literature paper by Berlly and Shem (2007:311) agree that the excessive fluid resuscitation that is often necessary might further accentuate acute lung injury or ARDS and further impair gas exchange and hypoxemia. Overhydration is a common cause of pulmonary edema and the healthcare practitioner needs to differentiate between spinal shock and traumatic shock in order to avoid overhydration.

According to Sheerin (2005:29), nurses can help in prevention and early identification of pulmonary edema. The nurse must monitor for signs of pulmonary edema and administer fluids with caution as excess fluids can exacerbate pulmonary edema. Furthermore, a literature review by Ball (2001:S29) states that volume resuscitation is the first-line treatment for hypotension but as indicated in the previous literature review, fluids should be administered cautiously in patients at risk of developing pulmonary edema; therefore, alpha and beta adrenergic agents such as dopamine and norepinephrine can be used to counter the effect of sympathetic tone and provide chronotropic support, which can be used instead of administering fluids.

#### 3.6.2.6 Ventilator-associated pneumonia (VAP)

According to two literature reviews, the presence of the endotracheal and tracheostomy tube places the patient at risk of ventilator-associated pneumonia

(VAP) as it passes the natural defence mechanism. VAP occurs due to intubation and mechanical ventilation with an incidence of 1-3% per day of intubation. The overall mortality rate for VAP is 27% (Winslow and Rozovsky, 2003:810-811; Ball, 2001:S28).

#### 3.6.2.7 Pneumonia / aspiration pneumonia

A literature review by Stevens *et al.*, (2003:224) states that factors that increase the risk of pneumonia in the SCI patient include aspiration, prolonged tracheal cannulation, ineffective ability to clear the airway of secretions and atelectasis. Acute SCIs often have gastric distension and ileus which increases the risk of aspiration and further compromises respiratory function. An additional literature review by Berlly and Shem (2007:312) adds that consideration needs to be given to air swallowing and regurgitation of gastric contents that can lead to aspiration pneumonia.

#### 3.6.2.8 Hypersecretion

According to the literature review by Berlly and Shem (2007:311), hypersecretion is thought to occur as a result of the loss of sympathetic control and unopposed vagal activity in the days to weeks after injury. Hypersecretion of bronchial mucous can occur within one hour of injury and occurs in 40% of patients with acute tetraplegia. Secretions are abnormal in frequency, consistency and amount but return to normal over the next few months, suggesting neuronal influence of the bronchial mucous gland.

Mucous plugs are common during the first five days and this is due to increased secretions compounded by ineffective coughing and bronchospasms. According to a literature review by March (2005:24), impairment in coughing may lead to the production of more viscous secretions and cause mucous plugging and accumulation of infection. The effective clearance of respiratory secretions can help to prevent respiratory and airway compromise caused by sputum retention in acute SCIs. Another literature review by Brown *et al.*, (2006:864) agree that impaired



coughing leads to accumulation of secretions that arise from respiratory infections or that are due to the presence of the tracheostomy tube.

#### 3.6.2.9 Respiratory failure

According to Berlly and Shem (2007:312), respiratory failure is defined by a  $PCO_2 > 50$  mmHg and/or  $PaO_2 < 50$  mmHg on room air/or need for ventilatory support. Risk of respiratory failure is directly related to the neurological level of impairment and occurs in 40% of individuals with C1-C4 injuries, 23% in C5-C8 injuries and 9.9% in thoracic-level SCIs (Berlly and Shem, 2007:312, Winslow and Rozovsky, 2003:811). Respiratory failure occurs more frequently in complete as opposed to incomplete injuries and the length of days on mechanical ventilation is related to the level of injury: 65 days for patients with C1-C4 injuries, 22 days for C5-C8 injuries and 12 days for patients with thoracic injuries (Ball, 2001:S28).

Respiratory failure is the complication that has the longest duration, lasting 35.9 days and is the biggest contributor to hospital costs during the acute care of the SCI patient. Cause of respiratory failure after an SCI can be attributed to hypoxemia due to ventilation/perfusion mismatches from retained secretions, atelectasis, pneumonia or hypercarbia, resulting from respiratory muscle weakness, or both literature review by Winslow and Rozovsky, (2003:811).

Ventilatory failure due to inspiratory muscle weakness mainly affects high cervical SCI, but expiratory muscle weakness, which is also seen in midthoracic, can also result in ineffective cough (Consortium for Spinal Cord Medicine, 2008:454). Respiratory failure in injuries below C5 and in thoracic injuries is often a consequence from direct trauma. Injuries below C5 are associated with lesser degrees of ventilatory impairment but remain at risk for pulmonary complications (Stevens *et al.*, 2003:221). Cervical SCIs with incomplete injuries requiring mechanical ventilation showed that 89% were able to resume spontaneous breathing as opposed to 76% of patients with complete injuries. Ventilatory failure may occur immediately after injury or develop gradually over the next few days (guideline by the Consortium for Spinal Cord Medicine, 2008:453).

A literature review by Stevens *et al.*, (2003:221) agrees that ventilatory failure has a significant time course, worsening during the first two to five days and then improving slowly although never returning to the baseline. A retrospective study by Como *et al.*, (2005:914) agrees that respiratory function may improve within the first few weeks after injury and, as a result, patients who were ventilator dependant may be liberated from the ventilator.

### **3.6.3 Prevention and management of respiratory complications**

In order to improve the management of SCIs, nurses must be able to access available and up-to-date literature so that they can provide the best care possible thereby promoting treatment options that will ultimately promote recovery and prevent further complications (March, 2005:25).

Various procedures and techniques are available for managing and/or preventing respiratory complications including positioning, postural drainage, deep breathing, inspirometers and kinetic therapy. Some of these are nursing as well as collaborative treatments.

#### **3.6.3.1 Management and prevention of atelectasis**

Management of atelectasis is multifaceted and includes nursing and collaborative management. Ventilator strategies have already been discussed previously under mechanical ventilation. According to a guideline on the respiratory management of the SCI by the Consortium for Spinal Cord Medicine (2005:5), the following markers are suggestive of atelectasis or infection including a raised temperature, alteration in respiratory rate, shortness of breath, increased pulse rate, anxiety, large volumes of secretions, frequency of suctioning, tenacity of secretions, deteriorating vital capacity and deteriorating peak expiratory flow rate especially during coughing. The critical care nurse must be aware of changes in these vital signs to monitor for respiratory failure. Management will include obtaining a chest X-ray if temperature, respiratory rate, vital capacity and peak expiratory flow are heading in an adverse direction. The guideline further states that atelectasis and pneumonia can possibly be treated by re-expanding the lung through: deep breathing and voluntary coughing, assisted

coughing techniques, insufflation–exsufflation, IPPB “stretch”, glossopharyngeal breathing, incentive spirometry, chest physiotherapy, intractable percussive ventilation (IPV), CPAP and BiPAP, bronchoscopy and bronchial lavage, positioning of the patient in the supine or the Trendelenburg position, abdominal binders and medications.

A literature review by Royster *et al.*, (2004:17) agree that atelectasis is managed with incentive spirometry, percussion and vibration, frequent position changes, intermittent positive pressure breathing and beta agonists in some situations. Wallbom *et al.*, (2005:3) also conducted a literature review and agree that intermittent positive pressure breathing (IPPB) can be used to prevent atelectasis. An additional literature review agrees that intermittent positive pressure breathing, inflation by inflation bags as well as incorporating sighs into mechanical ventilation are different methods to prevent and treat atelectasis. The level of pressure should be started at 10-15cmH<sub>2</sub>O and slowly increased but never exceed more than 40 cmH<sub>2</sub>O (Walker, 2009: 53).

An additional literature review by Winslow and Rozovsky, (2003:810) states that assisted-coughing techniques can prevent atelectasis and might cause an increased lung inflation, which can promote the clearance of secretions. A literature review by March (2005:23) suggests that kinetic therapy when combined with percussion to treat patients with the diagnosis of atelectasis is effective. Perhaps a combination of treatments may be more beneficial than a single one in the prevention of respiratory complications.

### 3.6.3.2 Management and prevention of VAP

According the guideline by the Consortium for Spinal Cord Medicine (2008:455), protocol to prevent VAP in the acute SCI patient who needs mechanical ventilation should be implemented. Preventative strategies are the same as for non–SCI patients and still need to be applied to the SCI patient with the exception of the 45 degree head-of-bed elevation. A literature review suggests management strategies, for instance, the elevation of the head of the bed (45 degrees), closed suctioning

system and weekly replacement of circuits as well as good oral hygiene can reduce the incidence of infection (Tollefsen and Fondenes, 2012:1112). Two literature reviews state that the effective treatment of VAP depends on accurate diagnosis and if the diagnosis is missed or delayed, this can negatively affect the SCI patient (Ball, 2001:S28 and Berlly and Shem, 2007:311-312). Ball (2001:S28) states that management includes the selection of an antibiotic based on results from the tracheal aspirate. Therefore, an antibiotic cover of suspected organisms should be commenced until culture results are available. Further strategies for preventing VAP include elevation of head of the bed, daily sedation vacation, daily assessment for readiness for extubation, peptic ulcer disease prophylaxis as well as deep venous thrombosis prophylaxis. All strategies are appropriate for most SCI patients with the exception of the elevation of the head of the bed.

According to the guideline from the Consortium for Spinal Cord Medicine (2008:455), universal VAP preventative strategies not specific to the SCI include elevation of the head of the bed to 45 degrees in the absence of other contraindications, interruption of sedation daily to assess the readiness for ventilator weaning and extubation, following accepted protocols for weaning from mechanical ventilation, intubating the patient via the orotracheal route as opposed to nasotracheal route, only changing ventilator circuits if they become soiled and for new patients, using closed endotracheal suctioning systems that can be changed for each new patient as clinically indicated, using heat moisture exchangers if not contraindicated and changing these weekly and performing mouth care with chlorhexidine.

### 3.6.3.3 Management and prevention of pneumonia

Three literature reviews (Stevens *et al.*, 2003:224; El-Said, 2011:104 and Berlly and Shem, 2007:312) were found that discussed the management of pneumonia. It is recommended that these patients have nasogastric or orogastric suctioning as well as use of prokinetics such as erythromycin or metoclopramide. The critical care nurse should insert a nasogastric or orogastric tube as gastric atony may compromise the respiratory status of the patient and lead to aspiration. On commencement of nasogastric feeds, gastric residual volumes need to be

monitored. Cuffed tracheostomies protect the patient from aspiration and vomiting. Cuff pressures should be monitored and maintained at 25 cmH<sub>2</sub>O to avoid tracheal injury (Berlly and Shem, 2007:314).

#### 3.6.3.4 Management and prevention of hypersecretion and retained secretions

Cook (2003:150) suggests that therapies should be centred on draining secretions from the left lower lobe as studies have demonstrated a higher incidence of atelectasis, consolidation and pneumonia in this region possibly due to the angle of the left main-stem bronchus off the trachea, resulting in suctioning of the right main-stem bronchus more probable. A literature review by Tollefsen and Fondenes (2012:1112) revealed that retained secretions can be treated with chest physiotherapy, postural drainage, suction, manual coughing support, and mechanical insufflation and exsufflation (cough-assist device), manual coughing assist and air stacking.

March (2005:23) recommends postural drainage to decrease the incidence of pneumonia. Postural drainage can be used for 20 minutes each morning, followed by aggressive respiratory therapy (Berlly and Shem, 2007:314). A literature review by Cook (2003:150) agrees that postural drainage and percussion can reduce respiratory complications through clearing the airways but are even more beneficial when combined with turning and prone positioning.

Another literature review by Brown *et al.*, (2006:864) suggests several methods are available to deal with secretions which include spinal-cord stimulation, spontaneous coughing, quad coughing, suction catheter, mechanical in-exsufflation, and doing a bronchoscopy. In a literature review by March (2005:24), manually assisted coughing has become a vital intervention to be used in the care of the SCI patient. If the patient is unable to take a deep breath prior to each cough, then positive pressure ventilation may be used.

An additional literature paper suggests warm moist air, bronchodilators and mucolytics can be helpful for managing secretions as well as IPV (intrapulmonary

percussive ventilation). IPV can be used in combination with mechanical ventilation. Aggressive respiratory care needs to begin immediately after injury and clearing of secretions through IPV, bronchodilators, postural drainage and cough assist machines can virtually eliminate the need for bronchoscopies (Berlly and Shem, 2007:313-317). Quad coughing is beneficial for removing secretions but contraindications to quad coughing include unstable spine in traction, internal abdominal complications, chest trauma such as fractured ribs, and a recently placed vena cava filter. Nurses must also be aware that repetitive quad coughing performed by a care provider places them at risk of wrist, shoulder and back injuries (Berlly and Shem, 2007:313).

The cough assist mechanical insufflation-exsufflation device (the cough assist machine) is more effective than quad coughing and can be used on an unstable spine and is less of a risk to staff members with less staff injuries (Berlly and Shem, 2007:314). A literature review by Jia *et al.*, (2011:4) recommends techniques such as manually assisted coughing by abdominal compression following maximum insufflation capacity (MIC) manoeuvres and mechanical insufflation-exsufflation (MIE) for assisting in clearing the airway of secretions as more successful and safer in removing secretions than suctioning which only clears the right main-stem bronchus. According to a literature review by Cook (2003:151), manually assisted coughing through abdominal support and thrusts has been shown to be the most effective. Assisted coughing is favourable at removing secretions that cannot be removed with suction catheter. Various other techniques including the “quad cough”, or “abdominal thrust” and the tussive squeeze or costaphrenic technique, in which hands are placed over the lower rib cage instead of the epigastrium, can easily be performed in the acute care setting. Contraindications do exist and include abdominal injuries or recent surgery with the abdominal thrust and a recently placed IVC is a relative contraindication as it may potentially migrate. Contraindications to the tussive squeeze include lower rib fractures and thoracic injury or surgery. The mechanical insufflator-exsufflator (M-IE) is extremely effective and can be administered via tracheostomy or mouth piece (Wuermsen, *et al.*, 2007:S57).

In a literature review by Wallbom *et al.*, (2005:3), it is suggested that bronchodilator therapy can be given while patients are on the ventilator or as nebulizer treatments off the ventilator. Various options relating to removal of secretions include postural drainage, intrapulmonary percussive ventilation (IPV) on and off ventilator followed by a “cougholator”, cough assist or in-exsufflator in addition to suctioning. Thick secretions are treated with adequate hydration, glycopyrrolates and mucolytics. Quad coughing can assist with secretion management but requires individual evaluation as the patient may have other complications including unstable spine, traction, internal abdominal complications, chest trauma, fractured ribs or a recently placed inferior vena cava (IVC) filter. According to Sheerin (2005:29), nurses can assist in removal of secretions from the airways through nebulisation, humidified oxygen, suctioning of secretions, incentive spirometry, assisted coughing and frequent position changes. Two literature reviews, (El-Said, 2011:107; Denton and McKinlay, 2009:83) suggest that bronchoscopy is the best way of clearing pulmonary secretions, obtaining bronchial lavage specimens and reinflating collapsed lung specimens.

Several literature review papers indicated that suctioning is essential for the removal of secretions (Berlly and Shem, 2007:314; Brown *et al.*, 2006:864; Tollefsen and Fondenes, 2012:1112; Sheerin, 2005:29; Jia *et al.*, 2011:4). However, Jia *et al.*, (2011:4) state that suctioning only clears the right main bronchus. The guideline by the Consortium for Spinal Cord Medicine (2008:453) suggests the management of retained secretions by manually assisted coughing (“quad coughing”), pulmonary hygiene, mechanical insufflation-exsufflation, or similar expiratory aids in addition to suctioning. A systematic review by Fehlings, Cadotte and Fehlings (2011:1331) suggests that copious secretions be managed with physiotherapy and suctioning in order to avoid further respiratory complications. However, another systematic review suggests that weak evidence is available to suggest chest physiotherapy and suctioning is associated with a reduction in respiratory complications (Casha and Christie, 2011:1493).

Although suctioning is extremely beneficial, the procedure is not without complications. A literature review by Berlly and Shem (2007:314) lists the following



complications that may occur during suctioning including hypoxia, hypotension, infection, tracheal mucosa damage, vagal nerve stimulation, patient anxiety and fear, increased bronchial mucous production as well as an increased intracranial pressure in patients with a brain injury. A literature review by Cook (2003:145) agrees with the above-mentioned complications but adds the following complications that can occur during suctioning: atelectasis, obstruction, cardiac arrest, pulmonary haemorrhage and impaired cough reflex impairing the expectoration of mucus. Sheerin (2005:27) agrees in a literature review that the patient's heart rate needs to be monitored during suctioning as vagal stimulation can compound, presenting bradycardia and leading to asystole.

A literature review by Wuermsier *et al.*, (2007:S57) states that standard suctioning has draw-backs as it only suctions the right bronchus and there is an increased risk of pneumonia on the left. There is also a risk, as with traditional suctioning, of excessive vagal stimulation and bradycardia in tetraplegia. A literature review by Jia *et al.*, (2011:4) agrees that suctioning only clears the right main-stem bronchus.

Recommendations for suctioning have been made by various papers, which will be discussed. Two literature reviews by Berlly and Shem (2007:315) and Cook (2003:147-148) suggest aseptic techniques: using sterile gloves, a maximum of two passes at each procedure, suctioning pressure at 100 – 200 mmHg, applying suction as the catheter is drawn out to avoid damage to the tracheal mucosa, using multi-eyed catheters as they produce less tracheal damage, inserting a catheter to 1/3<sup>rd</sup> of its length or 15cm in an adult tracheostomy tube. A suction catheter should be roughly ½ the diameter of the endotracheal/tracheostomy tube and should be hyperoxygenated for one minute with 100% oxygen before suctioning. A closed suctioning system should be maintained to reduce the risk of infection.

Cook (2003:147-148) further adds that the suctioning procedure should not occur for longer than 10 seconds so as to prevent hypoxia and atelectasis and recommends closed suctioning as opposed to open suctioning in patients requiring positive end expiratory pressure (PEEP) or on continuous positive airway pressure. Before benefits from such therapies occur, it will take 30 minutes to return to the pre-suction



baseline. Movement of the endotracheal tube should also be limited, as movement can be associated with a rise in ICP. Hyperoxygenation for one minute (O<sub>2</sub> at 100%) before and after suctioning is advocated to counteract falls in oxygen saturation and cardiac dysrhythmias. However, this must be administered with caution and on an individually assessed basis, especially in those with a 'hypoxic drive'. To gain access to the left main-stem bronchus, a curved tip catheter is useful, while turning the patient's head to the right. However, this is considered impractical in those with cervical SCIs and raised ICPs due to the obstruction of venous return to the heart and manipulation of the cervical spine.

According to a literature review by Berlly and Shem (2007:314), normal saline is used during suctioning to mobilize secretions that are thickened due to dehydration. However another literature review by Cook (2003:148) argues that the use of normal saline to reduce the accumulation of dried secretions on the inner tube of the tracheostomy or endotracheal tube could be avoided with heated humidification. A literature review by Wallbom *et al.*, (2005:3) agrees that adequate hydration is successful for treating thick secretions.

Cook (2003:148-149) further adds that the theory that instilling normal saline produces a cough has been considered an invaluable rationale as the suction catheter alone can stimulate a cough and this avoids the complications of normal saline. No benefit was found regarding the instillation of normal saline and, in contrast, several hazards can occur including unnecessary anxiety in intubated patients as well as the following complications in patients who have received neuromuscular blocking agents: a decrease in oxygen saturation when compared to suctioning without normal saline (which can lead to sudden hypotension and cardiac dysrhythmias), as well as an undesirable effect on mixed venous saturation, which can predispose the patient to tissue oxygen deprivation. A literature review by Sheerin (2005:29) recommends using humidified oxygen to treat retained secretions and Berlly and Shem (2007:313) agree in their literature review that warm moist air, bronchodilators and mucolytics are beneficial in the management of secretions.

### 3.6.3.5 Prevention and management of respiratory failure

The guideline by the Consortium of Spinal Cord Medicine (2008:453) recommends monitoring the SCI patient closely for respiratory failure in the first few days post injury. The monitoring includes baseline respiratory parameters (including vital capacity and FEV1). Arterial blood gas is recommended when the patient is first assessed and at regular intervals until stable. Mechanical ventilation for patients with tetraplegia should be considered as ventilator failure is common and occurs in 74% of acute tetraplegics. All patients with complete tetraplegia and injury level at C5 or rostral should be admitted to a CCU.

A literature review by Winslow and Rozovsky (2003:811) states the treatment for respiratory failure is endotracheal intubation and mechanical ventilation. However, non-invasive mechanical ventilation can be used successfully to treat respiratory failure in tetraplegia but this method is underutilized and further research is necessary to determine its appropriate application. Non-invasive ventilatory support offers the SCI patient many benefits but the focus of this study is on mechanical ventilation so this will not be discussed. Bedside measures of respiratory function may be better predictors than the level of injury and tidal volume of less than or equal to 6ml/kg is a better predictor of respiratory failure than either a vital capacity of less than or equal to 15ml/kg or level of injury.

Furthermore a literature review by Wuermser *et al.*, (2007:S57) state that restrictive ventilatory dysfunction occurs after an SCI with a resultant decrease in lung volumes. Vital Capacity (VC) decreases in tetraplegia and high paraplegia from respiratory muscle weakness. Quick mechanical assistance (either from intubation or non-invasive means) should be performed in SCI patients with severe respiratory distress or in patients with a vital capacity less than 15ml/kg.

### 3.6.3.6 Positioning

According to two literature reviews, frequent turning is beneficial as it prevents pressure sores and atelectasis (Denton and McKinlay, 2009:83, El-Said, 2011:107). Furthermore, Christie (2008:639-640), who conducted a literature review on

therapeutic positioning in multi-injured trauma patients including SCIs in CCUs noted that positioning had favourable outcomes for patients with chest injuries including improved ventilation as well as encourage drainage / removal of secretions. Communication with other members of the multidisciplinary team is beneficial to discuss the benefits of positioning patients with unilateral lung disease or injury with the “good lung down”, if not contraindicated in the SCI is recommended.

Another literature review by March (2005:23) recommends two-hourly position changes in the CCU but it is unclear whether the reason for this is for patient comfort or postural drainage. A literature review by Cook (2003:150) agree that patient positioning has the ability to improve respiratory mechanics and would be beneficial to the SCI patient and that regular turning and prone positioning can reduce respiratory complications. However, March (2005:23) states that literature on respiratory care illustrates the benefit of prone positioning in the prevention of pulmonary complications. However, no papers could be found on the benefit of this technique in the management of the SCI patient. Two literature reviews by Walker (2009:53) and March (2005:22) agree that regular repositioning utilises the beneficial effects of gravity on the redistribution of ventilation and perfusion throughout the lungs and optimises oxygen transport. However, repositioning of patients may increase there oxygen demand; therefore, nurses must monitor respiratory effort, rate and oxygen saturation so that patients do not develop respiratory distress following position change.

Body positioning can have an effect on the respiratory system in the healthy as well as the critically ill. A guideline by the Consortium for Spinal Cord Medicine (2005:12) states that positioning mechanically ventilated patients with SCI in either the supine or the Trendelenburg position can improve ventilation. Gutierrez *et al.*, (2010:269) conducted a randomised clinical intervention trial with cross-over experimental design and agree that placing ventilator-dependant patients in the Trendelenburg position improves ventilation, mobilises secretions and expands alveoli in lung regions vulnerable to atelectasis.

Ball (2001:S28), who performed a literature review, agree that the supine position is associated with improved respiratory function of quadriplegics possibly due to the fact that the abdominal muscles are paralysed allowing for the abdominal contents to descend and overdistend the diaphragm. March (2005:23) further highlights in their literature review that tetraplegics are sensitive to effects of gravity and suffer breathing difficulties in the sitting position as the vital capacity is reduced, and breathing is most comfortable in the supine position or the reverse Trendelenburg. Gutierrez *et al.*, (2010:267) promote the positioning of the SCI patient in the Trendelenburg position as their randomised trial with cross-over experimental design noted a 6% increase in vital capacity when placed in this position.

#### 3.6.3.7 Deep breathing

Two literature reviews discuss deep breathing exercises. March (2005:25) states deep breathing exercises are essential to the prevention of respiratory complications and nurses can encourage these to increase tidal volumes and functional residual capacity. Incentive spirometry is also beneficial when assessing how effective a patient's inspiratory efforts are. Spirometers have been promoted by two literature reviews (March, 2005:25 and Walker, 2009:53), who both agree that this strengthens respiratory muscles. Walker (2009:53) adds that spirometers encourage mobilisation of chest secretions.

#### 3.6.3.8 Kinetic therapy

Kinetic therapy has been considered beneficial in treating and preventing respiratory complications. A literature review by Berlly and Shem (2007:314) states that a Roto-rest (kinetic therapy) bed can assist with drainage of secretions and might decrease the incidence of pneumonia. Cook (2003:150), agree in their literature review, that oscillating bed therapy has been shown to reduce pulmonary complications.

Furthermore, an additional literature review by El-Said (2011:107) adds that improved pulmonary hygiene is another advantage of kinetic therapy for patients in spinal traction who are not able to sit up and is available in supine, rotating and percussive beds. Denton and McKinlay (2009:83) agree in a literature review that

supine, rotating and percussive beds are available which can help to prevent atelectasis. A literature review by Christie (2008:639) recommends kinetic therapy when further spinal injury precautions are going to be prolonged, for example, longer than 48 hours to prevent worsening respiratory function and there is some degree of regular position change. However, Berlly and Shem (2007:314) state that kinetic therapy is contraindicated for the SCI patient with strict immobilisation due to unstable SCIs.

#### 3.6.3.9 Chest physiotherapy

According to three literature reviews, chest physiotherapy can reduce the incidence of respiratory complications and is recommended (Walker, 2009:53;Berlly and Shem, 2007:317 and March, 2005:24.) In a CCU, chest physiotherapy is undertaken by physiotherapists and nurses alike (Walker, 2009:53).

### 3.7 SUMMARY OF THE CHAPTER

This chapter provided the finding of the systematic review on the respiratory management of the mechanically ventilated spinal cord injured patient in a critical care unit. After reviewing the literature, results from the study will be used to make recommendations for practice which will be presented in Chapter Four.

## **CHAPTER FOUR: CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS**

The purpose of this research study was to explore the latest evidence available for nursing the mechanically ventilated spinal cord injured patient in a critical care unit. The systematic review report was discussed in Chapter Three. This chapter discusses the conclusions, limitations and recommendations related to nursing education, practice and research. Furthermore, the chapter will discuss the recommendations concluded from the systematic review report on the respiratory management of the mechanically ventilated SCI patient in a CCU.

### **4.1 INTRODUCTION**

Evidence-based nursing is more than utilizing the latest research evidence. It is a process of integrating the best research evidence together with patient preferences, the clinical setting and circumstances, as well as healthcare resources when making decisions regarding patient care (Ciliska, 2006:38). Nurses who provide evidence-based practice or who are involved in conducting research can improve outcomes for mechanically ventilated patients (Chlan, Tracy and Grossbach, 2003:46). Evidence-based recommendations and guidelines are essential to quality care. Nurses are personally and professionally ethically responsible to provide quality health care to their patients (Muller, 2001:199).

### **4.2 CONCLUSION OF THE STUDY**

SCI patients have an abnormal respiratory function and can suffer respiratory complications as a result of their injuries. Respiratory complications are the leading cause of death during the acute period (Denton and McKinlay, 2009:82; and Tollefsen and Fondenes, 2012:1111). The consequences of an SCI and associated injuries may have a profound effect on the respiratory system of the SCI patient with many requiring mechanical ventilation during the acute phase and in the long term. Respiratory complications during the acute phase follow a predictable pattern and respiratory assessment and proper monitoring reveal how the patient should be managed. Timely management assists in the prevention and treatment of these

complications and is associated with improved outcomes for these patients (Berlly and Shem, 2007:316-317).

Respiratory complications after acute SCIs are prevalent and predictable based on neurological impairment, associated injuries and premedical conditions. Patients commonly deteriorate in the first few days post injury and require intubation and mechanical ventilation. The critical care nurse is in a vital position to anticipate and plan for predictable respiratory complications during the acute phase of SCI, particularly focussing on airway and breathing which are essential to survival. Care within specialised centres such as spinal units is recommended but this is not always possible, so care is also recommended in CCUs to decrease the number and severity of complications. Aggressive respiratory care needs to begin immediately after injury.

According to Gutierrez *et al.*, (2003:100) and Jia *et al.*, (2011:4) the mortality and morbidity rates are strongly associated with the dependence on mechanical ventilator. SCI patients who are mechanically ventilated have a higher mortality than SCI patients who are not. Mechanical ventilation, although a life-saving intervention, has many complications as well. Nursing care rendered to the critically ill, mechanically ventilated SCI patient should be done in such a way as to prevent complications and promote patient safety. One way to ensure the patient receives the best possible care is to base nursing care on the latest available evidence.

The researcher successfully achieved the primary objective of the study, which was to explore and describe existing literature for respiratory management of the mechanically ventilated SCI patient in a CCU. A systematic review was performed. The process of conducting a systematic review was reported in Chapter Two and the findings of the systematic review were described in Chapter Three of this study. Based on the findings of the systematic review, the researcher has developed recommendations for practice that focussed on the priorities of care during the acute phase, priorities of respiratory care within the CCU as well as priorities of preventative care to prevent and manage specific respiratory complications. Please refer to table 3.3 for themes and subthemes.

### **4.3 RECOMMENDATIONS BASED ON RESULTS FROM THE SYSTEMATIC REVIEW ON THE RESPIRATORY MANAGEMENT OF THE MECHANICALLY VENTILATED SCI PATIENT IN A CCU**

Recommendations are based on the results of the systematic review report that was performed in Chapter Three of this research study. The United States Preventative Services Task Force (USPSTF) grading system has been utilised to rank recommendations for practice and is presented in relation to the hierarchies of evidence as discussed in Chapter Two. Grade A recommendation will be based on Levels I and II types of evidence, Grade B indicates Level III evidence including quasi-experimental, non-randomised controlled trial, Grade C indicates Level IV evidence including observation, descriptive and cohort studies and Grade D recommendations are assigned to Level VII evidence including case studies and expert opinion. The recommendations were done according to the themes and subthemes as illustrated in Table 3.2.

#### **4.3.1. Priorities of care for the SCI patient in the acute phase**

Recommendations will be made on the priorities of care of the SCI patient during the acute phase.

##### **4.3.1.1 Admission to the CCU**

The following recommendations are made with regards to the admission of the SCI patient in a CCU.

- It is recommended that the SCI patient, regardless of the neurological level or completeness of the injury should be admitted to a CCU for intensive ventilatory, cardiopulmonary support and hemodynamic monitoring (Grade A).
- It is recommended that the SCI patient be assessed for organ failure by using the multiple organ dysfunction score (MODS) and Sequential Organ Failure Assessment (SOFA) score (Grade D).
- It is recommended that the critical care nurse should have adequate knowledge regarding the pathophysiology of the SCI patient, in particular the



cardiopulmonary function to promote health and prevent complications from admission and throughout the treatment of these patients (Grade D).

#### 4.3.1.2 Airway management

The following recommendations were made regarding airway management.

- It is recommended that supporting the respiratory system of the SCI patient by maintaining airway, breathing and circulation should be regarded as a priority of care (Grade A).
- It is recommended that non-invasive ventilation should be attempted before intubation, however if unsuccessful the patient should be intubated promptly (Grade A and D).
- It is recommended that SCI patients with an injury severity score > 16, cervical SCI above C5, and complete quadriplegia are intubated regardless of the initial presentation (Grade C).
- It is recommended that bag-mask ventilation may be used initially for ventilatory failure but is not a long-term solution as air may be introduced into the stomach and cause gastric distension and increase the risk of aspiration of gastric contents (Grade D).
- While oral intubation is safe, the use of manual in-line cervical traction with orotracheal intubation is recommended. This should be done in a controlled as opposed to emergency situation (Grade D).
- It is recommended that atropine be available during intubation as bradycardia can occur and that it may be considered for giving to patients who present with bradycardia prior to airway management (Grade A).
- It is recommended that rapid sequence induction with cricoid pressure and manual inline stabilization be used in an emergency, if a difficult intubation is anticipated. If the patient is awake and co-operative, awake fiberoptic intubation is the method of choice (Grades A, C and D).
- It is recommended that Succinylcholine is the agent of choice for rapid sequence intubation in SCI patients within the first 48 hours of injury. Succinylcholine is not considered safe thereafter (Grades A and D).

- Succinylcholine is the first agent of choice; however, other agents may be used once the time period for Succinylcholine is no longer considered safe and could include etomidate in unstable patients. Ketamine may be used but its use must be monitored for hypertension. Propofol and thiopental may be used but may aggravate hypotension. (Grade A)

#### **4.3.2. Priorities of respiratory care for the SCI patient in a CCU**

Once the patient is intubated, breathing efforts need to be maintained by mechanical ventilation. The next section will discuss the recommendations made for priorities of care in the CCU including mechanical ventilation, tracheostomy care, respiratory management and weaning from a mechanical ventilator.

##### **4.3.2.1. Mechanical ventilation**

The following recommendations were made regarding mechanical ventilation of the SCI patient:

- It is recommended that all SCI patients with complete injuries at C5 and above be intubated and ventilated (Grade C).
- It is recommended that SCI patients with high cervical complete injuries as well as intractable atelectasis, lack of diaphragm function, advanced age, previous cardiopulmonary disease, tachypnea at admission, copious sputum, pneumonia and major lobe collapse should be treated with ventilatory support early during management (Grade A).

##### **4.3.2.2 Ventilator management strategies**

- It is recommended that mechanically ventilated SCI patients with complete injuries (C3 and above) be ventilated on modes such as controlled mandatory ventilation or assist control. However, controlled ventilation is recommended when respiratory muscles are not equally affected on both sides of the diaphragm (Grade D).
- It is recommended that mechanically ventilated incomplete injuries should be ventilated on modes that incorporate spontaneous breathing, for example,

pressure support ventilation or synchronised intermittent mandatory ventilation (Grade D).

- It is recommended to use larger tidal volumes (15ml/kg-20ml/kg of ideal body weight) and low respiratory rates during the acute phase of the SCI as this lowers the risk of atelectasis and pneumonia, as well as accelerates the weaning process. The use of larger tidal volumes is also associated with improved comfort and less dyspnea (Grade A and D).
- In the event of evident atelectasis, tidal volumes can be temporarily increased by 100ml/day and up to 20ml/kg and flow rate increased by 10L/min at periodic intervals whilst monitoring peak airway pressures which must be kept below 40cmH<sub>2</sub>O in order to prevent barotraumas (Grade D).
- Positive-end expiratory pressure (PEEP) is not recommended because of lack of studies showing the effectiveness of PEEP in treating atelectasis in acute SCI. By gradually increasing tidal volumes, risk of barotraumas remains low because peak pressures only increase slightly (Grade D).
- Careful monitoring of respiratory function for all SCI patients receiving higher tidal volumes and using lung protective ventilation, which includes low tidal volume ventilation (6ml/kg) if acute lung injury, contusion, infection or ARDS are present is recommended (Grade A and D).

#### 4.3.2.3 Weaning from the mechanical ventilator

The following recommendations were made regarding weaning the patient from mechanical ventilation:

- It is recommended that despite the level of injury, weaning in the SCI patient should be commenced as soon as possible as prolonged endotracheal intubation might increase laryngeal and tracheal trauma and prolong the patient's stay in the CCU (Grade D).
- It is recommended that before attempting to wean the SCI patient, the patient should be hemodynamically stable for 24 hours, have spontaneous respiratory efforts, be co-operative, have appropriate nutrition, no current infection, must not be dependent on oxygen greater than 25% and have no positive-end expiratory pressure, clear chest X-Ray with manageable

secretions and a arterial blood gas with a  $\text{PaO}_2 >75$ ,  $\text{PCO}_2$  35-45, pH 7.35 – 7.45, inspiratory force  $>-24\text{cmH}_2\text{O}$  and no narcotics which can affect respiratory muscle activity. Vital capacity above 15ml/kg ideal body weight, good cough, being a non-smoker and aged below 45 with no previous pulmonary disease can affect the weaning of these patients (Grade D).

- A variety of ventilator strategies may be used in the weaning process including T-piece trials, intermittent mandatory ventilation, progressive ventilator free breathing, continuous positive airway support and pressure support ventilation (Grade D).
- It is recommended that the following parameters be closely monitored whilst weaning the SCI patient including: arterial blood gas, pulse oximetry and end tidal capnography. Weaning the patient in the supine position is associated with increased vital capacities. (Grade D).

#### 4.3.2.4 Tracheostomy care

The following recommendations are made regarding tracheostomy care:

- A cuffed tracheostomy is recommended for patients who aspirate (Grade A).
- It is recommended that an early tracheostomy be more frequently considered for patients with the following risk factors: older age (45years), high neurological level of injury (above C5), complete cervical injuries, pre-existing medical conditions, for example, lung disease and pneumonia, smoking history. SCI patients requiring long-term mechanical ventilation as well as those who had a failed extubation should also be considered (Grade A).
- Percutaneous and surgical tracheostomies can be carried out safely in the CCU at the bedside. Percutaneous tracheostomy has been recommended as the first method of choice (Grade C).
- A cuffed tracheostomy is recommended for patients who aspirate (Grade A).

#### 4.3.3 Respiratory management in the CCU.

Recommendations can be made, regarding respiratory management in a CCU, which must include assessment of the respiratory status.

#### 4.3.3.1 Assessment of the respiratory status of the SCI patient in a CCU

The following recommendations are made regarding the assessment of the respiratory status of the SCI patient:

- It is recommended that respiratory assessment be performed at regular intervals until the SCI patient is stable and signs of respiratory failure should be monitored, especially in the first 5 days post SCI (Grade A).
- It is recommended that the initial assessment includes the patient's relevant health history. It should also include a physical examination of the respiratory system and the respiratory function. Baseline respiratory parameters such as vital capacity, forced expiratory volume or peak cough, maximum negative inspiratory pressure, chest X-rays as well as initial laboratory assessment including arterial blood gas must be included. Respiratory monitoring is also of great importance (Grade A).
- It is recommended that cervical SCIs receive comprehensive assessment of pulmonary status as well as continuous monitoring for respiratory dysfunction as they can suddenly lose airway control (Grade D).
- Monitoring oxygen saturation and end tidal CO<sub>2</sub> to measure the quality of gaseous exchange in the following few days and comparing this data with the patient's level of respiratory distress is recommended (Grade A and D).
- Clinical assessment should include evaluating the airway, breathing and circulation as well as neurological level of injury and should be performed during the first few days (Grade D).
- It is recommended that vital capacity be performed every nursing shift and if vital capacity approaches 10mL/kg, it implies that the patient is fatigued and intubation should be considered (Grade D).
- It is recommended that chest radiography be obtained and followed in patients with atelectasis, pulmonary edema, chest trauma, aspiration, when the patient desaturates and in patients with the following co-morbidities: anemia, obesity, lung disease, history of smoking, chest trauma and copious secretions (Grade D).

- The use of spirometry has been recommended to monitor respiratory reserve and a value less than 12-15ml/kg is an indicator of the need for mechanical ventilation (Grade D).
- It is recommended that the respiratory assessment and monitoring be done to help anticipate and prevent respiratory complications noting for signs of respiratory failure, signs of pulmonary edema, signs of infection including culture and sensitivity and the effectiveness of antimicrobial therapy (Grade D).

#### 4.3.3.2 Priorities of preventative care

Respiratory complications are common and need to be prevented, where possible. The following recommendations are made regarding prevention of respiratory complications.

- It is recommended that pulmonary and cardiac monitoring is necessary to detect life-threatening complications in CSCI (Grade A).
- Due to the high incidence of respiratory complications it is recommended that intensive monitoring and aggressive pulmonary care be given to both high thoracic and cervical SCIs (Grade C).
- It is recommended that mechanical compressive devices be applied early after injury as well as low molecular weight heparin or unfractionated heparin to prevent venous thromboembolism (Grade D). SCI ventilated patients should be closely monitored for occurrence of pulmonary embolism (Grade A and D).
- It is recommended that nurses monitor the SCI patient for bronchospasms and give bronchodilators as prescribed (Grade D).
- It is recommended that copious secretions in the chest should be managed with physiotherapy and suctioning and that retained secretions be treated with manually assisted coughing (“quad coughing”), pulmonary hygiene, mechanical insufflation-exsufflation, or similar expiratory aids in addition to suctioning (Grade A).

- It is recommended that the SCI patients have cuffed tracheostomies which need to be monitored and kept at 25 cmH<sub>2</sub>O to avoid tracheal injury (Grade D).
- It is recommended that preventative strategies used for VAP are the same in the SCI as the non-SCI patient with the exception of the 45 degree headup which should be avoided (Grade A).
- It is recommended that secretions can be removed through chest physiotherapy, postural drainage, suction, manual cough support, mechanical insufflation – exsufflation, manual cough assist, airstacking, spinal cord stimulation, spontaneous cough, quad cough, tussive squeeze and costaphrenic technique. These are recommended for clearing the airway of secretions, bronchoscopy and suctioning. Additional measures such as warm moist air, bronchodilators, mucolytics and intrapulmonary percussive ventilation, incentive spirometry are successful in managing secretions (Grade D).
- It is recommended that the patient be turned 2 hourly to prevent pressure sores, promote postural drainage, clearance of secretions and prevent atelectasis (Grade D). The supine and the Trendelenburg positions are associated with improved ventilation (Grade A).
- It is recommended that nurses should encourage deep breathing exercises to increase tidal volumes and functional respiratory capacity (Grade D).
- Kinetic therapy that can assist with the drainage of secretions and decrease the risk of pneumonia is recommended for patients when spinal precautions are going to be prolonged in order to prevent worsening respiratory function (Grade D).
- It is recommended that the patient's heart rate be monitored during suctioning, that it is an aseptic procedure, and a maximum of 2 suction passes be done at a time. Suction pressure should be kept between 100-200mmHg and pressure only applied pressure as the catheter is removed. The catheter should be inserted to 1/3<sup>rd</sup> length and should be ½ size of the tube. The patient must be hyperoxygenated for 1 minute before suctioning. Closed suctioning is recommended to prevent infection and, where possible,

movement of the endotracheal tube limited as this may stimulate the vagus nerve. A curved catheter tip is recommended to gain access to the left main-stem bronchus whilst turning the patient's head to the right. However, this should be avoided in patients with high ICP (Grade D). Manual hyperinflation is beneficial at re-expanding areas of lung collapse (Grade D).

#### 4.4 LIMITATIONS

The limitations of the systematic review are listed below:

- Free access to electronic journals was limited and other articles needed to be requested via interlibrary loans. Articles not available via interlibrary loans would have to be purchased and this was not possible due to lack of funds.
- There was limited availability of independent reviewers to perform the critical appraisal independently of the researcher, who was the primary reviewer.
- Grey literature was difficult to obtain.
- Information on airway management mainly came from emergency department journals and no articles were found on the role of the nurse involved in assisting with intubation.
- There was a paucity of literature on respiratory assessment in relation to the SCI patient as well as a paucity of literature focussing on the nursing interventions relating to respiratory management of the mechanically ventilated SCI but there were various levels of evidence regarding respiratory management by multidisciplinary team.
- Many articles found were focussed on the management of the cervical SCIs only but the paucity of those related to the management of lower level injuries to the spinal cord may have influenced recommendations made.
- There is a paucity of guidelines on the nursing management of the mechanically ventilated SCI in a CCU in relation to respiratory management. Other guidelines were available and discussed collaborative care in managing these patients, which is of great importance, but none is specific to the South African context.



## **4.5 RECOMMENDATIONS**

Recommendations for the research study are made for nursing research, education and practice.

### **4.5.1 Recommendations for Nursing Research**

No clinical guidelines related to the nursing care of the mechanically ventilated spinal cord injured patient could be found except one very outdated guideline from 1986. The researcher recommends that systematic reviews be done on monitoring of mechanical ventilator settings, suctioning and secretion management, assisted coughing, positioning, cuff pressure monitoring, ventilator-associated pneumonia (VAP) bundling all be done in relation to the SCI. Clinical practice guidelines can then be developed based on results from the systematic review and used to base nursing decisions on the latest available evidence to offer SCI patients the best care possible. Evidence-based nursing care will assist in the prevention of complications and promote quality care which will result in improved patient outcomes, as well as a reduction of hospital costs, time on mechanical ventilation and in the CCU. Nursing care based on the latest available evidence ensures the patient receives the best possible care available. According to Berney *et al.*, (2011:26) moderate evidence is available to suggest that respiratory protocols alter the need for mechanical ventilation. Therefore, respiratory protocols may be beneficial in the respiratory management of the SCI patient. The systematic review report that was conducted on the respiratory management of the mechanically ventilated SCI patient in a CCU can be used to develop evidence-based guidelines in future research studies.

Once evidence-informed clinical guidelines or recommendations for practice are developed, the researcher advocates that they be implemented to improve patient care. Additional research should then be conducted to evaluate whether the guideline was implemented successfully, have the results of the guideline influenced the care of the SCI patient and as well as the effect of the implemented guideline on the patient. Statistics should also be available to compare the incidence of respiratory complications as well as complications from mechanical ventilation, such as VAP, before and after implementation of the guideline to assess the impact made.

Follow-up research studies can focus on stakeholder analysis and environmental readiness for guideline development and implementation. Intervention studies can be done to assess the effectiveness of guideline implementation. Future research is necessary to explore and describe the knowledge of nurses on evidence-based practice, its utilization and how to integrate this when making decisions in practice that will affect the patient.

#### **4.5.2 Recommendations for education**

The researcher recommends that evidence-based nursing care and evidence-based practice as well as decision making relating to nursing care be focussed on at all levels of nursing education. The aim is to create professionals who are aware and knowledgeable with regards to evidence-based practice and who are confident in obtaining and identifying relevant, reliable evidence amongst the wealth of information available.

It is recommended that professional nurses, regardless of their age and level of expertise, be encouraged to attend short learning courses and seminars where they will be taught how to search for the latest best evidence available from which they can make decisions related to practice.

A short learning programme which specifically addresses the nursing care of the mechanically ventilated spinal cord injured patient in a critical care unit can be developed and key aspects making the care of this vulnerable population different from the rest of the critically ill mechanically ventilated patients needs to be highlighted. Recommendations based on results from this systematic review can be presented in this short learning programme.

SCI nursing is a specialist field. Post-graduate diplomas should be available to offer nurses an additional qualification in providing comprehensive care to these patients especially in areas which have a spinal centre or spinal CCU. Journal clubs are also recommended amongst staff to discuss the latest available evidence with regards to specialist areas of nursing or patient populations. Journal clubs can occur locally at

one institution or combine with other institutions. Information technology can be utilised and a short computerised programme developed on the latest evidence for caring for these patients. Social media such as twitter and Facebook can also be used to share information with regards to the latest evidence and management of the SCI patient and the benefit is that information can be shared from all around the world in an affordable way.

#### **4.5.3 Recommendations for nursing practice**

The development of clinical practice guidelines for the respiratory management of the mechanically ventilated SCI patient as well as the implementation of these guidelines was beyond the scope of this study. It is recommended that these guidelines be developed, then piloted and implemented amongst critical care nurses in CCUs in both the public and private sectors. The clinical practice guideline or algorithm can be incorporated into unit policies and in-service educational programmes within CCUs within the Nelson Mandela Bay. Dissemination of guidelines/algorithms amongst all nurses will reduce practice variations amongst nurses. The researcher recommends an up-to-date resource/research file be available in all CCUs including the latest evidence on the respiratory management of the mechanically ventilated SCI patient.

There are no specialist spinal units to my knowledge in the Eastern Cape in the government or private sector although a private rehabilitation centre called Aurora has facilities to take care of SCIs who have a medical aid. A recommendation for practice would be the development of specialized SCI centres. The researcher is aware that this is a costly process. If it is not possible to develop spinal units, then the researcher recommends that critical care/acute care facilities within specialized spinal units/orthopaedic wards would allow patients with prolonged recovery (because of respiratory complications and ventilator dependence) to be admitted, in order to allow earlier rehabilitation however this is a costly and challenging process.

Clinical algorithms can be used at the patient's bedside to ensure information is easily accessible and attainable. Checklist or care bundles can be developed based

on guidelines and recommendations from systematic reviews and included in the documentation as a way of incorporating the evidence into nursing practice. Regular auditing of the documentation will allow evaluation to assess if compliance to the recommendations is carried out. Checklist or care bundles can be developed based on recommendations from this systematic review regarding priorities of care during the acute phase, priorities of respiratory care in the CCU as well as priorities of care during the preventative phase.

Evidence-based practice is essential when caring for the critically ill patients. Nurses must be supported and empowered to provide the best care possible to mechanically ventilated patients. Nurses are faced with the challenge of compiling many sources of information and must work together with members of the multidisciplinary team to ensure the best outcomes for the patient. Nurses need to be aware that systematic reviews provide the latest evidence available on a topic. Academic ward rounds which occur twice daily and are attended by members of the multidisciplinary team are perfect opportunities to discuss the latest evidence-based practice and ensure that the patient receives the best treatment possible. This gives the critical care nurse an opportunity to learn and share knowledge on the topic. The critical care nurse works as part of a team and many opportunities are available throughout the day where on-the-spot training can occur and knowledge should be shared as needed. Managers must be supportive, identify learning needs and organise in-service training as an ongoing process. In-service training as well as short learning courses can be implemented at a macro and micro level and all new nursing staff should receive this training as part of their orientation.

#### **4.6 SUMMARY OF THE CHAPTER**

The research study emphasised how systematic reviews are considered the highest level of evidence on which to base medical decisions. Every nurse practitioner is ethically responsible to provide the best care possible to their patients, this includes basing decisions related to treatment on the best evidence available. As discussed previously, respiratory complications are the leading cause of mortality and morbidity in the SCI patient during the short and long term, and every effort should be made to

prevent and limit these complications. The research study was successful in finding the latest evidence on the respiratory management of the mechanically ventilated SCI patients in a CCU and recommendations based on the systematic review were made to inform practice. These recommendations aim to help assist practitioners in making evidence-based nursing decisions when treating this special population in order to limit and prevent complications and thus decrease the mortality and morbidity of SCI patients.

**NOTE:** Two different reference lists are available in this research study and are divided as follows:

Reference list A: includes references for the completed study, except those used for the systematic review.

Reference list B: includes the references used for the systematic review on nursing the mechanically ventilated spinal cord injured patient in a critical care unit.

### REFERENCE LIST A

1. Aarabi, B., Harrop, J.S., Tator, C.H., Alexander, M., Dettori, J.S., Grossman, R.G., Dettori, J.R., Grossman, R.G., Fehlings, M.G., Mirvis, S.E., Shanmuganathan, K., Zacherl, K.M., Burau, K.D., Frankowski, R.F., Toups, E., Shaffrey, C.I., Guest, J.D., Harkema, S.J., Habashi, N.M., Andrews, P., Johnson, M.M. and Rosner, M.K. 2012. Predictors of pulmonary complications in blunt traumatic spinal cord injury. Journal of Neurosurgery Spine. Supplement. Vol. 17 No.1: 38-45.
2. Adam, S.K. and Osborne, S. 2005. Critical Care Nursing: science and practice. 2<sup>nd</sup> edition. Oxford: University Press.
3. The AGREE Next Step Consortium 2009. Appraisal of Guidelines for research and Evaluation AGREE II Instrument <http://www.agreetrust.org>.: 1-11. [Accessed 25/11/2011].
4. Aveyard, H. 2010. Doing a literature review in health and social care: A practical guide. 2<sup>nd</sup> edition. Berkshire: University Press.
5. Barker, J. 2010. Evidence-based practice for nurses. London: SAGE Publications Ltd.
6. Bettany – Saltikov, J. 2012. How to do a systematic literature review in nursing, a step-by-step guide. London: McGraw Hill.

## REFERENCE LIST

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7. Bettany – Saltikov, J. 2010. Learning how to undertake a systematic review: part 2. Nursing Standard. Vol.24 No.51: 47 – 56.
8. Burns, N. and Grove, S.K., 2009. The practice of nursing research appraisal, synthesis, and generation of evidence. 6<sup>th</sup> edition. St Louis, Missouri: Saunders Elsevier.
9. Carnett, W.G. 2002. Clinical practice guidelines: A tool to improve care. Journal of Nursing Care Quality. Vol.16 No. 3: 60-70.
10. Carver, J.D., Dellva, B., Emmanuel, P.J. and Parchure, R. 2011. Ethical considerations in scientific writing. Indian Journal of Sexually Transmitted Diseases and AIDS. Vol. 32 No.2: 124 – 128.
11. Cheng, P.T., Chen, C.L., Wang, C.M. and Chung, C.Y. 2006. Effect of neuromuscular electrical stimulation on cough capacity and pulmonary function in patients with acute cervical cord injury. Journal of Rehabilitation Medicine. Vol.38 No.1:32-36.
12. Chlan, L., Tracy, M.F. and Grossbach, I. 2003. Achieving quality patient-ventilator management: advancing evidence-based nursing care. Critical Care Nurse. Vol. 31 No.6: 46 – 50.
13. Clarke, M. 2000. What is so important about systematic reviews. Acta Psychiatrica Scandinavica. Vol.102 No.4 :239-240.
14. Ciliska, 2006. Evidence-based nursing: how far have we come? What's next? Evidence-based Nursing. Vol. 9 No. 2: 38 - 40.
15. Comer, S. 2005. Delmar's critical care nursing care plans. 2<sup>nd</sup> ed. United States of America: Thomson–Delmar Learning.

## REFERENCE LIST

---

16. Draulans, N., Kiekens, C. and Roels, E and Peers, K. 2011. Etiology of spinal cord injuries in Sub-Saharan Africa. Spinal Cord. Vol. 49 No. 12: 1148 – 1154.
17. Egerod, I. 2006. Evidence-based practice and critical care nursing. Nursing in Critical Care. Vol. 11 No. 3:107-108.
18. Elliot, D., Aitken, L. and Chaboyer, W. 2007. ACCCN's critical care nursing. Australia: Mosby. Elsevier.
19. Estaban, A., Anzueto, A. and Frutos, F. 2002. Characteristics and outcomes in adult patients receiving mechanical ventilation: a 28 day international study. Journal American Medical Association. Vol. 287 No.3: 345-355.
20. Evans, D. 2001. Systematic reviews of nursing research. Intensive and Critical Care Nursing. Vol. 17 No. 2: 51-57.
21. Flint, L., Meredith, J.W., Schwab, C.W., Trunkey, D.D., Rue, L.W. and Taheri, P.A., 2008. Trauma: contemporary principles and therapy. Philadelphia: Wolters Kluwer, Lippincott Williams & Wilkins.
22. Gibson, K.L., 2003. Caring for a patient who lives with a spinal cord. Nursing, Vol. 33 No. 7: 36–41.
23. Grossman, R.G., Frankowski, R.F., Burau, K.D., Toups, E.G., Crommett, J.W., Johnson, M.M., Fehlings, M.G., Tator, C.H., Shaffrey, C.I., Harkema, S.J., Hodes, J.E., Aarabi, B., Rosner, M.K., Guest, J.D. and Harrop, J.S. 2012. Incidence and severity of acute complications after spinal cord injury. Journal of Neurosurgery Spine. (Supplement) Vol. 17 No. 1:119 – 128.
24. Hargrove, P. and Lund, B. 2005. A guideline for applying systematic reviews to child language intervention. Communication Disorders Quarterly. 26 No. 4: 226 – 235.



## REFERENCE LIST

---

25. Harvey, L. 2008. Management of spinal cord injuries: A guide for physiotherapists. Philadelphia: Butterworth Heinemann Elsevier.
26. Higginson, R. and Jones, B. 2009. Respiratory assessment in critically ill patients: airway and breathing. British Journal of Nursing, Vol. 18 No. 8: 456-461.
27. Holloway, I. and Wheeler, S., 2002. Qualitative research in nursing. 2<sup>nd</sup> ed. Oxford: Blackwell.
28. Holopainen, A., Hakulinen – Viitanen, T. and Tossavainen, K., 2008. Systematic review – a method for nursing research. Nurse Researcher. Vol. 16 No. 1: 72 - 83.
29. Jelic, S., Cunningham, J.A. and Factor, P. 2008. Clinical review: Airway hygiene in the intensive care unit. Critical Care. Vol. 12 No. 2: 209 – 218.
30. Jevon, P. and Ewens, B. 2002. Monitoring the critically ill patient. Oxford: Blackwell Science.
31. Joanna Briggs Instituted (JBI) for Nursing and Midwifery. 2001. Supplement 1: 1-6 <http://www.joannabriggs.edu.au> [Accessed 16:01:2011].
32. Joanna Briggs Institute Reviewers Manual. 2011 edition. 1-200 The Joanna Briggs Institute, Australia <http://www.joannabriggs.edu.au> [Accessed 24/11/2011].
33. JBI SUMARI user manual version 5.0. 1-238. available from <http://www.joannabriggs.edu.au>.
34. Katapodi, M.C. and Northouse, L.L., 2011. Comparative effectiveness research: using systematic reviews and meta-analysis to synthesize empirical evidence. Research and Theory for Nursing practice. Vol. 25 No. 3:191 – 209.

35. Kearns, M. and Shimabukuro, D. 2012. Respiratory complications and management of mechanical ventilation in cervical spine injury. ICU Director. Vol. 3 No. 5: 220 – 223.
36. LoBiondo-Wood G. and Haber J. 2010. Nursing research: methods and critical appraisal for evidence-based practice. 7th Edition. St Louis, Missouri: Mosby.
37. Lohne, V. 2009. The incomprehensible injury – interpretations of patients' narratives concerning experiences with an acute and dramatic spinal cord injury. Scandinavian Journal Caring Spinal cord injury, Vol. 23 No. 1: 67 – 75.
38. Marani, R. and Perri, A.G. 2010. An electronic medical device for preventing and improving the assisted ventilation of the intensive care unit patients. The Open Electrical and Electronic Engineering Journal, Vol 4: 16 – 20.
39. Masri, W.E., 2006. Traumatic spinal cord injury: The relationship between pathology and clinical implications. Trauma. Vol. 8 No. 1: 29 - 46.
40. Matter, B., Feinberg, M., Schomer, K., Harniss, M., Brown, P. and Johnson, K. 2008. Information needs of people with spinal cord injuries. Journal of Spinal Cord Medicine. Vol. 32 No. 5: 545 – 554.
41. McKinley, W., Santos, K., Meade, M., Brooke, K. 2007. Incidence and outcomes of spinal cord injury clinical syndromes. Journal of Spinal Cord Medicine. Vol. 30 No. 3: 215 – 224.
42. McQuillan, K.A., Makic, M.B.F. and Whalen, E. 2009. Trauma nursing from resuscitation through rehabilitation. 4th Ed. St Louis, Missouri: Saunders Elsevier.
43. Morton, P.G. and Fontaine, D.K. 2009. Critical care nursing a holistic approach. Wolters Kluwer: Lippincott Williams and Wilkins.

## REFERENCE LIST

---

44. Muller, M. 2001. Nursing dynamics. Sandton: Heinemann Publishers (Pty) Ltd.
45. National Spinal Cord Injury Statistical Centre. Spinal Cord Injury Facts and Figures at a Glance. Information Sheet. 2012 <http://nscisc.uab.edu> [Accessed:16/03/2012]
46. Noordzij, M. Hooft, L., Dekker, F.W., Zoccali, C. and Jager, K.J. 2009. Systematic reviews and meta-analyses: when they are useful and when to be careful. Kidney International. 76 No. 11: 1130 - 1136.
47. O'Mathuna, D.P., Fineout-Overholt, E. and Kent, B. 2008. How systematic reviews can foster evidence-based clinical decisions: part II. Worldviews on Evidence-Based Nursing. Vol 5 No. 5: 102-107.
48. Ones, K., Yilmaz, E., Beydogan, A., Gultekin, O. and Caglar, N. 2007. Comparison of functional results in non-traumatic and traumatic spinal cord injury. Disability and Rehabilitation. Vol. 29 No. 15: 1185 – 1191.
49. Parahoo, K. 2006. Nursing research principles, process and issues 2<sup>nd</sup> edition. New York: Palgrave Macmillan.
50. Pearson, A., Field, J. and Jordan, Z. 2007. Evidence-based clinical practice in nursing and health care. Oxford: Blackwell Publishing.
51. Petticrew, M. and Roberts, H. 2010. Systematic reviews in the social sciences a practical guide. Malden USA: Blackwell Publishing.
52. Polit, D.F., Beck, C.T. 2010. Essentials of nursing research appraising evidence for nursing practice 7<sup>th</sup> edition. China: Wolters Kluwer Health: Lippencott Williams and Wilkins.

## REFERENCE LIST

---

53. Rees, A. and Booth, A. 2005 resource guide: guideline production and implementation. Evidence-Based Healthcare and Public Health. Vol. 9 No. 4: 315-316.
54. Reid, W.D., Brown, J.A., Konnyu, K.J., Rurak, J.M..E., Sakakibara, B.M. and The SCIRE Research Team. 2010. Physiotherapy secretion removal techniques in people with spinal cord injury: a systematic review. Journal of Spinal Cord Medicine. Vol. 33 No. 4: 353 - 370.
55. Rew, L. 2011. The systematic review of literature: Synthesizing evidence for practice. Journal for Specialists in Paediatric Nursing. Vol. 16 No. 1: 64 - 69.
56. Scanlon, A. 2007. Critical appraisal of systematic review for nursing practice. Australasian Journal of Neuroscience. Vol. 18 No. 1: 8 - 14.
57. Smeltzer, S.C., Bare, B.G., Hinkle, J.L. and Cheever, K.H. 2008. Brunner & Suddarth's testbook of medical – surgical nursing. 11<sup>th</sup> ed. Philadelphia: Lippincott Williams & Wilkins.
58. Sole, M.L, Klein, D.G. and Moseley, M.J. 2009. Introduction to critical care nursing. 5<sup>th</sup> ed. St Louis Missouri, Mosby: Elsevier.
59. Sutherland, S.E. 2004. An Introduction to systematic reviews. Journal of Evidence-based Dental Practice. Vol. 4 No. 1: 47 – 51.
60. Swinglehurst, D. 2005. Evidence – based guidelines: the theory and the practice. Evidence – based healthcare and Public Health. Vol. 9 No. 5: 308 – 314.
61. Terre Blanche, M., Durrheim, K. and Painter, D. 2007. Research in practice: applied methods for the social sciences 2<sup>nd</sup> edition. Cape Town: University of Cape Town Press.

62. The Nursing Act No. 33 of 2005. Pretoria: Government Printer.
63. The United States Preventive Services Task Force (USPSTF) grading system, accessed via [www.ahcpr.gov/clinic/uspst-fix.htm](http://www.ahcpr.gov/clinic/uspst-fix.htm) [Accessed 17/10/2012]
64. Unpublished institutional stats from the CCU. 2012.
65. Torgerson, C. 2003. Systematic reviews. London: Continuum.
66. Urden, L.D, Stacy, K.M. and Lough, M.E. 2010, Critical care nursing diagnosis and management. 6<sup>th</sup> ed. St. Louis, Missouri: Mosby. Elsevier.
67. West, S.L. 2006. Physical assessment, whose role is it anyways? Nursing in Critical Care. Vol. 11 No. 4: 161 – 167.
68. Wieseler, B. and McGauran, N. 2010. Reporting a systematic review. Chest. Vol. 137 No. 5: 1240 – 1246.
69. Wong, S.L., Shem, K. and Crew, J. 2012. Specialized respiratory management for acute cervical spinal cord injury: a retrospective analysis. Topics in Spinal Cord Injury Rehabilitation. Vol. 18 No. 4: 283 – 290.
70. Whiting, L.S. 2009. Systematic review protocols: an introduction. Nurse Researcher. Vol. 17 No. 1: 34 – 43.
71. Wyndaele, M. and Wyndaele, J.J. 2006. Incidence, prevalence and epidemiology of spinal cord injury: what learns a worldwide literature survey? Spinal Cord. Vol. 44 No. 9: 523 – 529.
72. Yoshii, A., Plaut, A., McGraw, K.A., Anderson, M.J. and Wellik, K.E. 2009. Analysis of the reporting of search strategies in Cochrane systematic reviews. Journal of Medical Library Association. Vol. 97 No.1: 21-29.

## REFERENCE LIST

---

73. Zhu, W., Jia, I.S., Shao, J. and Chen, X.S. 2007. Time of early death after cervical spinal cord injury. Zhonghua Yi Xue Za Zhi. Vol. 87 No. 33: 2342 - 2345.

### REFERENCE LIST B

Reference list for systematic review report on the respiratory management of the mechanically ventilated SCI patient in a CCU (See Chapter 3)

#### Books used (introduction)

1. LoBiondo-Wood G and Haber J. 2010. Nursing research: methods and critical appraisal for evidence-based practice. 7th Edition. St Louis, Missouri: Mosby.
2. Pearson, A., Field, J. and Jordan, Z. 2007. Evidence-based clinical practice in nursing and health care. Oxford: Blackwell Publishing.

#### Articles used in the introduction

1. Aarabi, B., Harrop, J.S., Tator, C.H., Alexander, M., Dettori, J.S., Grossman, R.G., Dettori, J.R., Grossman, R.G., Fehlings, M.G., Mirvis, S.E., Shanmuganathan, K., Zacherl, K.M., Burau, K.D., Frankowski, R.F., Toups, E., Shaffrey, C.I., Guest, J.D., Harkema, S.J., Habashi, N.M., Andrews, P., Johnson, M.M. and Rosner, M.K. 2012. Predictors of pulmonary complications in blunt traumatic spinal cord injury. Journal of Neurosurgery Spine. Supplement. Vol. 17 No.1: 38-45.
2. Gibson, K.L., 2003. Caring for a patient who lives with a spinal cord. Nursing, Vol. 33 No. 7: 36–41.
3. Hamunen, K. 2012. Systematic reviews-great gains, significant pitfalls. Scandinavian Journal of Pain. Vol.3 No. 2: 68-69.
4. Matter, B., Feinberg, M., Schomer, K., Harniss, M., Brown, P. and Johnson, K. 2008. Information needs of people with spinal cord injuries. Journal of Spinal Cord Medicine. Vol. 32 No. 5: 545 – 554.
5. JBI SUMARI user manual version 5.0. 1-238. available from <http://www.joannabriggs.edu.au>.

### **Papers included in the systematic review**

1. Ball, P.A. 2001. Critical care of spinal cord injury. SPINE (Supplement). Vol. 26 No. 24: S27 – S30.
2. Berlly, M. and Shem, K. 2007. Respiratory management during the first five days after spinal cord injury. Spinal Cord Medicine. Vol. 30 No.4: 309–318.
3. Berney, S., Bragge, P., Granger, C., Opdam, H. and Denehy, L. 2011. The acute respiratory management of cervical spinal cord injury in the first 6 weeks after injury: a systematic review. Spinal Cord. Vol. 49 No.1: 17-29.
4. Berney, S.C., Gordon, I.R., Opdam, H.I. and Denehy, L. 2011. A classification and regression tree to assist clinical decision making in airway management for patients with cervical spinal cord injury. Spinal Cord. Vol. 49 No.2: 244–250.
5. Brown, R., DiMarco, A.F., Hoit, J. and Garshick, E. 2006. Respiratory dysfunction and management in SCI. Respiratory Care. Vol. 51 No.8: 853-870.
6. Call, M.S., Kutcher, M.E., Izenberg, R.A., Singh, T. and Cohen, M.J., 2011. Spinal cord injury: outcomes of ventilatory weaning and extubation. The Journal of Trauma, Injury, Infection, and Critical Care. Vol. 71 No.6: 1673-1679.
7. Casha, S. and Christie, S. 2011. A systematic review of intensive cardiopulmonary management after spinal cord injury. Journal of Neurotrauma. Vol. 28 No.8: 1479-1495.
8. Christie, R.J., 2008. Therapeutic positioning of the multi-injured trauma patient in ICU. British Journal of Nursing. Vol.17 No.10: 638 – 642.
9. Como, J.J., Sutton, E.R., McCunn, M., Dutton, R.P., Johnson, S.B., Aarabi, B. and Scalea, T.M. 2005. Characterizing the need for mechanical ventilation following cervical spinal cord injury with neurological deficit. Journal of Trauma. Vol. 59 No.4: 912-916.



## REFERENCE LIST

---

10. Consortium for Spinal Cord Medicine. 2008. Early acute management in adults with spinal cord injury: A clinical practice guideline for health-care professionals. The Journal of Spinal Cord Medicine. Vol. 31 No.4: 403–479.
11. Consortium for Spinal Cord Medicine. 2005. Respiratory management following spinal cord injury: A clinical practice guideline for health-care professionals. The Journal of Spinal Cord Medicine. Vol. 28 No.3: 1-12.
12. Cook, N. 2003. Respiratory care in spinal cord injury with associate traumatic brain injury: bridging the gap in critical care nursing interventions. Intensive and Critical Care Nursing. Vol. 19 No.3: 143-153.
13. Cotton, B.A., Pryor, J.P., Chinwalla, I., Wiebe, D.J., Reilly, P.M. and Schwah, C.W. 2005. Respiratory complications and mortality risks associated with thoracic spine injury. The Journal of TRAUMA. Injury, Infection and Critical Care Vol. 59 No.6: 1400–1409.
14. Denton, M. and McKinlay, J., 2009. Cervical cord injury and critical care. Continuing Education in Anaesthesia, Critical Care and Pain. Vol. 9 No.3: 82-86.
15. EL-Said, A.M. 2011. Critical care of spinal cord injuries. Ain Shams Journal of Anesthesiology. Vol. 4 No.2: 99-111.
16. Fehlings, M.G., Cadotte, D.W. and Fehlings, L.N., 2011. A series of systematic reviews on the treatment of acute spinal cord injury: A foundation for best medical practice. Journal of Neurotrauma. Vol. 28 No.8: 1329-1333.
17. Ganuza, J.R., Forcada, A. G., Gambarrutta, C., De La Lastra Buigues, E.D., Gonzalez, V.E.M., Fuentes, F.P. and Luciani, A.A. 2011. Effect of technique and timing of tracheostomy in patients with acute traumatic spinal cord injury undergoing mechanical ventilation. The Journal of Spinal Cord Medicine. Vol. 34 No.1: 76 – 84.

## REFERENCE LIST

---

18. Gutierrez, C.J., Harrow, J. and Haines, F. 2003. Using an evidence-based protocol to guide rehabilitation and weaning of ventilator dependent cervical spinal cord injury patients. Journal of Rehabilitation Research and Development. Vol. 40 No.5: 99-110.
19. Gutierrez, C.R., Stevens, C., Merritt, J., Pope, C., Tanasescu, M. and Curtiss, G. 2010. The Trendelenburg chest optimization prolongs spontaneous breathing trials in ventilator dependent patients with low cervical spinal cord injury. Journal of Rehabilitation Research and Development. Vol. 47 No.3: 261-272.
20. Hadley, M.N., Walters, B.C., Grabb, P.A., Oyesiku, N.M., Przybylski, G.J., Resnick, D.K., Ryken, T.C. and Mielke, D.C. 2002. Guidelines for the management of acute cervical spine and spinal cord injuries. Clinical Neurosurgery. Vol. 49 No.3: 407 – 498.
21. Hassid, V.J., Schinco, M.A., Tepas, J.J., Griffen, M.M., Murphy, T.L., Frykberg, E.R. and Kerwin, A.J. 2008. Definitive establishment of airway control is critical for optimal outcome in lower cervical spinal cord injury. The Journal of TRAUMA. Injury, Infection and Critical Care. Vol. 65 No.6: 1328–1332.
22. Jia, X., Kowalski, R.G., Sciubba, D.M. and Geocadin, R.G. 2011. Critical care of Traumatic Spinal Cord Injury. The Journal of Intensive Care Medicine. Vol. 000 No.00: 1-12.
23. March, A. 2005. A review of respiratory management in spinal cord injury. Journal of Orthopaedic Nursing. Vol. 9 No.1: 19-26.
24. Markandaya, M., Stein, and M.D, Menaker, J. 2012. Acute treatment options for spinal cord injury. Current Treatment Options in Neurology Vol.14 No.2: 175 - 187.

## REFERENCE LIST

---

25. McLeod, A. 2004. Traumatic injuries to the head and spine 2: nursing considerations. British Journal of Nursing. Vol 13 No.17: 1041-1049.
26. Romero, J., Vari, A., Gambarrutta, C. and Oliveriero, A. 2009. Tracheostomy timing in traumatic spinal cord injury. European Spine Journal. Vol. 18 No.10: 1452-1457.
27. Royster, R.A., Barboi, C. and Peruzzi, W. 2004. Critical care in the acute cervical spinal cord injury. Topics in Spinal Cord Injury Rehabilitation. Vol. 9 No.3: 11-32.
28. Seidl, R.O., Wolf, D., Nusser – Muller – Busch, R. and Niedeggen, A. 2010. Airway management in acute tetraplegics: a retrospective study. European Spine Journal. Vol. 19 No.7: 1073–1078.
29. Sheerin, F. 2005. Spinal Cord Injury: Acute care management. Emergency Nurse. Vol. 12 No.10: 26-34.
30. Stevens, R.D., Bhardwaj, A., Kirsch, J.R. and Mirski, M.A. 2003. Critical care and perioperative management in traumatic spinal cord injury. Journal of Neurosurgical Anesthesiology. Vol. 15 No.3: 215–229.
31. Tollefsen, E. and Fondenes, O. 2012. Respiratory complications associated with spinal cord injury. Tidsskrift Norske Laegeforening. Vol. 9 No.132: 1111-1115.
32. Walker, J. 2009. Spinal cord injuries: acute care management and rehabilitation. Nursing Standard. Vol. 23 No.42: 47-56.
33. Wallbom, A.S., Naran, B., Thomas, E. 2005. Acute ventilator management and weaning in individuals with high tetraplegia. Topics Spinal Cord Injury Rehabilitation. Vol.10 No.3: 1-7.

## REFERENCE LIST

---

34. Winslow, C., Rozovsky, J. 2003. Effect of spinal cord injury on the respiratory system. American Journal of Physical Medicine and Rehabilitation. Vol. 82 No.10: 803-814.
35. Wurmser, L., Ho, C.H., Chiodo, A.E., Priebe, M.M., Kirshblum, S.C., Scelza, W.M., 2007. Spinal Cord Injury Medicine. 2. Acute Care Management of Traumatic and Nontraumatic Injury. Archives Physical Medicine Rehabilitation. (Supplement) .Vol 88 No. 1: S55-S61

**ANNEXURE A: LETTER TO HOSPITAL**



**DEPARTMENT OF NURSING SCIENCE**

2012

Medical Superintendant  
Livingstone Hospital  
Stanford Road  
Korsten  
Port Elizabeth  
6020

Dear Madam/Sir

I am a professional nurse currently employed by the Department of Health and am working in the Intensive Care Unit at Livingstone Hospital. I am currently engaged in a research study related to the respiratory management of the mechanically ventilated spinal cord injured patient in the critical care unit.

I am requesting permission to access the current policies and guidelines in the Critical Care Unit regarding spinal cord injured patients as part of my research. Your permission will be appreciated. Should you have any queries please do not hesitate to contact me or my supervisor, Dr. Portia Jordan.

Yours sincerely

**JANINE LOVE  
RESEARCHER  
0798797003**

**ANNEXURE B: LETTER TO UNIT MANAGER**



**Faculty of Health Sciences  
DEPARTMENT OF NURSING SCIENCE**

2012

Livingstone Hospital  
Stanford Road  
Korsten  
Port Elizabeth  
6020

Dear Mrs Mkoto

I am a registered nurse currently employed by the Department of Health and am working in the Critical Care Unit at Livingstone Hospital. I am currently engaged in a research study regarding the respiratory management of the mechanically ventilated spinal cord injured patient in a critical care unit.

I am requesting permission to access the current policies and guidelines in the Critical Care Unit regarding spinal cord injured patients as part of my research. Your permission will be appreciated. Should you have any queries please do not hesitate to contact me or my supervisor, Dr. Portia Jordan

Yours sincerely

**JANINE LOVE  
RESEARCHER  
0798797003**

### **ANNEXURE C: SYSTEMATIC REVIEW PROTOCOL: RESPIRATORY MANAGEMENT OF THE MECHANICALLY VENTILATED, SPINAL CORD INJURED PATIENT IN A CRITICAL CARE UNIT**

#### **TITLE OF THE REVIEW**

Respiratory management of the mechanically ventilated spinal cord injured patient in a critical care unit.

#### **BACKGROUND**

According to Aarabi *et al.*, (2012:38) respiratory complications are the most common complications following SCIs and add to mortality, morbidity and length of hospital stay amongst these patients. According to Wong *et al.*, (2012:283) respiratory complications including hypoventilation, hypercapnia, reduction in surfactant production, mucous plugging, atelectasis and pneumonia. These can arise within hours to days post-injury, and the consequence of the paralysis of the respiratory muscles places these patients at risk of respiratory failure. Respiratory failure is the leading cause of early death in cervical SCIs and the peak time of death occurs within the first week (Zhu, Jia, Shao and Chen, 2007:2342). Respiratory complications are directly related to the neurological level of injury sustained in the spinal cord, and injuries occurring higher up on the spinal cord are associated with a higher risk of respiratory complications (Harvey, 2008:205). Respiratory failure often results in these patients requiring assistance with ventilation and management in a critical care unit. If the work of breathing becomes laborious and the patient fatigues or deteriorates, intubation and mechanical ventilation are often required regardless of the level of the injury (McQuillan *et al.*, 2009: 590).

Maintaining an open airway, ensuring adequate breathing (ventilation) and oxygenation are essential nursing interventions for all patients including mechanically ventilated SCI ones (Sole *et al.*, 2009:173). The respiratory assessment of the critically ill in the CCU differs to the assessment of patients in general wards due to the presence of artificial airways and mechanical ventilation. The critical care nurse, caring for the mechanically ventilated patient, needs to

incorporate the ventilator and ventilator alarms as part of the respiratory assessment and evaluate the patient's response to mechanical ventilation (Smeltzer *et al.*, 2008:576). Mechanical ventilation is a life-saving intervention but is not without complications. Possible complications include ventilator-associated lung injury, volutrauma, atelectrauma and biotrauma, pneumothorax, ventilator-associated pneumonia, eye-care complications and oral hygiene insufficiency (Estaban *et al.*, 2002:351). Critical care nurses are expected to perform thorough respiratory assessments of their patients, as these will allow the critical care nurse to recognise improvements or deterioration of the patient's condition and respond accordingly (West, 2006:163).

According to Wong *et al.*, (2012:283) specialized respiratory management is necessary when treating the SCI patient to prevent respiratory complications. McQuillan *et al.*, (2009:590) state that pulmonary hygiene is essential to prevent and treat respiratory complications.

Considering the fact that the SCI patient is at risk of respiratory complications related to mechanical ventilation, in addition to the predictable consequence of the SCI, the critical care nurse needs to be aware of how to manage, treat and prevent these complications. It is imperative that the patient receives the best care available and that treatment is in line with the latest and the best evidence.

### REVIEW QUESTION

- The following review question will be posed: "What is the latest, best evidence that should inform the respiratory management of the mechanically ventilated spinal cord injured patient in a critical care unit?"

### SEARCH STRATEGY

The search strategy, designed in order to access all relevant studies, will comprise of three phases, namely:

1. Searching Medline, ScienceDirect, EBSCOhost, Health Source: Nursing/Academic Edition, CINAHL with Full Text, PubMed central and the



Cochrane Library to identify and become familiar with relevant keywords contained in the title, abstract and subject descriptors.

2. Searching all databases using the identified search terms.
3. Searching the reference list and bibliographies of all papers for additional studies.

Search terms can include: “Mechanical ventilation”, “spinal cord injury (SCI)”, “critical care unit (CCU)”, “nursing care”, “respiratory management”, “evidence-based practice”, “evidence-informed clinical guideline”, “respiratory assessment”, “respiratory complications”, “respiratory failure”, “acute respiratory care”, “preventive strategies”, “guidelines”, “pulmonary care”.

### **SELECTION OF STUDIES**

Studies for inclusion in the review were selected according to inclusion and exclusion criteria which will be discussed below.

#### **Inclusion criteria**

The inclusion criteria include the types of studies, types of participants, interventions and outcome measures.

#### **Types of evidence**

The review will consider randomized controlled trials (RCTs). However, in the absence of RCTs, other research designs, such as non-randomized controlled trials, cohort, observational and descriptive studies, best practice information sheets, clinical practice guidelines, expert opinion papers as well as literature papers will be considered for inclusion in the review to enable the identification of the latest best evidence. The hierarchy of evidence, as stated in LoBiondo-Wood and Haber (2010:16), will be used to rank the evidence.

#### **Types of participants**

The review will consider all studies that include human, adult patients, aged 18 and above, who have sustained an injury to the spinal cord and who are mechanically ventilated. Studies need not be contextualized to the critical care unit, and can include other high acuity units such as the emergency care unit, high dependency

unit, spinal units and operating theatre as the patient may initially be intubated and mechanically ventilated.

### **Types of interventions or activities**

Interventions of interest include those related to the respiratory management of mechanically ventilated SCI patients. Specific interventions include frequent respiratory assessment, maintaining an open airway and monitoring the patient's response to mechanical ventilation and tracheostomy care. All patients on mechanical ventilation are at risk of diverse complications but for purposes of this research, only respiratory complications related to the SCI will be focussed on.

### **Types of outcomes measured**

The primary outcome would be the reduction of respiratory complications in the adult, mechanically ventilated, SCI patient. Secondary outcomes include improved respiratory management of these patients, reduction in the duration of mechanical ventilation, duration of stay in the CCU, decreased costs, decreased mortality related to respiratory complications and increased patient safety and better quality of life

### **Language of publications**

Only articles published in English will be considered for inclusion in the systematic review due to the costs involved in translating the articles into English.

### **Time period**

Studies dated from 2000 will be included in the review. However, if due to the paucity of literature, it may be deemed necessary to include older studies, it will be done.

### **Exclusion criteria**

The following will be excluded in the review:

- All animal studies
- All studies in neonatal or paediatric settings.

### **Critical appraisal**

Identified studies that meet the inclusion criteria will be grouped into the different categories as indicated by hierarchy of evidence (LoBiondo–Wood and Haber, 2010:36). These studies will be assessed for validity by two independent reviewers, prior to inclusion in the review. Critical appraisal tools will be developed and/or adapted from the System for Unified Management, Assessment and Review of Information (SUMARI) suite developed by the Joanna Briggs Institute (JBI).

### **DATA EXTRACTION**

Following assessment of their methodological quality, the papers will be grouped according to the study design. The Joanna Briggs Institute data extraction tools will be used to extract data.

### **DATA SYNTHESIS**

For quantitative data, where possible, odd ratio or standardized mean differences and their 95% confidence intervals will be calculated from data generated by each, including randomized control trails. If appropriate to applicable data, results from comparable groups of studies will be pooled into statistical meta–analysis. Heterogeneity between combined studies will be tested using the standard chi–square test. Where statistical pooling is not possible, the findings will be presented in a narrative form.

**ANNEXURE D: LIST OF HAND-SEARCHED JOURNALS**

CHEST
Critical Care Medicine
European Spine Journal
Intensive Care Medicine
JAMA – Journal of American Medical Association
Journal of Advanced Nursing
Journal of Joint and Bone Surgery
Respiratory and Critical care Medicine
The Lancet
The Journal of Trauma (Injury, Infection and Critical Care)
The New England Journal of Medicine

# ANNEXURE E: SEARCH TERMS: RESPIRATORY MANAGEMENT OF THE MECHANICALLY VENTILATED SPINAL CORD INJURED PATIENT IN A CRITICAL CARE UNIT

Database	Search strategy
<b>PubMed Central</b>	<p>#1 mechanically ventilated AND spinal cord injuries AND critical care</p> <p>#2 nursing AND mechanically ventilated spinal cord injured AND evidence-based practice</p> <p>#3 respiratory failure AND spinal cord injured</p> <p>#4 ventilator dependant spinal cord injuries AND critical care</p> <p>#5 suctioning AND spinal cord injuries AND critical care</p> <p>#6 #5 NOT animal NOT paediatric</p> <p>#7 respiratory assessment of spinal cord injury AND critical care</p> <p>#8 VAP AND spinal cord injury</p> <p>#9 acute spinal cord injur* AND respira*</p> <p>#10 airway management AND spinal cord injury AND critical care NOT anesthesia NOT animal</p> <p># 11 respiratory management AND spinal cord injuries AND critical care unit</p>
<b>ScienceDirect</b>	<p># respiratory management AND spinal cord injury</p> <p># mechanical ventilated spinal cord injured AND critical care</p> <p># mechanical ventilation AND spinal cord injuries AND nursing care</p>
<b>CINAHL</b>	<p># spinal cord injuries AND mechanical ventilation AND evidence-based practice</p> <p># spinal cord injury and respiratory management</p> <p># spinal cord injuries OR Spin* injur* AND critical care nurse</p> <p># spinal cord injuries AND critical care AND mechanical ventilation</p> <p># spin* injur* AND critical care AND mechanical ventilation</p> <p># spinal cord injuries AND critical care AND respiratory</p>

	complications # spinal cord injuries AND respiratory complications # spinal cord injuries AND respiratory complications AND mechanical ventilation # spinal cord injuries AND respiratory failure # spinal cord injuries AND acute care and respiratory management
<b>JBI</b>	# spinal cord injuries # mechanical ventilation
<b>Cochrane Library Database of Abstracts and Reviews (DARE)</b>	# nursing care AND mechanically ventilation AND spinal cord injured patients # acute care AND spinal cord injuries # respiratory management AND spinal cord injuries AND acute care # spinal cord injuries AND mechanical ventilation # spinal cord injuries AND respiratory AND evidence-based practice
<b>MEDLINE</b>	# acute spinal cord injuries AND mechanical ventilation # acute spinal cord injuries AND mechanical ventilation AND nursing # spinal cord injury AND acute respiratory management # acute spinal cord injury AND critical care AND evidence-based practice # acute spinal cord injuries and critical care
<b>Biomed Central</b>	# nursing AND acute spinal cord injuries AND critical care

**ANNEXURE F: COPY OF THE AGREE II INSTRUMENT**

<b>Citation Information</b>								
<b>Description of context</b>								
<b>Domain 1: SCOPE AND PURPOSE</b>								
<b>ITEM (1) = strongly disagree (7) = Strongly agree</b>	<b>Comments</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>
1. The overall objective(s) of the guideline is (are) specifically described								
2. The health question(s) covered by the guideline is (are) specifically described								
3. The population (patients, public, etc.) to whom the guideline is meant to apply is specifically described								
<b>Domain 2: Stakeholder Involvement</b>								
<b>ITEM</b>	<b>Comments</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>
4. The guideline development group includes individuals from all the relevant professional groups								
5. The views and preference of the target population (patients, public, etc.) have been sought								
6. The target users of the guideline are clearly defined								

<b>DOMAIN 3. RIGOUR OF DEVELOPMENT</b>								
<b>ITEM</b>	<b>Comments</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>
7. Systematic methods were used to search for evidence								
8. The criteria for selecting the evidence are clearly described								
9. The strengths and limitations of the body of evidence are clearly described								
10. The methods for formulating the recommendations are clearly described								
11. The health benefits, side effects, and risks have been considered in formulating the recommendations								
12. There is an explicit link between the recommendations and the supporting evidence								
13. The guideline has been externally reviewed by experts prior to its publication								
14. A procedure for updating the guideline is provided								
<b>DOMAIN 4 Clarity of presentation</b>								
<b>ITEM</b>	<b>Comments</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>
15. The recommendations are specific and unambiguous								
16. The different options for management of the condition or health issue are clearly presented								
17. Key recommendations are								



easily identifiable								
<b>DOMAIN 5. Applicability</b>								
<b>ITEM</b>	<b>Comments</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>
18. The guideline describes facilitators and barriers to its application								
19. The guideline provides advice and/or tools on how the recommendations can be put into practice								
20. The potential resource implications of applying the recommendations have been considered								
21. The guideline presents monitoring and/or auditing criteria								
<b>DOMAIN 6 Editorial Independence</b>								
<b>ITEM</b>	<b>Comments</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>
22. The views of the funding body have not influenced the content of the guideline								
23. Competing interests of guideline development group members have been recorded and addressed								
<b>OVERALL GUIDELINE ASSESSMENT</b>								
<b>ITEM</b>	<b>Comments</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>
1. Rate the overall quality of this guideline								
2. I would recommend this guideline for use	YES/NO	Reason						

### Overall Appraisal:

Domain 1: Scope and Purpose	/21
Domain 2: Stakeholder Involvement	/21
Domain 3: Rigour of Development	/49
Domain 4: Clarity of Presentation	/21
Domain 5: Applicability	/28
Domain 6: Editorial Independence	/14
Total:	/134

### Comments:

Included

Excluded

- Each domain needs to be calculated separately and not aggregated in a single quality score.
- Domain scores are calculated by summing up all the scores of individual items in the domain and by scaling the total as a percentage of the maximum possible score for that domain.
- EG. Maximum possible score for domain 1 = 7 (strongly agree) x 3 = 21
- Minimum possible score = 1 (strongly disagree) x 3 items = 3
- Obtained score- minimum possible score/ maximum possible score – minimum possible score

# ANNEXURE G: JBI CRITICAL APPRAISAL TOOL FOR EXPERIMENTAL STUDIES (MAStARI)

<b>Citation information</b>			
<b>Type of evidence</b>			
<b>Description of context</b>			
<b>Description methods</b>	<b>Yes</b>	<b>No</b>	<b>Unclear</b>
Was the assignment to treatment groups random?			
Were participants blinded to treatment allocation?			
Was allocation to treatment groups concealed from the allocator?			
Were the outcomes of people who withdrew described and included in the analysis?			
Were those assessing outcomes blind to the treatment allocation?			
Were the control and treatment groups comparable at entry?			
Were control groups treated identically other than for named interventions?			
Were outcomes measured in the same way for all groups?			
Were outcomes measured in a reliable way?			
Was appropriate statistical analysis used?			
<b>Overall appraisal:</b>			
<b>Include</b>	<input type="checkbox"/>	<b>Exclude</b>	<input type="checkbox"/>
		<b>Seek further information</b>	<input type="checkbox"/>
<b>Comments</b>			

**ANNEXURE H: JBI CRITICAL APPRAISAL TOOL FOR COHORT STUDIES  
(MAStARI)**

<b>Citation information</b>			
<b>Description of context</b>			
<b>Description of methods</b>	<b>Yes</b>	<b>No</b>	<b>Unclear</b>
Is the sample representative of patients in the population as a whole?			
Are the patients at a similar point in the course of their condition?			
Was follow-up carried out over a sufficient period of time?			
Were the outcomes of people who withdrew described and included in the meta analysis?			
Were the outcomes measured in reliable way?			
Was the appropriate statistical analysis used?			
<b>Overall appraisal:</b> <b>Include</b> <input type="checkbox"/> <b>Exclude</b> <input type="checkbox"/> <b>Seek further information</b> <input type="checkbox"/>			
<b>Comments</b> <b>Conclusions from the study:</b> <b>Recommendation:</b>			

**ANNEXURE I: JBI CRITICAL APPRAISAL TOOL FOR OBSERVATIONAL STUDIES (MAStARI)**

<b>Citation information</b>			
<b>Description of context</b>			
<b>Description of methods</b>	<b>Yes</b>	<b>No</b>	<b>Unclear</b>
Is the study based on random or pseudo-random sample?			
Are the criteria for inclusion in the sample clearly defined?			
Were outcomes assessed using objective criteria?			
If comparisons are being made was there sufficient description of the groups?			
Was the appropriate statistical analysis used?			
<b>Overall appraisal:</b> Include <input type="checkbox"/> Exclude <input type="checkbox"/> Seek further information <input type="checkbox"/>			
<b>Comments:</b>   			

# ANNEXURE J: JBI CRITICAL APPRAISAL TOOL FOR NARRATIVE, TEXTUAL OR OPINION PAPERS (NOTARI)

<b>Citation Information</b>					
<b>Type of evidence</b>					
<b>Description of context</b>					
<b>Description of methods</b>	<b>Yes</b>	<b>No</b>	<b>Unclear</b>	<b>Not Applicable</b>	<b>Comment</b>
Is the source of opinion clearly identified?					
Does the source of the opinion have standing in the field of expertise?					
Are the interests of patients/clients the central focus of the opinion?					
Is the opinion's basis in logic/ experience clearly argued?					
Is the argument developed analytical?					
Is there reference to the extant literature/evidence and any incongruency with it logically defended?					
Is the opinion supported by peers?					
Overall appraisal:					
Include <input type="checkbox"/>					
Exclude <input type="checkbox"/>					
Reason					
Seek further information					
Comments					

# ANNEXURE K: CRITICAL APPRAISAL TOOL FOR SYSTEMATIC REVIEW (ADAPTED FROM THE JBI APPRAISAL TOOLS)

<b>Citation information</b>			
<b>Description of context</b>			
<b>Description of methods</b>	<b>Yes 2</b>	<b>No 1</b>	<b>Unclear 0</b>
1. Is the specific purpose of the review stated?			
2. Is the review question (s) clearly and explicitly stated?			
3. Were comprehensive methods used to locate studies?			
4. Was a thorough search done of appropriate databases and were other potentially important sources explored?			
5. Was the selection of studies for inclusion into the review clearly stated?			
6. Are the inclusion criteria reported?			
7. Was the validity of included studies assessed?			
8. Was the validity of studies assessed appropriately?			
9. Are the validity criteria reported?			
10. Are the treatments similar enough to combine?			
11. Were the reasons for any differences between individual studies explored?			
12. Were the findings from individual studies combined appropriately?			
13. Are the methods used to combine studies reported?			
14. Are the review methods clearly reported?			
15. Is a summary of findings provided?			
16. Are the specific directives for new research proposed?			
17. Were the conclusions supported by the reported data?			
Overall appraisal: Total score: /34=			
Include <input type="checkbox"/> Exclude <input type="checkbox"/> Seek further information <input type="checkbox"/>			
Comments			

**ANNEXURE L: JBI MASTARI DATA EXTRACTION TOOL**

Review date: \_\_\_\_\_

Author: \_\_\_\_\_

Journal: \_\_\_\_\_

Year: \_\_\_\_\_

**Study method:**

RCT	Quasi- RCT	Cohort	Observational	Retrospective
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Other: \_\_\_\_\_

Method of randomization: \_\_\_\_\_

Allocation of concealment: \_\_\_\_\_

Blinding of outcome: \_\_\_\_\_

**Participants:**

Setting: \_\_\_\_\_

Population: \_\_\_\_\_

Sample Size: \_\_\_\_\_

Time period of study: \_\_\_\_\_

**Interventions:** \_\_\_\_\_**Outcomes:**

Primary: \_\_\_\_\_

Secondary: \_\_\_\_\_

If study excluded state reasons: \_\_\_\_\_

Summary of main results \_\_\_\_\_



**ANNEXURE M: JBI NOTARI DATA EXTRACTION TOOL**

Review date: \_\_\_\_\_

Author: \_\_\_\_\_

Journal: \_\_\_\_\_

Year: \_\_\_\_\_

Study description: \_\_\_\_\_

Type of text: \_\_\_\_\_

Stated: \_\_\_\_\_

Allegiance/position: \_\_\_\_\_

Intervention: \_\_\_\_\_

Setting: \_\_\_\_\_

Geographical: \_\_\_\_\_

Cultural: \_\_\_\_\_

Logic of argument: \_\_\_\_\_

Data Analysis: \_\_\_\_\_

Authors conclusions: \_\_\_\_\_

Comments: \_\_\_\_\_

Findings: \_\_\_\_\_

Illustration from publication: \_\_\_\_\_

Extraction of findings complete: Yes \_\_\_\_\_ No \_\_\_\_\_

**ANNEXURE N: Characteristics of excluded studies for review on the respiratory management of the mechanically ventilated SCI in a CCU**

Characteristics of excluded studies related to Adult SCI patient not relevant or not answering the review question (110)		
No.	Study	Reason for exclusion
Animal Studies (n=3)		
1	Kreyer, S., Putensen, C., Berg, A., Soehle, M., Muders, T., Wrigge, H., Zinserling, J. and Hering, R. 2010. Effects of spontaneous breathing during airway pressure ventilation on cerebral and spinal cord perfusion in experimental acute lung injury. <u>Journal of Neurosurgical Anesthesiology</u> . Vol. 22. No.4: 323 – 329.	Animal study.
2	Lane, M.A., Fuller, D.D., White, T.E. and Reier, P.J. 2008. Respiratory neuroplasticity and cervical spinal cord injury: translational perspectives. <u>Trends in Neurosciences</u> . Vol. 3 No.10: 538–547.	Animal study.
3	Skjodt, N.M., Farran, R.P., Hawes, H.G., Kortbeek, J.B. and Easton, P.A. 2001. Stimulation of acute spinal cord injury: effects on respiration. <u>Respiration Physiology</u> . Vol. 127. No.1: 3 – 11.	Animal study.
Paediatrics (n=1)		
4	Teruel, C. G., de la Maza, T.S.V., Palomeque, R.A. and De pediatria, A. 2006. Pediatric acute spinal cord injury. <u>Anales Pediatria (Barcelona)</u> . Vol.65. No.2: 162 – 165.	Paediatric.

Characteristics of excluded articles not answering the review question (n=106)		
5	Adams, M.G. and Pelter, M.M. 2005. Bedside Monitoring of Spinal Cord Injuries. <u>American Journal of Critical Care</u> . Vol.14. No.1: 85-86.	Not relevant.
6	Agarwal , N.K. and Mathur, N. 2009. Deep vein thrombosis in acute spinal cord injury. <u>Spinal Cord</u> . Vol. 47. No.10: 769–772.	Not answering the review question.
7	Alexander, M.S., Andersone, K., Biering-Sorensen, F., Blight, A.R., Brannon, R., Bryce, T., Creasy, G., Catz, A., Curt, A., Donovan, W., Ditunno, J., Ellaway, P., Finnerup, N.B., Graves, D.E., Haynes, B.A., Heinemann, A.W., Jackson, A.B., Johnston, M., Kalpakjian, C.Z., Kleitman, N., Krassioukov, A., Krogh, K., Lammertse, D., Magasi, S., Mulcahey, M.J., Schurch, B., Sherwood, A., Steeves, J.D., Stiens, S., Tulskey, D.S., van Hedel, H.J.A. and Whiteneck,G. 2009. Outcome measures in Spinal Cord Injury: Recent Assessments and Recommendations for Future Directions. <u>Spinal Cord</u> . Vol. 47. No. 8: 582-591.	Not relevant.
8	Anderson, K., Aito, S., Atkins, M., Biering-Sorensen, F., Charlifue, S., Ditunno, J., Glass, C., Marino, R., Marshal, R., Mulcahey, M.J., Post, M., Savic, G., Scivoletto, G. and Catz, A. 2007. From the 2006 NIDRR SCI Measures Meeting Functional Recovery Measures for Spinal Cord Injury: An Evidence-Based Review for Clinical Practice and Research Report of the national Institute on Disability and Rehabilitation Research Spinal Cord Injury Measures Meeting. <u>Journal of Spinal Cord Medicine</u> . Vol. 31. No. 2: 133-144.	Not relevant.

9	Baid , H. 2006. The process of conducting a physical assessment: a nursing perspective. <u>British Journal of Nursing</u> . Vol.15. No.13:710-714.	Not answering the review question.
10	Banovac, K.. Williams, J.M., Patrick, L.D. and Levi, A. 2004. Prevention of heterotopic ossification after spinal cord injury with COX-2 selective inhibitor (rofecoxib). <u>Spinal Cord</u> . Vol. 42. No.12: 707–710	Not relevant.
11	Beilby, J. and Mulligan, H. 2008. Deep vein thrombosis and heterotopic ossification following spinal cord injury - a clinical perspective for physiotherapists. New Zealand <u>Journal of Physiotherapy</u> . Vol. 36 No.1: 7-14.	Not answering the review question.
12	Berney, S., Stockton, K., Berlowitz, D. and Denehy, L. 2002. Can early extubation and intensive physiotherapy decrease length of stay of acute quadriplegic patients in intensive care? A retrospective case control. <u>Physiotherapy Research International</u> . Vol. 7 No.1: 14 – 22.	Not answering the review question.
13	Bergmann, S.B., Yarkony, G.M. and Stiens, S.A., 1997. Spinal Cord Injury Rehabilitation. 2. Medical Complications. <u>Archives of Physical Medicine and Rehabilitation</u> . Vol. 78 No.3 : S53- S58.	Not answering the review question.
14	Biering, SoRensen, F. and Hansen, B., Lee. BEB. 2009. Non-pharmacological treatment and prevention of bone loss after spinal cord injury: a systematic review. <u>Spinal Cord</u> . Vol.47 No.7: 508–518.	Not relevant.
15	Botel, U., Glaser, E. and Niedeggen, A. The surgical treatment of acute spinal paralysed patients. 1997. <u>Spinal Cord</u> . Vol. 35 No.7: 420-428.	Not relevant.
16	Brown, R. and Macefield, V.G. 2008. Assessing the capacity of the sympathetic nervous system to	Not relevant.

	respond to a cardiovascular challenge in human spinal cord injury. <u>Spinal Cord</u> . Vol. 46 No.10: 666–672.	
17	Burns, S.P., Weaver, F.M., Parada, J.P., Evans, C.T., Hampton, R.Y. and Kapur, V. 2004. Management of community-acquired pneumonia in persons with spinal cord injury. <u>Spinal Cord</u> . Vol. 42 No.8: 450-458.	Not answering the review question.
18	Calder, K.B., Estores, I.M. and Krassioukov, A., 2009. Case Report Autonomic dysreflexia and associated acute neurogenic pulmonary edema in a patient with a spinal cord injury: a case report and review of the literature. <u>Spinal Cord</u> . Vol. 47 No. 5: 423 – 425.	No answering the review question.
19	Chakrabarti, B. and Calverley, P.M.A., Management of Acute Ventilatory Failure. 2006. <u>Postgraduate Medical Journal</u> . Vol. 82 No.962: 438-445.	Not answering the review question.
20	Chang, H.T., Evan, C.T., Weaver, F.M., Burn, S.P. and Parada, J.P. 2005. Etiology and Outcomes of Veterans With Spinal Cord Injury and Disorders Hospitalized With Community-Acquired Pneumonia. <u>Archives of Physical Medicine and Rehabilitation</u> . Vol 86 No.2: 262 – 267	Not relevant.
21	Chen, C, Lin, C., Tzeng, Y. and Hsu, L. 2009. Successful Mechanical Ventilation Weaning Experiences at Respiratory Care Centers. <u>Journal of Nursing Research</u> . Vol 17 No. 2: 93-101	Not relevant.
22	Chen, H.Y. and Boore, J.R.P. 2008. Living with a relative who has a spinal cord injury: a grounded theory approach. <u>Journal of Clinical Nursing</u> , Vol. 18 No.2: 174–182.	Not relevant.
23	Chiang, L.L., Wang, L., Wu, C., Wu, H. and Wu, Y. 2006. Effects of physical training on functional status	Not relevant.

	in patients with prolonged mechanical ventilation. <u>Physical Therapy</u> . Vol 86. No.9: 1271-1281.	
24	Chiodo, A. 2005. Pain management with interventional spine therapy in patients with spinal cord injury: a case series. <u>The Journal of Spinal Cord medicine</u> . Vol. 28 No. 4: 338-342.	Not relevant.
25	Chiodo, A.E., Scelza, W. and Forchheimer, M. 2008. Predictors of ventilator weaning in individuals with high cervical spinal cord injury. <u>Journal Spinal Cord Medicine</u> . Vol. 31 No. 1: 72-77.	Not answering the review question.
26	Claxton, A.R., Wong, D.T., Chung, F. and Fehlings, M.G. 1998. Predictors of hospital mortality and mechanical ventilation in patients with cervical spinal cord injury. <u>Canadian Journal Anaesthesia</u> . Vol.45 No.2: 144-149.	Not relevant. Excluded as too old.
27	Colvin, M.P., Healy, M.T. and Samra, G.S., 1998. Early management of the severely injured patient. <u>Journal of the Royal Society of Medicine</u> . Vol. 91. No.1: 26-29.	Not relevant to the review question.
28	Crew, J.D., Svircev, J.N. and Burns, S.P. 2010. Mechanical Insufflation-Exsufflation Device Prescription for outpatients with tetraplegia. <u>The Journal of Spinal Cord Medicine</u> . Vol. 33 No.2: 128-134.	Not answering the review question.
29	Crowe, J., Geddes, E.L., Brooks, D. and Reid, W.D., 2006. Inspiratory muscle training for individuals with cervical spinal cord injury or chronic obstructive pulmonary disease: a survey of Canadian physical therapists. <u>Physiotherapy Canada</u> . Vol.58 No.4: 271 – 279.	Not answering the review question.
30	Davies, D.S. and McColl., M.A. 2002. Lifestyle risks for three disease outcomes in spinal cord injury.	Not relevant.

	<u>Clinical Rehabilitation</u> . Vol. 16 No.1: 96-108.	
31	Davis, K. Jr., Johannigman, J.A., Campbell, R.S., Marraccini, A., Luchette, F.A., Frame, S.B. and Branson, R.D. 2001. The acute effects of body position strategies and respiratory therapy in paralysed patients with acute lung injury. <u>Critical Care</u> . Vol. 5 No.2: 81-87.	Not relevant.
32	DeVivo, M., Biering-Sorensen F., S Charlifue, S., Noonan, V., Post, M., Stripling, T. and Wing, P. 2006. International spinal cord injury core data set. <u>Spinal Cord</u> . Vol. 44 No.9: 535–540.	Not answering the review question.
33	DeVivo, M.J, and Chen Y. 2011. Trends in new injuries, prevalent cases, and aging with spinal cord injury. <u>Archives of Physical Medicine and Rehabilitation</u> Vol.92 No.3: 332-338.	Not answering the review question.
34	DiMarco, A.F., Kowalski, K.E., Geertman, R.T., Hromyak, D.R., Creasey, G.H. and Nemunaitis, G.A. 2009. Lower thoracic spinal cord stimulation to restore cough in patients with spinal cord injury: results of a national institutes of health-sponsored clinical trial. Part II: Clinical outcomes. <u>Archives of Physical Medicine and Rehabilitation</u> Vol. 90 No.5: 726-732.	Non relevant.
35	DiMarco, A.F. 2001. Neural prostheses in the respiratory system. <u>Journal of Rehabilitation Research and development</u> . Vol. 38 No. 6: 601 – 607.	Not relevant.
36	DiMarco, A.F., 2005. Restoration of respiratory muscle function following spinal cord injury review of electrical and magnetic stimulation techniques. <u>Respiratory Physiology and Neurobiology</u> . Vol. 147 No. 2-3: 273-287.	Not focussed on the review question.

37	DiMarco, A.F., Kowalski, K.E., Geertman, R.T., Hromyak, D.R., Frost, F.S., Creasey, G.H. and Nemunaitis, G.A. 2009. Lower thoracic spinal cord stimulation to restore cough in patients with spinal cord injury: results of a national institutes of health-sponsored clinical trial. Part II: clinical outcomes. <u>Archives Physical Medicine Rehabilitation</u> . Vol. 90 No.5: 726 – 732.	Not relevant.
38	DiMarco, A.F., Kowalski, K.E., Geertman, R.T. and Hromyak, D.R. 2006. Spinal cord stimulation a new method to produce effective cough in patients with spinal cord injury. <u>American Journal of Respiratory and Critical Care Medicine</u> . Vol. 173 No.12: 1386-1389.	Not answering the review question.
39	DiMarco, A.F., Onders, R.P., Kowalski, K.E., Miller, M.E., Ferek, S. and Mortimer, J.T., 2002. Phrenic nerve pacing in a tetraplegic patient via intramuscular diaphragm electrodes. <u>American Journal of Respiratory and Critical Care Medicine</u> . Vol. 166 No.12: 1604-1606.	Not answering the review question.
40	Divanoglou, A., Seiger, A. and Levi, R. 2010. Acute management of traumatic spinal cord injury in a Greek and a Swedish region: a prospective, population-based study. <u>Spinal Cord</u> . Vol. 48 No.6: 477- 482.	Not answering the review question.
41	Evans, S.E. and Scanlon, P.D., 2003. Current Practice in Pulmonary Function Testing. <u>Mayo Clinical Proceedings</u> . Vol 78 No.8: 758-763	Not relevant.
42	Franga, D.L., Hawkings, M.L., Medeiros, R.S. and Adewumi, D. 2006. Recurrent Asystole resulting from High Cervical Spinal Cord Injuries. <u>The American Surgeon</u> . Vol. 72 No.6: 525-529.	Not relevant.



43	Furlan, J.C., Singh, J., Hsieh, J. and Fehlings, M.G. 2011. Methodology of systematic reviews and recommendations. <u>Journal of Neurotrauma</u> . Vol. 28 No.8: 1335- 1339.	Not relevant. Discusses evidence transfer.
44	Garshick, E., Kelley, A., Cohen, S.A., Garrison, A., Tun, C.G., Gagnon, D. and Brown, R. 2005. A prospective assessment of mortality in chronic spinal cord injury. <u>Spinal Cord</u> . Vol. 43 No.7: 408-416.	Not relevant.
45	Gelis, A., Dupeyron, A., Legros, P., Benaim, C., Pelissier, J. and Fattal, C. 2009. Pressure ulcer risk factors in persons with SCI: part I: acute and rehabilitation stages. <u>Spinal Cord</u> Vol. 47 No.2: 99–107.	Not relevant.
46	Giaquinto, S. Haim Ring. 2007. Return to work in selected disabilities. <u>Disability and Rehabilitation</u> . Vol. 29 No.17: 1313 – 1316.	Not relevant.
47	Gill, M. 1999. Psychosocial Implications of Spinal Cord Injury. <u>Critical Care Nursing Quarterly</u> Vol. 22 No.2: 1–7.	Not relevant.
48	Grap, M.J. 2009. Not-so-trivial pursuit: mechanical ventilation risk reduction. <u>American Journal of Critical Care</u> .Vol.18 No.4:299-309.	Not relevant.
49	Griffiths, H. and Gallimore, D. 2005. Positioning critically ill patients in hospital. <u>Nursing Standard</u> . Vol.19 No.43 : 56- 64.	Not relevant.
50	Grimmer, K., Keller, S., Kumar, S. and Torvund, T. 2004. Effectiveness of physiotherapy interventions in posttraumatic neck disorders (Whiplash). A systematic review protocol. Centre for Allied Health Evidence. University of South Australia, Adelaide.	Not relevant.
51	Harness, E.T., Yozbatiran, N. and Cramer, S.C. 2008. Effects of intense exercise in chronic spinal cord	Not relevant.

	injury <u>Spinal Cord</u> . Vol. 46 No.11: 733–737.	
52	Higginson, R., Jones, B. and Davies, K. 2010. Airway Management for nurses: emergency assessment and care. <u>British Journal of Nursing</u> . Vol.19 No.16: 1006-1014.	Not relevant.
53	Hirschfeld, S., Exner, G., Luukkaala, T. and Baer, G.A. 2008. Mechanical ventilation or phrenic nerve stimulation for the treatment of spinal cord injury-induced respiratory insufficiency. <u>Spinal Cord</u> . Vol. 46 No.11: 738- 742.	Not relevant.
54	Jones, M.L., Marini, I. and Slate, J.R. 2005. Prevention Practice Differences Among Persons With Spinal Cord Injuries Who Rarely Versus Frequently Sustain Pressure Ulcers. <u>Rehabilitation Counselling Bulletin</u> Vol. 48 No.3: 139–145.	Not relevant.
55	Kalpajian, C.Z. and Scelza, W.M., Forchheimer, M.B., Toussaint, L.L. 2007. Preliminary reliability and validity of a spinal cord injury secondary conditions scale. <u>Journal Of Spinal Cord Medicine</u> . Vol. 30 No.2: 131-139.	Not answering the review question.
56	Kanno, N., Nakamura, T., Yamanaka, M., Kouda, K., Nakamura, T. and Tajima, F. 2009. Low-echoic lesions underneath the skin in subjects with spinal-cord Injury. <u>Spinal Cord</u> . Vol.47 No.3: 225–229.	Not relevant.
57	Karadag, O., Gurelik, M., Berkan, O. and Kars, H.Z. 2004. Stab wound of the cervical spinal cord and ipsilateral vertebral artery injury. <u>British Journal of Neurosurgery</u> . Vol. 18 No.5: 545-547.	Not relevant.
58	Kelleher, S. and Andrews, T., 2008. An observational study on the open-system endotracheal suctioning practices of critical care nurses. <u>Journal of Clinical Nursing</u> . Vol. 17 No.3: 360 – 369.	Not relevant to research question.

59	Krause, J. S. Reed, K.S. and McArdle, J.J. 2010. Structural Analysis of Health Outcomes After Spinal Cord Injury. <u>The Journal of Spinal Cord Medicine</u> Vol. 33 No.1: 22-32.	Not relevant.
60	Krogh, K., Perkash, I., Stiens, S.A. and Biering-Sorensen, F. 2009. International bowel function basic spinal cord injury data set. <u>Spinal Cord</u> . Vol. 47 No.3: 230-234.	Not relevant. .
61	Kroll, T., Groah, S., Gilmore, B., and M. Neri, M. 2008. Consumer-directed teaching of health care professionals involved in the care of people With spinal cord injury: the consumer– professional partnership program. <u>The Journal of Continuing Education in Nursing</u> . Vol 39. No.5:228-234.	Not relevant.
62	Le Pimpec-Barthes, F., Gonzalez- Bermejo, J., Hubschm J.P., Duguet, A., Morelot-Panzini, C., Riquet, M. and Similoski, I. 2011. Intrathoracic phrenic pacing: a 10-year experience in France. <u>Journal Thoracic Cardiovascular Surgery</u> . Vol. 142 No.2: 378-383.	No relevant.
63	Lin, C.Y., Wright, J., Bushnik, T., Shem, T. and Shem, K., 2011. Traumatic spinal cord injuries in horseback riding: a 35–year review. <u>The American Journal of Sports Medicine</u> . Vol.39 No.11: 2441- 2446.	Not relevant.
64	MacBean, N., Ward, E., Murdoch, B., Cahill, L., Solley, M., Geraghty, T. and Hukins, C. 2009. Optimizing speech production in the ventilator-assisted individual following cervical spinal cord injury: a preliminary investigation. <u>International Journal of language and communication Disorders</u> . Vol. 44 No.3: 382-393.	Not relevant.

65	Markou, N.K., Myrianthefts, P.M. and Baltopoulos, G.J.2004. Respiratory failure an overview. <u>Critical Care Nurse Quarterly</u> . Vol. 27 No.4: 353-379.	Not relevant.
66	Maruyama, Y., Hosoya, T., Mizuguchi, M., Yaginuma, T., Kusaka, M., Yoshida, H.,Yokoyama, K. and Kasahara, Y. 2008. Serum leptin, abdominal obesity and the metabolic syndrome in individuals with chronic spinal cord injury. <u>Spinal Cord</u> . Vol. 46 No.7: 494–499.	Not relevant
67	McBride, D.Q. and Rodts, G.E. 1994. Intensive care of patients with spinal trauma. <u>Neurosurgery Clinics of North America</u> . Vol. 5 No.4: 755 – 766.	Not answering the review question.
68	McGloin, S. 2008. Administration of oxygen therapy. <u>Nursing Standard</u> . Vol. 22 No.21: 46-48.	Not relevant.
69	McKinley, W., McNamee, S., Meade, M. Kandra, K. and Abdul. N. 2006. Incidence, etiology, and risk factors for fever following acute spinal cord injury. <u>Journal of Spinal Cord Medicine</u> . Vol. 29 No.5: 501–506.	Not answering the review question.
70	Mitcho, K. and Yanko, J.R., 1999. Acute care management of spinal cord injuries. <u>Critical Care Nurse Quarterly</u> . Vol. 22 No.2: 60-79.	Not answering the review question.
71	Mueller, G., Perret, C. and Spengler, C.M., 2006. Optimal intensity for respiratory muscle endurance training in patients with spinal cord injury. <u>Journal of Rehabilitation Medicine</u> . Vol. 38 No.6: 381-386.	Not answering the review question.
72	Mulcahey, M.J., Hutchinson, D. and Kozin, S. 2007. Assessment of upper limb in tetraplegia: Considerations in evaluation and outcomes research. <u>Journal of Rehabilitation Research and Development</u> . Vol. 44 No.1: 91 – 102.	Not relevant.

73	Murphy, M. 1999. Traumatic spinal cord injury: an acute care rehabilitation perspective. <u>Critical Care Nurse Quarterly</u> . Vol. 22 No.2: 51-59.	Not answering the review question.
74	Natale, A., Taylor, S., laBarbera, J., Bensimon, L., McDowell, S., Mumma, S.I., Backus, D., Zanca, j.M. and Gassaway, J. 2009. SCIRehab project series: the physical therapy taxonomy. <u>The Journal of Spinal Cord Medicine</u> . Vol. 32 No.3: 270 – 282.	Not relevant.
75	Nolan, S. 1994. Current trends in the management of acute spinal cord injury. <u>Critical Care Nurse Quarterly</u> . Vol. 17 No.1: 64 – 78.	Not answering the review question.
76	Nygren-Bonnier, M., Normi, L., Klefbeck, B. and Biguet, G. 2011. Experiences of decreased lung function in people with cervical spinal cord injury. <u>Disability and Rehabilitation</u> . Vol.33 No.6: 530-536.	Not answering the review question.
77	Onders, R.P., Khansarinia, S., Weiser, T., Chin, C., Hungness, E., Soper, N., DeHoyos, A., Cole, T. and Ducko, C. 2010. Multicentre analysis of diaphragm pacing in tetraplegics with cardiac pacemakers: positive implications for ventilator weaning in intensive care units. <u>Surgery</u> . Vol. 148 No.4: 893 – 898.	Not answering the review question.
78	Orakzai, S.H., Orakzai, R.H., Budoff, M.J., Ahmadi, H., Agrawal, N., Bauman, W.A., Yee, F., Adkins, R.H. and Waters, R.L. 2007. Measurement of coronary artery calcification by electron beam computerized tomography in persons with chronic spinal cord injury: evidence for increased atherosclerotic burden. <u>Spinal Cord</u> . Vol.45 No.12: 775–777.	Not answering the review question.
79	Parent, S., Barchi, S., LeBreton, M., Casha, S. and Fehlings, M.G. 2009. The impact of specialized centres of care for spinal cord injury on length of stay, complications, and mortality: A systematic review of	Not answering the review question.

	the literature. <u>Journal of Neurotrauma</u> . Vol. 28 No.8. 1363 – 1370.	
80	Parizel, P.M., Zijden, T.V.D., Gaudino, S., Spaepen, M., Voormolen, H.J., Venstermans, C., Belder, F.D., Hauwe, L.V.D. and Van Groethem, J. Trauma of the spine and spinal cord: imaging strategies. <u>European Spinal Journal</u> . (Supplement) Vol. 19 No. 1: 8-17.	Not relevant.
81	Pickelsimer, E., Shiroma, E.J. and Wilson, D.A. 2010. Statewide investigation of medically attended adverse health conditions of persons with spinal cord injury. <u>Journal Spinal Cord Medicine</u> . Vol. 33 No.3: 221-231.	Not answering the review question.
82	Ploumis, A., Ponnappan, R.K., Maltenfort, M.G, Patel, R.X., Bessey, J.T., Albert, T.J., Harrop, J.S. Fisher, C.G., Bono, C.M. and Vaccaro, A.R. 2009. Thromboprophylaxis in patients with acute spinal injuries: an evidence-based analysis. <u>The Journal of Bone and Joint Surgery</u> Vol. 91A No.11: 2568-2576.	Not answering the review question.
83	Ponte, J.1990. Assisted ventilation. 2. Indications for mechanical ventilation. <u>Thorax</u> Vol.45 No.11: 885-890.	Not relevant.
84	Powe, C.B. 2006. Cervical spine clearance in the blunt trauma patient: a review of current management strategies. <u>Journal of Trauma Nursing</u> . Vol. 13 No.2: 80-84.	Not relevant.
85	Rinehart, M.E. 1990. Early mobilization in acute spinal cord injury. 1990. A collaborative approach. <u>Critical Care Nursing Clinics of North America</u> . Vol. 2 No. 3: 399 – 405.	Not answering the review question. Article too old.
86	Saladin, L.K. and Krause, J.S. 2009. Pressure ulcer prevalence and barriers to treatment after spinal cord injury: comparisons of four groups based on race-	Not relevant.

	ethnicity <u>NeuroRehabilitation</u> . Vol.24 No.1: 57–66.	
87	Scherr, K., Urquhart, G., Eichorst, C. and Bulbuc, C. 2006. Paraplegia after coronary artery bypass graft surgery: case report of a rare event. <u>Critical Care Nurse</u> Vol. 26 No.5: 34-45.	Not relevant.
88	Shavelle, R.M., DeVivo, M.J., Strauss, D.J., Paculdo, D.R. and Lammertse, D.P. 2006. Long-term survival of persons ventilator dependent after spinal cord injury. <u>Journal of Spinal Cord Medicine</u> . Vol.29 No.5: 511-519.	Not relevant.
89	Sheel, W.A., Reid, D.W., Townson, A.F. and Ayas, N. 2010. Respiratory management. <u>Spinal Cord Injury Rehabilitation Evidence</u> . Volume 3.0: 1-46.	Not answering the review question.
90	Shilero, G.J., Spungen, A.M., Bauman, W.A., Radulovic, M. and Lesser, M., 2009. Pulmonary function and spinal cord injury. <u>Respiratory Physiology and Neurobiology</u> . Vol.166 No.3: 129-141.	Not answering the review question.
91	Shin, S.H., Heath, K., Reed, S., Collins, J., Weireter, I. J. and Britt, L.D. 2008. The Cuff Leak Test Is Not Predictive of Successful Extubation. <u>The American Surgeon</u> . Vol.74 No.12: 1182 – 1185.	Not relevant.
92	Sole, M.L., Byers, J.F., Ludy, J.E., Zhang, Y., Banta, C.M. and Brummel, K. 2003. A multisite survey of suctioning techniques and airway management practices. <u>American Journal of Critical Care</u> . Vol.12 No.3: 220-232.	Not relevant.
93	Story, D., Mariampillai, E., Nikfarjam, M., Howard, M., Nunn, A. and Onders, R. 2010. Anaesthetic aspects of implanting diaphragmatic pacing in patients with spinal cord injury. <u>Anaesthesia and Intensive Care</u> . Vol .38 No.4: 740 – 743.	Not answering the review question.

94	Tan, A.M., Zhao, P., Stephen G. Waxman, S.G. and Hains, B.C. 2009. Early microglial inhibition pre-emptively mitigates chronic pain development after experimental spinal cord injury. <u>Journal of Rehabilitation Research &amp; Development</u> . Vol. 46 No.1: 123–134.	Not relevant.
95	Tauqir, S.F., Mirza, S., Gul, S., Ghaffar, H. and Zafar, A., 2007. Complications in patients with spinal cord injuries sustained in an earthquake in northern Pakistan. <u>Journal of Spinal Cord Medicine</u> . Vol. 30 No.4: 373-377.	Not answering the review question.
96	Tchvaloon, E., Front, L., Gelernter, I., Ronen, J., Bluvstein, V. and Catz, A. 2008. Survival, neurological recovery and morbidity after spinal cord injuries following road accidents in Israel. <u>Spinal Cord</u> . Vol. 46 (2): 145 – 149.	Not relevant.
97	Theron, A. and Ford, P. Management of acute cervical spine injury. Update in anesthesia. <a href="http://www.worldanesthesia.org">www.worldanesthesia.org</a>	Not relevant. Not contextualised
98	Thomas, A.J. 2009. Exercise intervention in the critical care unit – what is the evidence? <u>Physical Therapy Reviews</u> . Vol. 14 No.1: 50-59.	Not answering the review question.
99	Toki, A., Tamura, R. and Sumida, M. 2008. Long-term ventilation for high level tetraplegia: a report of 2 cases of non-invasive positive pressure ventilation. <u>Archives of Physical Medicine Rehabilitation</u> . Vol.89 No. 4: 779-783	Not relevant.
100	Tran, K., Hukins, C., Geraghty, T., Eckert, B. and Fraser, L. 2010. Sleep-disordered breathing in spinal cord-injured patients : a short-term longitudinal study. <u>Respirology</u> . Vol.15 No.15: 272–276.	Not answering the review question.
101	Tromans, A.M., Mecci, M., Barrett, F.H., Ward, T.A.	Not answering the



	and Grundy, D.J. The use of BiPAP biphasic positive airway pressure system in acute spinal cord injury. <u>Spinal Cord</u> . Vol. 36 No.7: 481- 484.	review question.
102	Tully, K., Koke, K., Garshick, E., Lieberman, S.L., Tun, C.G. and Brown, R. 1997. Maximal expiratory pressures in spinal cord injury using two mouthpieces. <u>Chest</u> . Vol. 112 No.1: 113 – 116.	Not answering the review question.
103	Wadsworth, B.M., Haines, T.P., Cornwell, P.L. and Paratz, J.D. 2009. Abdominal binder use in people with spinal cord injuries: a systematic review and meta-analysis. <u>Spinal Cord</u> . Vol. 47 No.4: 274-285.	Not answering the review question.
104	Walter, J.S., Sacks, J., Othman, R., Rankin, A.Z., Nemchausky, B., Chintam, R. and Wheeler, J.S. 2002. A database of self-reported secondary medical problems among VA spinal cord injury patients: Its role in clinical care and management. <u>Journal of Rehabilitation Research and Development</u> . Vol. 39 No.1: 53-61.	Not answering the review question.
105	Watt, J.W.H., Wiredu, E., Silva, P. and Meechan, S. 2011. Survival after short - or long – term ventilation after spinal cord injury: a single-centre 25 – year retrospective study. <u>Spinal Cord</u> . Vol.48 No.3: 404-410.	Not answering the review question.
106	Wijkstra, P.J., Avendano, M.A. and Goldstein, R.S. 2003. Inpatient chronic assisted ventilatory care*: a 15-year experience. <u>CHEST</u> Vol. 124 No.3: 850-856.	Not answering the review question.
107	Wolf, C. and Meiners, T.H., 2003. Dysphagia in patients with acute cervical spinal cord injury. <u>Spinal Cord</u> . Vol. 41 No.6: 347-353.	Not answering the review question.
108	Yang, J.C. 2005. Prevention and treatment of deep vein thrombosis and pulmonary embolism in critically ill patients. <u>Critical Care Nursing Quarterly</u> . Vol. 28	Not answering the review question.

	No.1: 72-79.	
109	Yeziarski, R.P. 2009. Spinal cord injury pain: spinal and supraspinal mechanisms. <u>Journal of Rehabilitation Research &amp; Development</u> . Vol. 46 No.1: 95–108.	Not relevant.
110	Zanca, J.M., Natale, A., Labarbera, J., Schroeder, S.T., Gassaway, J. and Backus, D. 2011. Group physical therapy during inpatient rehabilitation for acute spinal cord injury: findings from SCIRehab Study. <u>Physical Therapy</u> . Vol. 91 No.12: 1877-1891.	Not relevant.

Characteristics of excluded abstracts related to Adult SCI patient not relevant or not answering the review question (9)+(2) that provided insufficient data. Total: (n=11)

111	Dietrich, W.D. 2000. Current state of neural cell transplantation after spinal cord injury. <u>European Journal of Anesthesiology</u> . (Supplement) Vol. 17 No.39. [Abstract 22]	Not relevant.
112	Guihan, M., Bosshart, H.T. and Nelson, A. 2004. Lessons learned in implementing SCI clinical practice guidelines. <u>SCI Nursing: a publication of the American Association of Spinal Cord Injury Nurses</u> . Vol. 21 No.3: 136 – 142. [Abstract]	Not answering the review question.
113	Jones, L. and Bagnall, A.M. 2008. Spinal injuries centres (SICs) for the acute traumatic spinal cord injury. Cochrane Library. [Abstract] DOI:10.1002/14651858.CD004442.pub2	Not relevant.
114	Kemler, M.A. and Van Kleef, 2000. Principles of spinal cord stimulation. <u>European Journal of Anesthesiology</u> . (Suppl. 17) Vol. 17 No. 41 [Abstract 23]	Not relevant.
115	Lam, A.M. 2000. Protection of the spinal cord in the ICU. <u>European Journal of Anesthesiology</u> . (Suppl. 17)	Not relevant.

	Vol. 17 No.37 [Abstract 20]	
116	Lizner, K. and Feinberg, M. 2006. Cough assist strategy for pulmonary toileting in ventilator-dependent spinal cord injured patients. <u>Rehabilitation Nurse</u> . Vol. 31 No.5: 218-221. [Abstract]	Not relevant.
117	Monstrey, J., Early surgical management after spinal cord injury. <u>European Journal of Anesthesiology</u> . Vol. 17 (Suppl. 17): 38. [Abstract 21]	Not relevant.
118	McIlvoy, L., Meyer, K. and Vitaz, T. 2000. Use of an acute spinal cord injury clinical pathway. <u>Critical Care Nursing Clinics North America</u> . Vol. 12 No.4: 521-530. [Abstract]	Not answering the review question.
119	Tirone, K., Parenteau, K. and Rozenboom, N. 2008. The rehab starts here: rehabilitation of the high cervical spinal cord injury begins in the ICU. <u>Critical Care Nurse</u> . Vol. 28 No.2: 16 CS177.	Not relevant.
Abstracts that provided insufficient data (2)		
120	Cortez, R. and Levi, A.D., 2007. Acute spinal cord injury. <u>Current Treatment Options Neurology</u> . Vol. 9 No. 2: 115-125 [Abstract]	Excluded as insufficient data to make conclusions.
121	Ritchie, L. 2012. Spinal Cord Injury: Managing the first 72 hours. Dynamics of critical care. <u>Canadian Association of Critical Care Nurses</u> . Vol. 23 No. 2:34 [Abstract]	Excluded as insufficient data to make conclusions.
Article not able to be accessed via interlibrary loan (n=1)		
122	McCorry, D.C. and Samsa, G.P. 2001. Treatment of pulmonary disease following cervical spinal cord injury. Evidence Reports/Technology Assessments, Vol. 27. No. 1-4 Agency for Healthcare Research and Quality (US).	Unable to obtain the systematic review via interlibrary loans.
PAPERS EXCLUDED AFTER CRITICAL APPRAISAL (28)		

1	Aito, S. on behalf of the 'Gruppo Italiano Studio Epidemiologico Mielolesioni' GISEm group. 2003. Complications during the acute phase of traumatic spinal cord lesions. <u>Spinal Cord</u> . Vol. 41 No.11: 629-635.	Not focussed on review question, no mention of MV or nursing management
2	Barker, E. and Saulino, M., 2002. First-ever guidelines for spinal cord injuries. <u>Registered Nurse</u> . Vol. 65 No.10: 32-37.	Excluded as no reference or mention made of mechanical ventilation or respiratory management.
3	Beatie, I.K. and Choi, J. 2006. Acute spinal injuries: assessment and management. <u>EBMEDICINE. NET</u> . Vol.8 No.5: 1-28	Focussed on airway management in the emergency room.
4	Brooks, D., O'Brien, K., Geddes, E.L. and Crouwe, J. 2005. Is inspiratory muscle training effective for individuals with cervical spinal cord injury? A qualitative systematic review. <u>Clinical Rehabilitation</u> . Vol. 19 No.3: 237 – 246.	Not answering the research question. Discusses inspiratory muscle training.
5	Castriotta, R.J. and Murthy, J.N. 2009. Hypoventilation after spinal cord injury. <u>Seminars in Respiratory and Critical Care Medicine</u> . Vol.30 No.3: 330 – 338.	Not contextualised to the high acuity unit and no mention of the nursing management.
6	Clough, P., Lindenauer, D., Hayes, M. and Zekany, B. 1986. Guidelines for routine respiratory care of patients with spinal cord injury: a clinical report. <u>Physical Therapy</u> . Vol. 66 No.9:1395 – 1402.	Although outdated was assessed for relevance but was found not to support the review question with the latest evidence.
7	Considine, J. 2005. The role of nurses in preventing adverse events related to respiratory dysfunction:	Article does not mention the SCI

	literature review. <u>Journal of Advanced Nursing</u> . Vol. 49 No.6: 624 – 633.	patient specifically.
8	Delp, S.M., Ruth-Sahd, L.A., 2005. The disease process of spinal cord injuries. A case study reflecting holistic nursing management. <u>Dimensions Critical Care Nurse</u> . Vol. 24 No.2: 57-63.	Excluded as does not answer the research question. No real conclusions could be made.
9	Docherty, B. 2002. Cardiorespiratory physical assessment for the acutely ill: 1. <u>British Journal of Nursing</u> . Vol. 11 No.11: 750 – 758.	Not relevant to the SCI or mechanical ventilation. Focussed on ward nurses, not CCU.
10	Docherty, B. 2002. Cardiorespiratory physical assessment for the acutely ill: 2. <u>British Journal of Nursing</u> . Vol. 11 No.12: 800 – 807.	Not focussed on the review question. The article is focussed on respiratory and cardiac assessment of patients in a general ward. Not specific to critical care or the SCI patient.
11	Duff, B., Gardiner, G. and Barnes, M. 2007. The impact of surgical ward nurses practising respiratory assessment on positive patient outcomes. <u>Australian Journal of Advanced Nursing</u> . Vol. 24 No.4: 52-56.	Not focussed on the mechanically ventilated SCI patient.
12	Fries, J.M., 2005. Critical rehabilitation of the patient With spinal cord injury. <u>Critical Care Nurse Quarterly</u> . Vol. 28 No.2: 179 – 187.	Not focussed on the respiratory management of the mechanically ventilated SCI patient.
13	Gall, A. and Turner-Stokes, L. Guideline Development Group. 2008. Chronic spinal cord injury: management	Excluded as no mention of

	of patients in acute hospital settings. <u>Clinical Medicine</u> . Vol.8 No.1: 70-74.	mechanical ventilation strategies.
14	Goldhill, D.R., Imhoff, M., McLean, B. and Waldmann, C. 2007. Rotational bed therapy to prevent and treat respiratory complications: a review and meta-analysis. <u>American Journal Of Critical Care</u> . Vol. 16 No.1: 50 – 61.	Not specific to the SCI. Concludes that rotational therapy may be useful for preventing and treating respiratory complications.
15	Hunter, J. and Rawlings-Anderson, K. 2008. Respiratory Assessment. <u>Nursing Standard</u> . Vol. 22 No.41: 41-43.	Not specific to critical care or SCIs.
16	Jackson, A.B., Groomes, T.E. 1994. Incidence of respiratory complications following spinal cord injury. <u>Archives of Physical Medicine and Rehabilitation</u> . Vol. 75 No.3: 270- 275.	Most articles discuss this article as a primary source so was considered for inclusion but was excluded as too old and, therefore, does not provide the latest research evidence.
17	Laffont, I., Bensmail, D., Lorat-Jacob, S., Falaize, I., Hutin, C. and le Bomin, E. 2008. Intermittent positive-pressure breathing effects in patients with high spinal cord injury. <u>Archives Physical Medicine Rehabilitation</u> . Vol. 89 No.8: 1575-1579.	Excluded as focussed on rehabilitation. Patients in wheelchairs. Not specific to the CCU.
18	McMichan, J.C., Michel, L. and Westbrook, P.R., 1980. Pulmonary dysfunction following traumatic quadriplegia. <u>Journal of American Medical Association</u> . Vol. 243 No.6: 528 – 531.	Most articles discuss this article as a primary source so was considered for inclusion but was excluded as too old

		and, therefore, does not provide the latest research evidence.
19	Peterson, W.P., Barbalata, L., Brooks, C.A., Gerhart, K.A., Mellick, D.C. and Whiteneck, G.G. 1999. The effect of tidal volumes on the time to wean persons with high tetraplegia from ventilators. <u>Spinal Cord</u> . Vol. 37 No.4: 284-288.	Most articles discuss this article as a primary source so was considered for inclusion but was excluded as too old and, therefore, does not provide the latest research evidence.
20	Pillastrini, P., Bordini, S., Bazzocchi, G., Belloni, G. and Menarini, M. 2006. Study of the effectiveness of bronchial clearance in subjects with upper spinal cord injuries: examination of a rehabilitation programme involving mechanical insufflation and exsufflation. <u>Spinal Cord</u> . Vol.44 No.10: 614 – 616.	Excluded as focussed on rehabilitation using mechanical insufflation and exsufflation.
21	Simpson, H. 2006. Respiratory assessment. <u>British Journal of Nursing</u> . Vol. 15 No. 9: 484 - 488.	Article does not answer the review question. Not specific to the SCO or CCU.
22	Teasell, R.W., Hsieh,T.J., Aubut, J.J.Eng., Krassioukov, A. and Tu, L and the SCIRE Research Team. 2009. Venous thromboembolism following spinal cord injury. <u>Archives of Physical Medicine Rehabilitation</u> . Vol. 90 No.2: 232-245.	Excluded as not contextualised to the CCU. Mainly focussed on the medical management of venous thromboembolism.

23	Van Houtte, S., Vanlandewijck, Y. and Gosselink, R. 2006. Respiratory muscle training in persons with a spinal cord injury: a systematic review. <u>Respiratory Medicine</u> . Vol. 100 No.11: 1886- 1895.	Excluded as focussed on respiratory muscle training, not MV or CCU.
24	Velmahos, G.C., TouTouzas, K., Chan, L., Tillou, A., Rhee, P., Murray, J. and Demetriades, D. 2003. Intubation after cervical spinal cord injury: to be done selectively or routinely? <u>The American Surgeon</u> . Vol. 69 No.10: 891 – 894.	Article only answers part of the review question. Not contextualised to the CCU.
25	West, S.L. 2006. Physical assessment: Whose role is it anyway? <u>Nursing in Critical Care</u> . Vol. 11 No.4: 161 – 167.	Article is not relevant to the critical care context and does not mention mechanical ventilation or SCI patients.
26	Wheeldon, A., 2005. Exploring nursing roles: using physical assessment in the respiratory unit. <u>British Journal of Nursing</u> . Vol. 14 No.10: 571-574.	The article discusses the importance of a physical assessment in the respiratory unit not focused on acute management or SCI or mechanical ventilation.
27	Zambas, S.I. 2010. Purpose of the systematic physical assessment in everyday practice: critique of a “sacred cow” <u>Journal of Nursing Education</u> . Vol. 49 No.6: 305-310.	Article discusses the importance of physical assessment skills taught to nurses. Not relevant to the review topic as make no mention of the SCI patient or mechanical



		ventilation.
28	Zimmer, M.B. Nantwi, K. and Goshgarian, H.G. 2007. Effect of spinal cord injury on the respiratory system: basic research and current clinical treatment options. <u>Journal of Spinal Cord Medicine</u> . Vol. 30 No.4: 319 – 330.	No mention of mechanical ventilation or respiratory management.