



Suctioning an Adult with a Tracheal Tube

NSW Health Statewide Guidelines for Intensive Care

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Disclaimer	<p>This clinical practice guideline (CPG) is aimed at providing the clinicians of NSW Intensive Care Units (ICU) with recommendations to frame the development of policies and procedures related to 'Suction of an adult with an artificial airway'.</p> <p>This CPG is a distillation of several processes: an integrative review of the literature (available up to December 2006); an evaluation of how this literature applies to the NSW intensive care context; the extensive clinical knowledge of the guideline development network members (GDN); and a guideline development process based on research evidence and consensus development.</p> <p>The CPG is not intended to replace the critical evaluation processes that underpin the development of local policy and procedure nor a clinician's judgment in an individual case.</p> <p>Users of this CPG must critically evaluate the CPG as it relates to local circumstances and any changes in the literature that may have occurred since the dates of the literature review. In addition NSW Health clinicians must review NSW state government policy documents to identify any directives that may relate to this clinical practice.</p> <p>These guidelines will be updated every 3 years.</p> <p>These guidelines are intended for use in adults only.</p> <p>NSW Health holds copyright of this CPG. No permission is given to redistribute, publish or commercialise this material in any way. The user agrees that in the event that part of the material in this CPG is reproduced or quoted, either in whole or in part, that the copyright owners name and interest in the matter will be acknowledged.</p> <p>Permission MUST be granted to publish this CPG as a stand-alone document on a website other than those of NSW Health.</p> <p>This permission may be obtained by contacting NSW Intensive Care Coordination and Monitoring Unit (ICCMU) Phone: 61 2 4734 1585 - FAX : 61 2 4734 1586 – Email: iccmu@wahs.nsw.gov.au</p>	

Index

Glossary	4
Executive Summary.....	5
Clinical Practice Guideline	8
Introduction	8
1 Scope.....	9
2 Purpose.....	9
3 Target Clinicians.....	9
4 How the Guideline was Developed	9
5 How to use the Guideline	9
6 Format of Guideline	10
7 Level of Evidence Taxonomy and how Consensus Opinion was Developed	10
8 Infection Control	10
9 Occupational Health and Safety	10
Recommendations for Practice	11
1 When to Suction	11
2 The Suction Catheter.....	13
3 Pre-oxygenation.....	14
4 Saline	15
5 Closed Suction	16
6 Hyperinflation	20
Process of Guideline Development	21
1 Description of Consensus Development Process	21
2 Guideline Construction.....	22
3 Academic Facilitators	22
4 External Validation Process	23
Integrative Literature Review	25
1 Introduction.....	25
2 Literature Search Protocol.....	25
3 Literature Review Process	27
4 Literature Synthesis Process.....	27
5 Taxonomy for Level of Evidence and Grade of Recommendation	28
Appendix 1 – Data Extraction Tools	41
References	43

List of Tables

Table 1: NHMRC Grade of Recommendations.....	5
Table 2: Recommendations for Practice.....	6
Table 3: Studies - Open vs Closed Suction & VAP	18
Table 4: Studies - Open vs Closed Suction & Lung Volumes or Oxygenation	19
Table 5: External Validation Members	24
Table 6: Results of EVP Process.....	24
Table 7: Literature Identified and NHMRC Levels of Evidence.....	28
Table 8: NHMRC Grading of Recommendations	28
Table 9: Summary Tables of Research	29
Table 10: Summary of Research not included	40

Glossary

Δ VL	Change in Lung Volume	LOS	Length of Stay
AACN	American Association of Critical Care Nurses	LR	Lung Recruitment
AARC	American Association for Respiratory Care	LVEF	Left Ventricular Ejection Fraction
ABG	Arterial Blood Gas	MAP	Mean Arterial Pressure
ACCCN	Australian College of Critical Care Nurses	MH	Manual Hyperventilation
ALI	Acute Lung Injury	MIAS	Minimally Invasive Airway Suction
APO	Acute Pulmonary Oedema	MIAS	Minimally Invasive Airway Suction
ARDS	Adult Respiratory Distress Syndrome	NGT	Nasogastric Tube
CAD	Coronary Artery Disease	OHS	Occupational Health and Safety
COPD	Chronic Obstructive Pulmonary Disease	OS	Open suction
CPG	Clinical Practice Guideline	OSS	Open Suction System
CPP	Cerebral Perfusion Pressure	OSS	Open Suction System
CS	Closed Suction	PaO ₂ / PO ₂	Partial Pressure of Arterial Oxygen
CSS	Closed Suction System	pCO ₂	Pressure of carbon dioxide in blood
CSS	Closed Suction System	PCV	Pressure Control Ventilation
CVC	Central Venous Catheter	PEEP	Positive End Expiratory Pressure
CXR	Chest X-ray	PICO	Population Intervention Comparison Outcome
EELV	End Expiration Lung Volume	PRCT	Prospective Randomised Controlled Trial
EELV	End Expiratory Lung Volume	PSV	Pressure Support Ventilation
ETCO ₂	End Tidal Carbon Dioxide	PUD	Peptic Ulcer Disease
ETS	Endotracheal Tube Suction	PUD	Peptic Ulcer Disease
ETT	Endotracheal Tube	RCT	Randomised Control Trial
EVP	External Validation Panel	RES	Routine Endotracheal Suction
FiO ₂	Fraction of Inspired Oxygen	RES	Routine Endotracheal Suction
GCS	Glasgow Coma Score	SAO ₂ /SAO ₂ /SPO ₂	Saturation of oxygen in blood
GDN	Guideline Development Network	SjO ₂	Jugular Bulb Oxygen Saturation
HCO ₃	Bicarbonate	SpO ₂	Saturation Oxygen
HME	Heat Moisture Exchange	VAP	Ventilator Associated Pneumonia
HR	Heart Rate	VC	Vital Capacity
ICC	Intensive Care Collaborative	VCV	Volume Control Ventilation
ICC-CDC	Intensive Care Collaborative – Consensus Development Conference	WCC	White Cell Count
ICCMU	NSW Intensive Care Coordination and Monitoring Unit		
ICP	Intracranial Pressure		
ICU	Intensive Care Unit		

Executive Summary

Suction of an artificial airway is a common procedure performed in the routine management of the critically ill. Although common, the procedure does carry substantial risk for the patient. Suctioning may induce hypoxaemia, lead to a loss of lung volume, cause dysrhythmias, effect cerebral blood flow and introduce pathogens to the lower airway increasing the risk of nosocomial pneumonia. The purpose of this set of Guidelines is to outline the best available evidence related to procedures which will facilitate the removal of airway secretions, while preventing potential complications of artificial airway suctioning.

This set of Guidelines has been developed from a methodological review of published research. Issues relating to the quality of study design were identified in most of the reviewed literature. Many of the practices used in suctioning artificial airways have developed through clinical practice in the absence of well-conducted randomised trials. The recommendations contained within these Guidelines should be implemented with recognition of these limitations.

A detailed, evidence based review (Thompson 2000) published by the Joanna Briggs Institute on suctioning artificial airways in adults was identified. This document was reviewed and accepted as an adequate review of the literature up to the date of publication. A systematic search of the literature was conducted for articles published after this document. The literature was identified using the PICO (population, intervention, comparison, outcome) format (Leslie and Finn 2003) and reviewed by senior clinical nurses using two critical appraisal tools [Appendix 1]. The quality of the evidence and grading for recommendations were assessed using the National Health and Medical Research Council (NHMRC) Levels of Evidence (Table 1). Where evidence was found to be insufficient, a consensus was achieved amongst the Guideline Development Group using a Likert scale 1-9.

Table 1: NHMRC Grade of Recommendations

Grade of recommendation	Description
A	Body of evidence can be trusted to guide practice
B	Body of evidence can be trusted to guide practice in most situations
C	Body of evidence provides some support for recommendation(s) but care should be taken in its application
D	Body of evidence is weak and recommendation must be applied with caution

Consensus Opinion	<p>Where no evidence could be applied consensus opinion developed by:</p> <ol style="list-style-type: none"> 1. Formulation of recommendation through discussion 2. Assignment of agreement by individual participants (Likert 1-9) 3. Consensus set at median of 7
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Table 2: Recommendations for Practice

Number	Recommendation Statement	Grade of Recommendation
1a	<p>Due to the potential for adverse effects, suctioning a tracheal tube should not be carried out on a routine basis. The decision to suction a tracheal tube must be made on the basis of the clinical need to maintain the patency of the tracheobronchial tree. This implies that different diagnostic groups and individual patients will have different requirements, and a tracheal tube should only be suctioned when clinically indicated by signs which could include:</p> <ol style="list-style-type: none"> i. Visible or audible secretions (such as sputum, blood or gurgling); ii. Respiratory: desaturation, rising peak inspiratory pressure, decreasing tidal volume, increased respiratory rate, increased work of breathing or coarse breath sounds on auscultation; iii. Cardiovascular: increased heart rate and blood pressure; iv. Other: restless patient or diaphoresis. 	C
1b	Assessment of the patient to identify the need to suction a tracheal tube should be continuous with chest auscultation performed every two hours or more frequently as indicated by clinical signs.	Consensus
1c	Patient assessment post suction should include an evaluation of the effects on the patient's pre suction signs and symptoms as well as the development of hypertension or increased intracranial pressure	Consensus
1d	To ensure patency of the tracheal tube the maximum time between individual suction procedures should be four hours.	Consensus
2a	Size of the suction catheter should be less than half the internal diameter of the tracheal tube.	D
2b	Suction should be applied for a maximum of 15 seconds, and only as the catheter is being withdrawn from the tracheal tube.	D

2c	During a routine suction procedure, trauma to and stimulation of the carina should be minimised, therefore the suction catheter should only be inserted down a tracheal tube until it just emerges out of the lumen of the tube.	Consensus
3a	Pre-oxygenation may assist in minimising hypoxia due to suctioning	B
3b	If pre-oxygenating, use the ventilator capability to deliver 100% oxygen.	B
3c	If a patient is hypoxic, then pre-oxygenation is essential.	B
4	To prevent the occurrence of adverse events, bolus instillation of normal saline should not be used prior to suctioning.	B
5a	Closed suction catheter systems should be used as the system of choice for all intubated intensive care patients.	C
5b	Closed suction catheter systems should be changed after 48 hours of use.	D
5c	Closed suction systems should be cleaned as per the manufacturers' guidelines to maintain patency and minimise colonisation.	Consensus
6	Hyperinflation should not be performed on a routine basis prior to suctioning.	B

Clinical Practice Guideline

Introduction

Tracheal suction through a tracheal tube (endotracheal tube or tracheostomy) bypasses the normal protective mechanisms such as the cough reflex that the upper airways provide. Critically ill patients often have an increase in the production of mucous and a weakened ability to clear secretions. If secretions are not cleared then the patient may be at risk of infection, atelectasis and alveolar collapse (Day et al, 2002). Appropriate management of the patient with an artificial airway can have an impact on reducing complications, length of stay and mortality and morbidity.

Tracheal suctioning has a number of potential risks that may lead to complications including hypoxia, cardiac dysrhythmias and mucosal damage. The procedure causes stress to patients, which may alter their haemodynamic status. Correct technique and preparation by the clinician can assist in reducing the risks of adverse events and reduce the level of discomfort for the patient. Although considered a routine procedure, suctioning should be carried out on the basis of clinical need and may vary among different diagnostic groups.

Suctioning for intubated and ventilated patients is a routine nursing procedure, yet practices vary among clinicians and hospitals. Some suctioning practices which have little to no evidence to support their use, are still being performed. It must be recognised that a lack of research evidence does not necessarily mean that a practice is of no benefit. Alternatively, there may be some practices that continue even when strong evidence clearly indicates either no benefit or actual harm. Invasive techniques such as manual ventilation with a bag-valve-mask and instillation of normal saline have been shown to have no benefit to the patient when suctioning (Thompson 2000) yet despite this, these practices continue in some Units.

Reducing the frequency of breaking the ventilator circuit has also changed suction practices. Closed suction systems offer a number of benefits including; protection from bodily fluids (for the clinician and the patient) and continuous ventilation by preventing the need to break the circuit to introduce a suction catheter. Altering ventilator settings prevents the need to disconnect the patient for manual hyperinflation, if required before or after suctioning. Minimising/preventing interruption of the ventilator circuit avoids pressure drops that may lead to complications in the critically ill patient.

The Guidelines provided have been developed after a comprehensive review of the literature. They will assist practitioners to develop local policy regarding tracheal suctioning of an artificial airway

1 Scope

Tracheal suction is an important procedure in the management of adults with artificial airways. Tracheal suction is required to maintain a patent airway and assist with preventing hypoxia and atelectasis from retention of sputum. Complications such as hypoxia, cardiac dysrhythmias and mucosal damage have been associated with tracheal suctioning. Competent suctioning technique aids in the prevention of complications associated with the procedure. The Guideline is relevant for practitioners who perform tracheal suction on patients with artificial airways. Although this Guideline addresses the suctioning requirements of most intubated patients, it does not address the specific needs of special patient groups such as patients with intra-cranial hypertension or severe lung injury. Sub-glottic suctioning technique may be an important component for the prevention of ventilator-associated pneumonia. While the literature was reviewed, recommendations regarding sub-glottic suctioning technique are not included in this Guideline.

2 Purpose

This Guideline has been developed to provide intensive care clinicians with recommendations to guide the development of local policy/procedures related to tracheal suction through an artificial airway. The Guideline should be seen as a resource document.

3 Target clinicians

It is intended that this Guideline can be used by all intensive care clinicians responsible for suctioning a patient with an artificial airway. It is assumed that users of this Guideline have knowledge of respiratory anatomy and physiology and the purpose of artificial airways including endotracheal tubes and tracheostomy tubes.

4 How the Guideline was developed

This Guideline was developed by the Suction Guideline Development Network comprised of senior nursing clinicians and academics as part of the NSW ICCMU Intensive Care Collaborative project.

5 How to use the Guideline

This Guideline is provided as a tool to inform the development of local practice policies in NSW Intensive Care Units. It should be used in conjunction with other processes normally used to develop practice guidelines which may include: local audit of practice and outcomes; review of relevant literature; and reference to other practice guidelines. Whilst a concerted effort was made to include relevant literature, other studies may have been published since this Guideline was written and these should be identified, reviewed and considered for inclusion. This Guideline should be critically evaluated like all identified literature.

6 Format of Guideline

The Guideline is presented in three main sections:

- Section 1 contains the recommendation statements and supporting narrative;
- Section 2 is a detailed explanation of the Guideline development process;
- Section 3 contains the integrative literature review.

7 Level of evidence taxonomy and how consensus opinion was developed

The Australian NHMRC (NHMRC 2005) levels of evidence were used to grade the recommendations. Where suitable research evidence was not available, the GDN members formulated a recommendation based on their clinical experience and the NSW survey of practice. These recommendations were then voted upon using a 1-9 (Disagree 1-3, Neutral 4-6 and Agree 7-9) Likert scale with consensus agreement was set as a median of 7.

8 Infection control

Prevention of infection is an important aspect of any clinical practice and guideline users are directed to NSW Health Policy Directive (PD2007_36) and local policy to identify the infection control elements of this clinical practice. This includes but is not limited to: use of personal protective equipment, hand hygiene, disposal of equipment and medical waste and isolation of infectious patients. The suctioning procedure should be completed using an aseptic technique to minimise the potential for the introduction of exogenous organisms into the respiratory tract of the critically ill patient. Additionally, personal protective equipment including goggles, gloves and masks should be worn where there is a risk of droplet formation during suctioning.

9 Occupational Health and Safety

Suctioning an artificial airway has a number of potential OHS issues including exposure to aerosolised sputum. Wearing personal protective equipment is mandatory when performing this procedure. Guideline users are directed to local occupational health and safety policy and procedures to ensure operator safety whilst performing this procedure.

Recommendations for Practice

Suctioning of a tracheal tube is a frequent, fundamental and clinically significant practice in adult intensive care. The variability of lung pathology between patients and the potential adverse effects of the procedure requires that suctioning be customised to the individual patient.

This section of the Guideline is organised into six sections with the recommendation statement/s followed by a supportive narrative, which includes a brief summary of the evidence where available.

1 - When to suction		
Number	Recommendation Statement	Grade of Recommendation
1a	<p>Due to the potential for adverse effects, suctioning a tracheal tube should not be carried out on a routine basis. The decision to suction a tracheal tube must be made on the basis of the clinical need to maintain the patency of the tracheobronchial tree. This implies that different diagnostic groups and individual patients will have different requirements and a tracheal tube should only be suctioned when clinically indicated by signs which could include:</p> <ul style="list-style-type: none"> i. Visible or audible secretions (such as sputum or blood); ii. Respiratory: desaturation, rising peak inspiratory pressure, decreasing tidal volume, increased respiratory rate, increased work of breathing or coarse breathe sounds on auscultation; iii. Cardiovascular: increased heart rate and blood pressure; iv. Other: restless patient or diaphoresis. 	C
1b	Assessment of the patient to identify the need to suction a tracheal tube should be continuous with chest auscultation performed every two hours or more frequently as indicated by clinical signs.	Consensus
1c	Patient assessment post suction should include an evaluation of the effects on the patient's pre suction signs and symptoms as well as the development of hypertension or increased intracranial pressure.	Consensus
1d	To ensure patency of the tracheal tube the maximum time between individual suction procedures should be four hours.	Consensus

Suctioning is an uncomfortable and distressing procedure for patients. Nonetheless, suctioning of a tracheal tube is an essential component of keeping the tracheobronchial tree and the artificial airway free of secretions thus ensuring delivery of gases to alveoli. There are a number of potential adverse effects, however, on several body systems including: 1) respiratory (e.g. reduction in lung volumes, hypoxia, alveoli collapse, introduction of infection and trauma to the trachea); 2) cardiovascular (e.g. bradycardia and hypertension); 3) neurological (e.g. increase in intracranial pressure and reduction in cerebral blood flow). Despite the relative frequency of this procedure the body of evidence is limited. A systematic review recommended to only suction when clinically indicated because of the potential complications associated with the procedure (Thompson 2000). A randomised controlled trial (RCT) compared a routinised procedure (RES) and a minimally invasive procedure (MIAS) and found no differences on length of intubation, ICU mortality and incidence of infection, but found significantly more adverse events in RES group (Leur, Zwaveling et al. 2003). The application of these findings is limited due to the differences in RES protocol and usual NSW ICU practice, the level of protocol violation and that the patients who did not receive their assigned protocol had an increased length of intubation and increased risk of infection.

The recommendation to only suction when clinically indicated is based on the Thompson (2000) review and the clinical experience of GDN members. In a prospective observational study Guglielminotti and colleagues (2000) examined the value of a number of clinical signs (including patient agitation, SpO₂ fall, respiratory sounds, changes in respiratory pattern and a 'saw-tooth' pattern on the flow-volume loop) as indicators of retained secretions in a cohort of 66 consecutive ventilated patients. In this group of patients, only a sawtooth pattern (sensitivity 0.82, specificity 0.70 and positive predictive value 0.80, likelihood of a positive test 2.70) and respiratory sounds (sensitivity 0.66, specificity 0.74 and positive predictive value 0.78, likelihood of a positive test 2.50) appeared to be of value. However, for two-thirds of patients there was only one observer who was not blinded to outcomes, limiting the value of these findings. Clinical indications for suctioning have not been systematically evaluated within the literature; therefore, the clinical signs listed within the recommendation are based on the clinical experience of the GDN members. These clinical indicators are inline with those listed by the Australian College of Critical Care Nurses (ACCCN) (Cuthbertson and Kelly 2007), American Association of Critical Care Nurses (ACCN) (Chulay 2005) and the American Association of Respiratory Therapists (AARC) (Branson, Campbell et al.). Identification of these clinical signs will require the nurse to constantly review the patient (visual inspection with regular chest auscultation to identify coarse breath sounds and/or changes in air entry) and ventilator (that is indications of disruption to gas flow such as alteration of flow-volume loop for sawtooth pattern or changes indicating reduction in tidal volume).

The effects of the suction procedure on the patient must be evaluated and this should include reversal of pre-suction clinical signs, examination of suction yield and possible adverse effects of

the suction procedure such as patient distress, hypertension, hypoxia and intracranial hypertension. This recommendation is based on the clinical experience of GDN members, is supported by other expert groups (Branson, Campbell et al.; Chulay 2005) and achieved consensus.

Maintenance of a patent tracheal tube is of vital importance and whilst there is evidence to indicate that suctioning should only be done when clinically indicated there was little quality evidence to identify what the maximum time between suction procedures should be. Difficulty passing the suction catheter through the tracheal tube may be an indication of the build up of secretions in the lumen of the tube (Cuthbertson and Kelly 2007). Therefore, it is the consensus opinion of GDN members that this time interval should not exceed four hours so that clinicians know with a high degree of certainty that the tracheal tube is patent.

All of these recommendations except 1b were agreed to by the external validation panel (EVP). The results for 1b were a median of 6 (IQR 5-7). The main concerns were: 1) the practicality of second hourly auscultation; 2) the need for individualising the frequency of auscultation based on patient lung pathology; and 3) possible insensitivity of auscultation as an indicator of the need to suction. The recommendation was not changed because: a) the EVP score indicates a neutral response, not a negative response and b) the recommendation is 'should' not 'must'. Further narrative has been added regarding the need for customising the procedure to individual patients needs.

2 - The Suction Catheter		
Number	Recommendation Statement	Grade of Recommendation
2a	Size of the suction catheter should be less than half the internal diameter of the tracheal tube.	D
2b	Suction should be applied for a maximum of 15 seconds and only as the catheter is being withdrawn from the tracheal tube.	D
2c	During a routine suction procedure, trauma to and stimulation of the carina should be minimised, therefore the suction catheter should only be inserted down a tracheal tube until it just emerges out of the lumen of the tube.	Consensus

The size of the suction catheter and the duration of suctioning (i.e. application of negative pressure) will directly influence the volume of secretions removed, however, it will also have potential adverse effects on respiratory function. Thompson (2000) found that there was some evidence to support limiting the diameter of the suction catheter to less than 50% of the internal

diameter of the tracheal tube and, whilst there was minimal research to support the duration of suction, the recommendation was made to limit the application time of negative pressure to less than 10-15 seconds. These recommendations are supported by other expert groups (Branson, Campbell et al.; Chulay 2005; Cuthbertson and Kelly 2007) and are in line with the consensus opinion of the GDN members. In addition to these aspects, expert opinion suggests limiting the suction procedure to a maximum of three passes (of the suction catheter) using a negative pressure setting of between 100-150mmHg (Chulay 2005; Cuthbertson and Kelly 2007).

Stimulation of the carina by the suction catheter has a number of potential adverse effects including patient distress, severe coughing and bradycardia as well as causing damage to the tracheal mucosa (Bourgault, Brown et al. 2006). Whilst it is recognised that there may be occasions where insertion of a suction catheter into either lobe may be of clinical benefit to the patient it is the consensus opinion of the GDN members that during a routine suction procedure the catheter should only be inserted until it just emerges from the lumen of the tracheal tube.

The EVP agreed to all of these recommendations.

3 - Pre-oxygenation		
Number	Recommendation Statement	Grade of Recommendation
3a	Pre-oxygenation may assist in minimising hypoxia due to suctioning	B
3b	If pre-oxygenating, use the ventilator capability to deliver 100% oxygen.	B
3c	If a patient is hypoxic, then pre-oxygenation is essential.	B

Preoxygenation of the patient using 100% oxygen delivered by the ventilator or through hyperventilation has been a standard of care for many years however the change to closed suction systems raised questions around the need for this practice to continue. Historically, pre-oxygenation through the delivery of an increased fraction of inspired oxygen via the mechanical ventilator or manual resuscitator, has been implemented to reduce the risk of hypoxia during suctioning on intubated mechanically ventilated adults. Closed suction systems, or suction bullets, maintain positive pressure and allow the patient to remain connected to the ventilator during suctioning (Maggiore, Lellouche et al. 2003). With these systems the incidence of desaturation is reduced. While routine pre-oxygenation has often been recommended as a precautionary measure to prevent possible instances of desaturation, it cannot be assumed that the administration of high concentrations of oxygen for this use is without risk to the patient. It has been demonstrated that

high concentrations of oxygen, even for a few minutes, can lead to the development of absorptive atelectasis in healthy individuals (Reber, Engberg et al. 1996). The development of atelectasis and subsequent loss of lung volume may be particularly deleterious for the critically ill patient and those with acute lung injury. Whilst there is little direct evidence of these phenomena in the critically ill, it seems sensible to avoid the routine use of 100% oxygen for patients who do not require it. However as oxygen saturation must be monitored before, during and after suctioning, if desaturation occurs then pre-oxygenation +/- lung recruitment strategies may be warranted. This may be especially prudent for patients who are already hypoxic or for patients with compromised cerebral circulation. Most ventilators include a facility whereby 100% oxygen can be delivered for a preset period, and less haemodynamic effects have been reported with this method (Thompson 2000).

The EVP agreed to all of these recommendations.

4 - Saline		
Number	Recommendation Statement	Grade of Recommendation
4	To prevent the occurrence of adverse events, bolus instillation of normal saline should not be used prior to suctioning.	B

Some critical care areas still practice routine instillation of saline as part of the suctioning procedure. There is no evidence to indicate that saline provides any benefit to suctioning. The studies reviewed relating to saline use had only small sample sizes and, as stand alone studies, provide little evidence of serious complications. Akgul et al (2002) noted some increase in heart rate post suctioning at the 4th and 5th minute. O’Neil et al (2001) reported some increase in dyspnoea in the younger population post suctioning. Despite there being no major complications recorded in the studies, instillation of saline may contribute to ventilator associated pneumonia as the biofilm on the endotracheal tube is flushed into the lower airways (Alp and Voss 2006). A Cochrane review described by Thompson (2000:40) could not be located. Therefore the recommendation to not routinely use saline is based on the theoretical concerns of the GDN members and is reflected by other expert groups (Chulay 2005).

The EVP agreed with this recommendation.

5 - Closed Suction		
Number	Recommendation Statement	Grade of Recommendation
5a	Closed suction catheter systems should be used as the system of choice for all intubated intensive care patients.	C
5b	Closed suction catheter systems should be changed after 48 hours of use.	D
5c	Closed suction systems should be cleaned as per the manufacturers' guidelines to maintain patency and minimise colonisation.	Consensus

Closed suction systems were introduced in the 1990s with the theoretical advantages for the patient of maintaining lung volumes, reducing suction-induced hypoxaemia and reduction of ventilator-associated pneumonia (VAP). Thompson (2000:30-32) identified a number of papers concerning open versus closed suction systems but did not provide a recommendation for practice. Since 2000, a number of papers were identified of varying methodology and quality. Tables 3 and 4 provide a brief summary of the findings of these studies however the full summary table for each can be found in Table 9. Two meta-analyses were identified (Vonberg, Eckmans et al. 2006; Jongerden, Rovers et al. 2007) after the literature review was completed, however the results were not able to be applied (e.g. heterogeneity of samples and lack of considerations for all aspects of practice). A review of the studies in tables 3 and 4 appears to indicate that, at this time, there is little apparent benefit of using closed suction over open suction for the individual patient, however a number of these studies (especially with respect to maintenance of lung volumes and oxygenation) are limited by flaws such as small sample sizes and measurement bias. Open suction techniques are significantly more complex than closed suction techniques, especially with respect to maintenance of a sterile catheter, and pose a significant infection risk both to the individual patient, other patients and clinicians as respiratory secretions are aerosolised. In addition, a closed suction system is recommended as part of infection control strategies to prevent VAP (Alp and Voss 2006). For these reasons, and as there is no evidence to suggest that closed suction systems result in adverse patient outcomes, closed suction systems should be available for suctioning intubated patients.

Any disconnection or break in the ventilation circuit increases the risk of introducing infective agents which may lead to ventilator associated pneumonia (VAP), particularly in the critically ill patient (Kollef, Prentice et al. 1997). In-line suction catheters remain in-situ in order to minimise airway contamination through disconnection of the ventilator circuit, but manufacturers recommend 24 hour change to prevent VAP (Darvas 2003). The relative cost of closed suction

systems has been a significant impediment to uptake, however recent studies have shown that the risk of VAP does not rise when in-line suction catheters are changed less often, thus reducing costs (Thompson 2000; Darvas and Hawkins 2003; Stoller, Orens et al. 2003).

Closed suction systems require rinsing to remove secretions and to minimise colonisation of the catheter. To date this has not been studied, therefore it is recommended that the catheters should be cleaned as per manufacturers' guidelines.

The EVP agreed to all of these recommendations.

Table 3: Studies - Open vs Closed Suction & VAP

Study Name/Type	Intervention /Sample size	Effects on VAP			
Darvas & Hawkins (2003) PRCT	Closed suction 24 hrs n = 53 48hrs n = 48		VAP		
		24hrs	10 (19%)		
		48hrs	13 (27%)		
		No significant differences between groups P=0.35			
Freytag et al (2003) Prospective cross over	N = 23 Group I - 24hr change of CS then 72hrs Group II - reverse	Increased colonisation of catheter at 72 hrs			
Lorente (2005) PRCT	OS n= 210 CS n= 233		VAP	Cases / 1000 vent days	
		OS	18.2%	15.84	
		CS	20.47%	17.59	
Rabitsch (2004) PRCT	Open Suction (OS) n = 12 Closed Suction (CS) n = 12 (change 24 hrs)		Cross contamination	VAP	
		OS	5	5	
		CS	0	0	
				P=0.037	
Stoller (2003) Cohort	I - Pre-intervention n = 146 Daily change of CS II - Post-intervention n = 143 weekly change of CS		VAP	Cost of	
		I	2	\$US 6,026	
		II	0	\$US 1,330	
		51% in II had same catheter > 3 days			
Topeli (2004) PRCT	Open Suction (OS) n = 41 Closed Suction (CS) n = 32		Colonisation	VAP	
		OS	13	9	
		CS	16	13	
Zeitoun (2003) PRCT	Open Suction (OS) n = 24 Closed Suction (CS) n = 23		VAP	OS - 11	CS - 7
OS Open suction CS Closed suction		VAP – Ventilator Associated pneumonia PRCT – prospective randomised controlled trial			

Table 4: Studies - Open vs Closed Suction & Lung Volumes or Oxygenation

Study Name	Intervention/ Sample size	Lung volume/oxygenation						
Bourgault (2006) Randomised crossover	N=18 I – OS, 14 gauge, 2 passes, 1 min preO2, catheter inserted until resistance II - CS	No differences between methods						
Cereda et al (2001) Randomised cross-over	N=10 4 consecutive tracheal suction manoeuvres using CS (closed suction) ×2 and OS (open suction) ×2 in an alternate randomised sequence at 20min intervals. During suction, continuous suction applied for 20 seconds.		OS		CS			
		ΔVL	1.4±0.11		0.14 ± 0.71			
		SpO2	Sig ↓↓↓		Non sig ↓			
		MAP/HR	↑ MAP = HR		= MAP/HR			
Demir & Dramali (2005) Cross-over randomised	N=30 I – no preoxygenation II – 100%		PaO2 before		PaO2 post			
		I	95.49 (+/- 25.09)		96.65 (+/- 26.11)			
		II	101.71 (+/- 34.30)		150.09 (+/- 65.58)			
		Between interventions	F=20.06, P<= 0.0001)					
		Difference before/after	Intervention 1 F not different		Intervention 2 F= 17.61 p<=0.001			
Fernandez (2004) Prospective cross-over	N = 10 mild to moderate acute lung injury I – quasi closed II – open III – closed Applied sequentially	No differences for MAP, HR, ETCO2 & SpO2						
		ΔVL	I	II	III			
		During	↓	↓	↓			
		1min post	↓	↓	↓			
		10min post	↓6±5	↓	↓			
Lascocki (2006) Cross-over	N = 18 I – closed suction followed open II – closed suction at 200-400mmHg		O2		Sputum aspirated			
		I	↓		good			
		II	equal		↓			
Maggorie et al (2003) Descriptive	N=9 I – open suction II – via swivel adaptor III – closed suction IV – swivel + PSv V – closed suction + PSV		I	II	III	IV	V	
		EELV	↓↓↓↓	↓↓	↓↓	↓	↓	
		SaO2	↓↓↓↓	↓	↓	↓	↓	
Rabitsch (2004) PRCT	OS n = 12 CS n = 12 (change 24 hrs)		Sao2		OS	CS	p-value	
		Day 1	Before	97.2±1.9		96.3±1.4		0.196
			After	89.6 ± 2.5*		96.8 ± 1		<0.0001
		Day 3	Before	96.8 ± 1		97 ± 1.		0.656
			After	89.6 ± 1.9*		96.4 ± 0.8		<0.0001
		ΔVL – change in lung volume EELV - End expiratory lung volume		* P<0.0001, SaO ₂ at beginning of suctioning vs SaO ₂ at end of suctioning in the same group				

6 - Hyperinflation		
Number	Recommendation Statement	Grade of Recommendation
6	Hyperinflation should not be performed on a routine basis prior to suctioning.	B

Hyperinflation using a manual resuscitator bag or the ventilator has been used as a method of both hyper oxygenation and as a lung recruitment manoeuvre. Hyperinflation is not a benign procedure and has been associated with adverse effects including significant increases in mean arterial pressure, cardiac output, pulmonary artery pressure and pulmonary airway pressure (Thompson 2000). Two recent cross-over studies evaluated the effects of hyperinflation on respiratory mechanics and found improvements in lung compliance and sputum return without adverse effects, however the methodology and small convenience sample preclude the application of these results on a routine basis (Berney and Denehy 2002; Choi and Jones 2005). Nonetheless, it is recognised that there may be occasions where hyperinflation during suctioning is clinically warranted, such as when a patient has a sputum plug.

The EVP agreed with this recommendation.

Process of Guideline Development

The Suction GDN was established at the 'Getting Evidence into Practice' workshop held on June 14 2005 (<http://intensivecare.hsnet.nsw.gov.au/five/htm/education.php>). The senior nurses were able to self-select which guideline to develop. In the period between June 2005 and December 2006 GDN meetings were convened via teleconference with ICCMU CNC coordinating the process. At the initial meeting the scope and state of current practice was established and the issues related to suctioning were brainstormed. At subsequent meetings a clinical question and literature review protocol were developed and literature review tasks allocated. The Project Manager and Academic Lead developed a critical appraisal tool (Elliott 2003; Schneider 2003) (see appendix 1) and GDN member training was completed during a scheduled meeting. The Project Manager collated the article reviews and these compilations were sent to GDN members some weeks prior to the Intensive Care Collaborative Development Conference (ICC-CDC). Prior to ICC-CDC, an on-line forum was established to promote discussion of evidence with respect to specific questions arising from the broader PICO question. See the Integrative Literature review for further explanation.

Midway through 2006 a group of critical care academics from Australia and New Zealand were identified as academic facilitators for each GDN. A number of meetings were held to establish the final processes of guideline development, in particular the taxonomy for levels of evidence and recommendations and consensus development (see Box A).

1 Description of consensus development process

On Friday December 1 2006 the ICC-CDC was held where all of the GDNs met to develop the recommendations for practice under the facilitation of an Australasian critical care academic. Each GDN followed the processes outlined in Box A. The Suction GDN reviewed the clinical questions and decided to: 1) discard the minor clinical questions of 7 and 8; and 2) to incorporate question 9 into question 6.

Box A: Process of Consensus Development at ICC-CDC

1. Establish current practice
2. Revisit clinical question
3. Review papers
 - a. Include relevant papers
 - b. Assign level of evidence for each paper
4. Address each question
5. Recommendation
 - a. Develop statement
 - b. Assign grade of recommendation
 - i. From literature
 - ii. Expert opinion
6. Assign agreement using Likert Scale
7. Review voting - consensus is a median of 7-9
8. Revisit process once only if consensus not reached

2 Guideline construction

All GDN members contributed to the development of the Guideline including literature critique, recommendation development, developing narrative to support recommendations and reviewing the completed document. The authors used the recommendations developed at ICC-CDC as well as a second consensus round to cover missing recommendations. In addition, the NSW Clinical Excellence Commission endorsed the process of guideline development.

3 Academic Facilitators

The role of the Academic Facilitators was to facilitate the development of recommendations for practices based on a synthesis of the literature and experiential knowledge. They were identified through professional networks and were not paid to participate in the ICC project however ICCMU paid the costs of travel and accommodation for the ICC-CDC. Apart from Professor Elliott, the other Academic Facilitators did not join the ICC project until June 2006. Five meetings were held, four by teleconference and one the day prior to the ICC-CDC. Tasks completed during these meetings included:

1. Assignment to a particular GDN
2. Discussion regarding the most appropriate levels of evidence and recommendation taxonomy
3. Format of the consensus conference (ICC-CDC)
4. Process of developing recommendations and reaching consensus
5. Process for writing guidelines and peer reviewed publications.

Convenor, Academic Facilitators	Professor Doug Elliott Director of Research, Faculty of Nursing, Midwifery and Health University of Technology Sydney
Oral Care GDN	Associate Professor Patricia Davidson School of Nursing, College of Health and Science University of Western Sydney
Eye Care GDN	Ms Andrea Marshall Sesqui Senior Lecturer in Critical Care Faculty of Nursing and Midwifery The University of Sydney
Suction of Tracheal Tube GDN	Associate Professor Bridie Kent Director of Clinical Nursing Research School of Nursing - Faculty of Medical and Health Sciences University of Auckland Professor Wendy Chaboyer Director, Research Centre for Clinical Practice Innovation Griffith University Queensland

Stabilisation of an Endotracheal Tube GDN	Associate Professor Anne Gardner Cabrini Hospital & School of Nursing, Faculty of Health Medicine Nursing & Behavioural Sciences Deakin University Melbourne
	Professor Sandy Middleton School of Nursing Australian Catholic University, National - North Sydney Campus
Arterial line GDN (nursing management)	Dr Tina Jones Manager The Australian Centre for Evidence Based Clinical Practice Flinders Medical Centre, Flinders University
CVC GDN (nursing management)	Dr Judy Currey Senior Lecturer, School of Nursing Deakin University Melbourne

4 External validation process

Validation of the guideline was conducted by external validation panel (EVP) using a limited Delphi round completed in September 2007

4a Formation of panels

Panel members (n = 47) for all guidelines were identified using professional networks and associations, and were allocated to a specific guideline using two processes. Firstly there were nine panel members who were approached directly because of their acknowledged expertise with a particular practice (including research or employment role). Next other panel members were randomly allocated to a specific guideline by placing all names into a hat and assigning names sequentially to each guideline until names and panel positions were exhausted. In order to describe the panels, panel members were asked to provide limited demographic data. In addition, they completed a 'Conflict of Interest' form. Table 5 lists panel members.

4b Method of validation

Panel members received the draft guideline and literature review (which included the data extraction tools completed by the GDN members) along with a recommendation agreement form. They were then requested to assign their level of agreement (likert 1-9) with each recommendation statement. A median score of 7 was set for consensus to be reached. Table 6 sets out the results of the EVP process for this Guideline.

Table 5: External Validation Members

EVP role	Name	Position and Facility
Nursing academic	Dr Ian Baldwin	Post Graduate Coordinator Intensive Care Austin Health, Melbourne Adjunct Professor RMIT
Nursing academic	Brendan Docherty	Area Clinical Stream Manager Critical Care and Cardiac Services South Eastern Sydney Illawarra Area Health Service
Clinical nurse	Hugh Davies	Clinical Nurse/Practitioner Scholar ICU Royal Perth Hospital Edith Cowan University
Clinical nurse	Chris Smith	NUM Intensive/ Coronary Care Mater Adult Hospital, South Brisbane
Physiotherapist	Lesley Howard	Senior Respiratory Physiotherapist Westmead Hospital Western Sydney Area Health Service
Intensive care medical specialist	Dr Stuart Lane,	Staff Specialist Nepean Hospital Western Sydney Area Health Service
Intensive care medical specialist	Dr Ray Parkin	Staff Specialist Nepean Hospital Western Sydney Area Health Service

Table 6: Results of EVP Process

	25 th	Median	75 th	Range		
				Minimum	Maximum	
Recommendations	1a	7.25	8.5	9	6	9
	i	8.5	9	9	8	9
	ii	9	9	9	8	9
	iii	6.5	7	8	5	9
	iv	6.5	7	8.5	4	9
	1b	5	6	7	5	9
	1c	8	8	9	7	9
	1d	5.5	7	8	2	9
	2a	7	7	7.5	5	8
	2b	7	8	9	3	9
	2c	7	7	8.5	7	9
	3a	8.5	9	9	5	9
	3b	8.5	9	9	7	9
	3c	9	9	9	8	9
	4	7.5	8	8.5	7	9
	5a	7	7	8	3	8
	5b	6	7	8	3	9
	5c	7	7	8	5	9
	6	7.5	8	9	7	9

Integrative Literature Review

1 *Introduction*

A thorough review of the literature is an integral part of developing evidence based practice guidelines. Suctioning a tracheal tube is a complex procedure, which involves considering a number of aspects including ventilator associated pneumonia, maintaining lung volumes and preventing hypoxia and minimising patient distress and other adverse sequelae. A recent systematic review was identified (Thompson 2000) therefore the beginning point for the literature review was 1999. In strict evidence-based practice terms, a systematic review involves only reviewing quality randomised control trials, however, once literature was identified for this guideline, it became clear that this could not be achieved. Therefore this review became includes a number of different study types (Whittemore and Knafl 2005).

The clinical question was developed at GDN teleconferences and the search conducted by Rolls. Articles were grouped into topics and assigned to two reviewers. A critical appraisal tool was developed (Elliott 2003; Schneider 2003) and GDN members trained during regular meetings. All GDN members completed article reviews which were collated by the Project Manager and this 'systematic review' was then sent to GDN members for review prior to the ICC-CDC.

2 *Literature search protocol*

PICO question

What is the optimal method of suctioning the critically ill adult with an artificial airway that minimises patient discomfort and the adverse effects of hypoxia, mucosal damage, alveolar de-recruitment and nosocomial pneumonia?

P	Population (of interest)	Critically ill adult with an artificial airway
I	Intervention	Tracheal suction through an artificial airway
C	Control (group)	N/A ✓
O	Outcome (measured)	Hypoxia (spO2 & PaO2), mucosal damage, VAP, length of catheter, catheter selection, Expiratory lung volume/functional residual capacity

Databases:	All on CIAP plus pubmed, google and scholar google			
Time:	1999-2005			
Key words:	Catheter selection Artificial airway	VAP Hypoxia Alveolar	De-recruitment Tracheostomy Closed suction system	Recruitment manoeuvre Tracheal suction
Search filters:	Publication years: 1999 - 2006	English language only	Adult >16	Research
Articles identified	CINAHL –19	Embase – 1	Ovid Medline – 25	Pubmed – 16
	Reference review - 15	Total - 76	Total Reviewed - 49	Total included in guideline - 28

Minor Clinical Questions:

1. How far down a tracheostomy tube should a suction catheter be passed that minimises the patient complications of:
 - a) tracheal mucosal damage
 - b) patient discomfort
 - c) autonomic effects→ No evidence was found related to this question

2. How far down an ETT should a suction catheter be passed that minimises the patient complications of:
 - a) tracheal mucosal damage
 - b) patient discomfort
 - c) autonomic effects→ Only limited evidence was found related to this question. See Leur et al 2003.

3. What is the optimal method of hyperventilation 1) disconnecting from ventilator and hand bagging OR 2) using the manual ventilation facility on a ventilator with respect to:
 - a) alveolar recruitment
 - b) maintaining oxygenation
 - c) sputum removal→ Question changed to '*What is the optimal method of hyperinflation for maintaining oxygenation and sputum removal?*'
→ See Berney et al 2002, Choi 2005 and Dhyr 2003

4. Under what circumstances is it appropriate to use normal saline to facilitate sputum removal from the patient's airways when suctioning an artificial airway?
 - a) Routine
 - b) emergency situations
 - c) bronchial lavage
 - d) other→ See Akgul 2002, Ji et al 2002 and ONeil 2001

5. What clinical practices minimise ventilator-associated pneumonia?
 - a. Closed suction vs open suction.→ A number of studies of variable methodology and quality were identified. See tables three and four.

6. What clinical practices prevent or minimise hypoxia?
 - See Bourgalt et al 2006, Cereda et al 2001, Demir and Dramali 2005, Lascocki et al 2006 and Pogson and Shirley 2002

7. What role does sub-glottic suctioning have?
 - This question was discarded due to time constraints.

8. When suctioning a patient with an acute lung injury what clinical practices minimise the adverse effects of:
 - a. alveolar de-recruitment
 - b. hypoxaemia
 - c. other e.g. hypotension, bradycardia etc
 - See Maggorie et al 2003

9. What conditions should determine the frequency of suctioning e.g.
 - a. Routine versus assessment
 - b. Emergency situations
 - c. Patient conditions such as raised intracranial pressure, pulmonary oedema and quantity and quality of secretions
 - This question was dealt with post ICC-CDC. Studies related to 9a include Leur et al 2003 and Thompson 2000. Only limited studies were found addressing the issues of suctioning a patient with acute lung injury (see Cereda et al 2001, Lascocki et al 2006, Fernandez et al 2004 and Dhyr et al 2003) or head injury (see Gemma 2002).

3 Literature Review Process

Articles were assigned to two reviewers who completed reviews using the critical appraisal tool. Rolls collated the reviews which can be found at the ICCMU website. Apart from editing, reviews were kept in the form returned by GDN members.

4 Literature Synthesis Process

The literature synthesis process was conducted online using the GDN forum space at the ICCMU website and through discussion at the ICC-CDC. The PICO question was broken down into nine sub questions and an online discussion forum established however there was only a small amount of online discussion. The literature was discussed further at the ICC-DC and levels of evidence applied for both individual studies and recommendations using the NHMRC taxonomy.

5 *Taxonomy for level of evidence and grade of recommendation*

Table 7: Literature Identified and NHMRC Levels of Evidence

Level	Intervention	Studies Identified
I	A systematic review of level II studies	1
II	A randomised controlled trial	9
III-1	A pseudo-randomised controlled trial (i.e. alternate allocation or some other method)	10
III-2	A comparative study with concurrent controls: <ul style="list-style-type: none"> • Non-randomised, experimental trial • Cohort study • Case-control study • Interrupted time series with a control group 	3
III-3	A comparative study without concurrent controls: <ul style="list-style-type: none"> • Historical control study • Two or more single arm study Interrupted time series without a parallel control group	1
IV	Case series with either post-test or pre-test/post-test outcomes	3
	Guidelines	1
	Total	28

Table 8: NHMRC Grading of Recommendations

Component	A	B	C	D
	Excellent	Good	Satisfactory	Poor
Volume of evidence	Several level I or II studies with low risk of bias	One or two level II studies with low risk of bias or a SR/multiple level III studies with low risk of bias	Level III studies with low risk of bias, or level I or II studies with moderate risk of bias	Level IV studies, or level I to III studies with high risk of bias
Consistency	All studies consistent	Most studies consistent and inconsistency may be explained	Some inconsistency reflecting genuine uncertainty around clinical question	Evidence is inconsistent
Clinical impact	Very large	Substantial	Moderate	Slight or restricted
Generalisability	Population/s studied in body of evidence are the same as the target population for the guideline	Population/s studied in the body of evidence are similar to the target population for the guideline	Population/s studied in body of evidence different to target population for guideline but it is clinically sensible to apply this evidence to target population	Population/s studied in body of evidence different to target population and hard to judge whether it is sensible to generalise to target population
Applicability	Directly applicable to Australian healthcare context	Applicable to Australian healthcare context with few caveats	Probably applicable to Australian healthcare context with some caveats	Not applicable to Australian healthcare context

Table 9: Summary Tables of Research

Short Reference	Design/Method	Sample Description	Outcomes/Findings	Methodological Quality
<p>Akgul, S. and Akyolcu, N. (2002), Effects of normal saline on endotracheal suctioning, Journal of Clinical Nursing, 11, pp. 826 – 830</p>	<p>Cross over design <i>Inclusion</i> – mechanically ventilated due to pulmonary or cardiovascular problems or trauma. <i>Exclusion</i> – chronic diseases, patients using muscle relaxants, temperatures over 38° C, urine output less than 30cc/ hour. Interventions: <i>Control:</i> 1 minute of pre-oxygenation 100%; Open suction (10 secs) using a 14fr catheter; 1 minute of post oxygenation <i>Experimental:</i> 1 minute of pre-oxygenation 100%; 5ml of normal saline was instilled followed by 5 ventilator breaths; Open suction (10 secs) using a 14fr catheter; 1 minute of post oxygenation Single operator (researcher) Blood gas results, pO2, pCO2, HCO3, pH, SaO2 Heart rate</p>	<p>20 patients only 42.9% were between the ages of 60-69 55% were male 40% had respiratory distress Cardiovascular disease Pulmonary distress Trauma</p>	<ul style="list-style-type: none"> • Partial decreases in pO2, pCO2, HCO3 and oxygen saturation post suctioning in saline and non-saline group, but did not reach a significant level. • No significant difference found between pH levels recorded prior to and 5min after suctioning without saline solution. • Significant increase in pH following suctioning with saline solution. • Suctioning with saline caused significant increase in heart rate in the fourth and fifth minute. • No increases were detected in non-saline group. • No significant difference in SpO2 values between groups. • No changes were of clinical significance 	<ul style="list-style-type: none"> • Limited description of study design, sample and outcomes • Possible Bias: <ul style="list-style-type: none"> • The researcher performed the suction on the patients. • Small sample number • Lack of statistical analysis • Daily blood gas was used before procedure (no time recorded) • Unclear how pre-/post-oxygenation was achieved • The data is reported as graphs only which limits the ability to assess the appropriateness of statistical analysis. • No differentiation between statistical significance and clinical difference
<p>Level of Evidence: III-2</p>				
<p>Berney, S. & Denehy, L. (2002). A comparison of the effects of manual ventilator hyperinflation on static lung compliance and sputum production in intubated and ventilated intensive care patients. <u>Physiotherapy Research International</u>, 7 (2), 100-108.</p>	<p>Prospective randomised, controlled crossover study One researcher blinded to patient treatment <i>Inclusions</i>- intubated and ventilated; pts who would normally receive hyperinflation as a part of their physio treatment. <i>Exclusions</i>- required FIO2 ≥0.6; had a PEEP ≥ 10cm H2O; had pulmonary pathology where lung hyperinflation was contraindicated e.g. ARDS, COPD; were prescribed a head-up position for brain disease; had an unstable cardiovascular condition as defined by a MAP ≤75mmHg with a fluctuation of 15mmHg with position change, a HR >130; had an arterial oxygen saturation ≤90%.</p>	<p>20 patients (17 male, 3 female) 10 acute quadriplegics 10 trauma All with respiratory failure</p>	<ul style="list-style-type: none"> • There was no significant difference in sputum wet weight between treatments (p=0.11). • Both hyperinflation techniques significantly improved pulmonary compliance (p<0.001). • There were no adverse changes in MAP, HR or SaO2 nor was there an increase in inotropic support during any treatment over the 2 days of measurement. 	<ul style="list-style-type: none"> • Although sample size was calculated and achieved the sample achieved was small and homogeneous, limiting application to these patient groups.
<p>Level of Evidence: II</p>				

Short Reference	Design/Method	Sample Description	Outcomes/Findings	Methodological Quality
<p>Bourgault, A, Brown, CA, Hains, S and Parlow JL (2006) Effects of endotracheal tube suctioning on arterial oxygen tension and heart rate variability Biological Research for Nursing, 7 (4): 268-278</p> <p>Level of Evidence: III-1</p>	<p>Cross over design repeated measures computer randomisation to treatment open or closed</p> <p>Interventions Open suction - 14G gauge suction catheter, 2 passes, 1 min pre O₂, catheter inserted until cough or resistance, with suction set at 120mmHg Closed suction</p>	<p>Convenience sample of 22 (cull to 18) Gender: 13 males/5 females Age: <65=10 - > 65=8 CAD: Yes 8 No 10 Resp D_x : 5 (+2) No Resp R_x : 13 (± 2)</p>	<p>No differences for MAP, HR, ETCO₂ & SpO₂</p>	<ul style="list-style-type: none"> • Bias <ul style="list-style-type: none"> • Sample – Heterogenous + convenience • Small sample size with limited information • Researcher not blinded • Lack of clinical meaningful outcomes. • Limited description of closed suction procedure • Unknown ETT size in relation to universal use of 14 G suction catheter
<p>Cereda M. Villa F. Colombo E. Greco G. Nacoti M. Pesenti A. (2001) Closed system endotracheal suctioning maintains lung volume during volume-controlled mechanical ventilation. Intensive Care Medicine: 27: 648-654</p> <p>Level of Evidence: III-1</p>	<p>Prospective, randomised study. Adult patients with ALI (acute lung injury), intubated & ventilated in volume-control VC) mode with PEEP at ≥5cmH₂O. <i>Exclusion:</i> bronchospasm or COPD, raised ICP, haemodynamic instability.</p> <p>Inspiratory times and trigger sensitivities similar; 20 mins between suction manoeuvres until SpO₂ stabilised; measurements taken in VC pre & post suctioning & during suctioning. ABG taken pre & post (after 2mins). Continuous data recording from 30s pre to 2mins post. No preoxygenation or hyperinflation pre or post. All suction performed at -100mmHg.</p>	<p>N=10 consecutive adult pts. ventilated on Siemens Servo 900C. PaO₂/FiO₂ 192 ± 70 PEEP 10.7 ± 3.9cmH₂O Continuous infusion sedation using Propofol or Fentanyl. Paralysed with hrly Pancuronium boluses @ 0.06mg/kg All had an arterial line insitu. 12 Fr suction catheter used in all pts.</p>	<p><u>Open suction</u> – loss in lung volume - ΔVL 1.2 ± 0.71 significantly higher than CS. Marked drop in SpO₂. Significant increase in MAP but not HR 2 mins post suction.</p> <p><u>Closed suction</u> - loss in lung volume – ΔVL 0.14 ± 0.11. Volume lost minimised by vent. trigger increasing RR & maintaining VE. Drop in SpO₂ minor. No significant increase in MAP or HR 2 mins post suction.</p>	<ul style="list-style-type: none"> • Small number of patients. • Unsafe manoeuvres used – no preoxygenation & suction for 20 secs. in pts. already identified at high risk. Also, these practices do not relate to clinical setting. • An ABG taken immediately post suction may have provided more data. • FiO₂ not recorded prior to suction for each patient.

Short Reference	Design/Method	Sample Description	Outcomes/Findings	Methodological Quality
Choi S, J., and Yee-Men Jones, A. (2005) Effects of manual hyperinflation and suctioning on respiratory mechanics in mechanically ventilated patients with ventilator-associated pneumonia, <i>Australian Journal of Physiotherapy</i> , vol 51, pp25- 29.	Convenience sample <i>Inclusion</i> – VAP requiring mechanical ventilation. <i>Exclusion</i> – ARDS, APO, acute head injury, unstable blood pressure, untreated tension pneumothorax, peak inspiratory higher than 40cmH2O or high respiratory support (FiO2> 0.7 and PEEP > 10cmH2O) Interventions: Manual hyperinflation followed by suction (manual hyperinflation plus suction) and suction alone were applied consecutively, in random order, on two occasions, four hours apart. Respiratory variables compliance and resistance were measured five times and the average value documented. Data were recorded before, immediately after and 30minutes after each intervention protocol.	15 patients Eight males Seven females Mean age 59.9 (range 25-83) Patients with ventilator associated pneumonia Ventilated	<ul style="list-style-type: none"> Compliance increased by 22% and resistance decreased by 21%, up to 30 minutes after manual hyperinflation plus suction, but not after suction alone. 	<ul style="list-style-type: none"> Poorly documented study Design Data reported Bias - Small convenience sample There would be differences in the compliance of the patients lungs with respect to age
Level of Evidence: III-2				
Combes P, Fauvage B and Oleyer C. Nosocomial pneumonia in mechanically ventilated patients, a prospective randomised evaluation of the stericath closed suctioning system. <i>Intensive Care Medicine</i> 2000 26:878-882. -	A prospective randomised study Carried out over a 40 month period <i>Inclusion</i> : No chronic chest disease Hospitalised within the last 48 hrs > 48 hrs of mechanical ventilation-predicted No active infection	Non-probability sample (consecutive pts) 104 consecutive patients Orally intubated Anti-bacterial filter (PAL) NGT in all PUD & steroid use got gastric acid prevention. Stericath S+ group = n 54 Open suction S- group = n 50	<ul style="list-style-type: none"> Univariate analysis failed to show any difference in the incidence rate of VAP between the 2 groups at the level of significance adopted. Following use of the adjusted hazard ratio estimated by multivariate analysis OSS was accompanied by a 3.5 fold higher risk of VAP (p= 0.05). VAP increased LOS (p=0.008) Prophylactic use of gastric acid secretion inhibitors significantly increased the risk of VAP 	<ul style="list-style-type: none"> OSS group received 100% O2 prior to suctioning whereas the CSS group did not. Bias: <ul style="list-style-type: none"> No CONSORT supplied Randomisation method not described Study period lengthy without description of how ongoing education of staff was completed Monitoring of staff suction techniques Control of Gastric acid inhibitors
Level of Evidence: II				

Short Reference	Design/Method	Sample Description	Outcomes/Findings	Methodological Quality															
Darvas J.A. & Hawkins L.G. (2003) The closed tracheal suction catheter: 24 hour or 48 hour change? Australian Critical Care: 16(3); 86-92	Prospective randomised controlled trial Australian JFICM 2 Sample inclusion Only pts. >16yrs of age who req'd >48 hrs ventilation. <u>Excl.:</u> extubation prior to 48hrs Admission diagnosis of pneumonia Trache tube insitu (□increased risk for VAP) <u>Interventions</u> Pts. Initially grouped into duration of stay in hospital prior to enrolment: Group 1- <72hrs Group 2 - >72hrs. Each pt. in each group was randomly assigned to 24 or 48hrs CSC change. Baseline : WCC, CXR, T°. thereafter daily. Sputum collected for analysis 2 nd daily immediately after CSC change at 0600hrs. T° per axilla-mercury thermometer-adjusted to core by adding 0.5°C.	Total recruited n=158 101 completed the study: 24hr group n=53 (52%) 48hr group n=48 (48%)	<ul style="list-style-type: none"> Groups 1&2 (length of time spent in hospital prior to enrolment) no sig. differences in demographics or outcomes. Modified criteria for diagnosis of VAP resulted in: <ul style="list-style-type: none"> 24hr group – VAP 10 (19%) 48hr group – VAP 13 (27%) p=0.35 VAP rates using original VAP criteria: Both groups = 0 VAP. Risk factors for VAP, demographics %, secondary outcomes not statistically different between the two groups. 	<ul style="list-style-type: none"> Bias <ul style="list-style-type: none"> Nurses caring for the patients unable to be blinded to the intervention groups. Time frame 29mnths did not reach numbers required for statistical power for study. Adjusted VAP diagnosis criteria according to the literature during the study to demonstrate differences between the two sets of criteria and keep up with current literature. 															
Level of Evidence: II																			
Demir, F. & Dramali, A. (2005). Requirement for 100% oxygen before and after closed suction. Journal of Advanced Nursing, 51 (3), 245-251.	Experimental, self control design Intervention 1 – no hyper oxygenation Intervention 11 – 100% O ₂ 1min before & after Sample - inclusion > 18 ventilated arterial line	30 pts 11 female 40% resp 12 post CA 6 FIO ₂ Range 30-60 (mean 0.43) PEEP mean 4 (SD 2.27) PSV 53 (n=16) VCV 36 (n=11) PCV 10 (n=3)	<table border="1"> <thead> <tr> <th></th> <th>PaO₂ before</th> <th>PaO₂ post</th> </tr> </thead> <tbody> <tr> <td>Intervention 1:</td> <td>95.49 ± 25.09</td> <td>96.65 ± 26.11</td> </tr> <tr> <td>Intervention 2</td> <td>101.71 ± 34.30</td> <td>150.09 ± 65.58</td> </tr> <tr> <td>Between interventions</td> <td colspan="2">F=20.06, P<= 0.0001</td> </tr> <tr> <td>Difference before/after</td> <td>Intervention 1 F not different</td> <td>Intervention 2 F= 17.61 p<=0.001</td> </tr> </tbody> </table>		PaO ₂ before	PaO ₂ post	Intervention 1:	95.49 ± 25.09	96.65 ± 26.11	Intervention 2	101.71 ± 34.30	150.09 ± 65.58	Between interventions	F=20.06, P<= 0.0001		Difference before/after	Intervention 1 F not different	Intervention 2 F= 17.61 p<=0.001	<ul style="list-style-type: none"> Outcome measures not clinically significant that is it doesn't address changes in parameters nor look at whether patient with higher O₂ requirements had different outcomes Small heterogenous sample. Lack of blinding or description of randomisation Measurement of outcomes not spread enough.
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Level of Evidence: III-1																			

Short Reference	Design/Method	Sample Description	Outcomes/Findings	Methodological Quality
Dyhr, T., Bonde,, J. and Larsson, A. (2003) Lung recruitment manoeuvres are effective in regaining lung volume and oxygenation after open endotracheal suctioning in acute respiratory distress syndrome, <i>Critical Care</i> , vol 7, pp. 55-62	Cross over design with patients I ETS & CR then ETS II ETS then ETS & LR All with PEEP 1 cm above lower inflection point. LR – 2 hyperinflation using CPAP? Pressure limit to 45 for 20 secs – x 2 with 1 min in between	7 ARDS 1 ALI - 1 3/5 F/M age 70 (SD7) Inclusion ALI or ARDS without exclusion Exclusion Patient history of COPD or haemodynamic unstable	Haemo dynamics – no clinical differences oxygenation +LR > - LR LR No LR PaO2 Return to baseline in 3mins Return to baseline in 7 mins EELV 5 mins ↓ 5mins (0.001) ↓ 15 mins (0.002)	<ul style="list-style-type: none"> • Patient group have diverse range of causes of ALI and were early in disease process. • Very small sample size
Level of Evidence: II				
Fernández, M., Piacentini, E., Blanch, L. & Fernández, R. (2004). Changes in lung volume with three systems of endotracheal suctioning with and without pre-oxygenation in patients with mild-to-moderate lung failure. <i>Intensive Care Med</i> , 30 221-2215	Prospective crossover study Patients were ventilated in volume control mode with a mean TV of 490± 88ml, PEEP 7± 4cmH2O and FiO2 0.36± 0.05. Suctioning was performed sequentially with a quasi-closed system, with an open system 10 min later and finally with a closed system. Thereafter, pure O2 was applied for 2 min and the whole suctioning sequence was repeated in reverse order. The techniques were not randomised so as to minimise the number of disconnections from mechanical ventilation.	Ten mechanically ventilated patients with mild-to-moderate acute respiratory failure Inclusions- patients who required mechanical ventilation for more than 48 hours due to mild-to-moderate respiratory failure (PaO2/FiO2>200mmHg) and who were under continuous sedation, orally intubated with 8.5mm ETT, and in stable clinical condition were enrolled over a 1 month period. Exclusions- suctioning induced bronchospasms, intracranial hypertension (ICP>20mmHg), and haemodynamic instability (MAP<70mmHg)..	<ul style="list-style-type: none"> • The reductions in lung volume during suctioning were similar with the quasi-closed and closed system, but significantly higher with the open system. • No significant haemodynamic effects or SpO2 reductions with all the studied suctioning techniques were found. • Pre-oxygenation with 100% O2 did not induce additive effects in lung volume changes. • With and without pre-oxygenation, lung volume returned to baseline in every patient within 10 mins. 	<ul style="list-style-type: none"> • Limited description of sample. • Effects of sequential treatment
Level of Evidence: III-1				

Short Reference	Design/Method	Sample Description	Outcomes/Findings	Methodological Quality																																
Gemma, M., Tommasino, C., Cerri, M., Giannotti, A., Piazzi, B., Borghi, T. (2002) Intracranial Effects of Endotracheal Suctioning in the Acute Phase of Head Injury, <i>Journal of Neurosurgical Anaesthesiology</i> , 14(1), pp. 50 –54	Prospective descriptive study Single pass ETS (endotracheal suction) manoeuvre (with 16-French catheter, negative pressure of 100mmHg, and duration of less than 30sec) was performed 60sec after the FiO2 was increased to 100%. After ETS, FiO2 was maintained at 100% for another 30sec.	Seventeen patients with severe head injury (Glasgow Coma Score <8, range 4-8), sedated and mechanically ventilated were studied during the first week after trauma. Female= 5 Male = 12 Craniotomy = 6	<ul style="list-style-type: none"> Endotracheal suctioning increased ICP, and the increase was more pronounced when sedation was inadequate (p<0.0001) When sedation was inadequate, CPP and S_jO₂ showed a significant reduction from well-sedated patients (p=0.003, and p<0.0001 respectively). 	Small convenience sample with large age range Not all patients were treated similar, Variations in medical regimens and levels of GCS.																																
Level of Evidence: IV	Inclusion- severe head injury (GCS<8) Exclusion – Patients with severe pulmonary failure caused by thoracic trauma or pre-existing disease, or with GCS =3.																																			
Guglielminotti J., Alzieu, M., Maury, E., Guidet, B. & Offenstadt, G. 2000. 'Bedside detection of retained tracheobronchial secretions in patients receiving mechanical ventilation: It is time for Tracheal Suctioning? Chest 118: 1095-1099.	Prospective observational study. All consecutive patients receiving mechanical ventilation. Interventions 1) tracheal suction then 2) Assess Ramsay Score, Ppeak, VT + SpO ₂ 3) Tracheal suction 2 these parameters were measured prior – 2/24 intervals. Retained secretions were considered significant if the volume of secretions removed by tracheal suction 2 was > 0.5 ml.	<ul style="list-style-type: none"> N=66 Mechanically ventilated patients with either a cuffed translaryngeal tube or through a cuffed tracheostomy tube Patients studied in a supine position with a 30° head lift inclination. 	<table border="1"> <thead> <tr> <th></th> <th>Sawtooth Pattern</th> <th>Resp sounds</th> <th>Combined</th> </tr> </thead> <tbody> <tr> <td>Sensitivity</td> <td>0.82</td> <td>0.66</td> <td>0.59</td> </tr> <tr> <td>Specificity</td> <td>0.70</td> <td>0.74</td> <td>0.96</td> </tr> <tr> <td>Pos pred value</td> <td>0.80</td> <td>0.78</td> <td>0.96</td> </tr> <tr> <td>Neg pred Value</td> <td>0.73</td> <td>0.60</td> <td>0.62</td> </tr> <tr> <td>LR# pos test</td> <td>2.7</td> <td>2.50</td> <td>14.7</td> </tr> <tr> <td>LR# neg test</td> <td>0.25</td> <td>0.45</td> <td>0.42</td> </tr> <tr> <td># LR likelihood ratio</td> <td></td> <td></td> <td></td> </tr> </tbody> </table>		Sawtooth Pattern	Resp sounds	Combined	Sensitivity	0.82	0.66	0.59	Specificity	0.70	0.74	0.96	Pos pred value	0.80	0.78	0.96	Neg pred Value	0.73	0.60	0.62	LR# pos test	2.7	2.50	14.7	LR# neg test	0.25	0.45	0.42	# LR likelihood ratio				<ul style="list-style-type: none"> Measurement bias <ul style="list-style-type: none"> Although 2 observers started the study and were in agreement for the first 20 patients the balance of observations were done by a single observer Observer not blinded Classification of retained secretions Selection bias <ul style="list-style-type: none"> Consecutive patients Small sample size Suction practice
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<p>Ji, Y, Hee-Seung Kim, & Jeong-Hwan Park. (2002). Instillation of normal saline before suctioning in patients with pneumonia. <i>Yonsei Medical Journal</i>, 43 (5), 607-612.</p> <p>Level of evidence III-1</p>	<p>Repeated-measure design. Subjects served as their own control. All 3 (0, 2 & 5ml) saline instillation methods were applied to the 16 patients, and were randomly assigned to patients: 1) no normal saline instilled before suctioning; 2) 2ml saline instilled before suctioning; 3) 5ml saline instilled before suctioning. After the procedure, patients rested for 80 minutes. No hyperinflation or hyperventilation were applied during the investigation.</p>	<p>21 patients who were admitted between September 1999 and February 2000. Of the 21 subjects, 16 pneumonic patients with a tracheostomy who had been admitted to the neurosurgical ICU at a University hospital in Seoul Korea completed the study. 1 subject was dropped due to loss of data during data collection, and 4 were excluded due to non-pneumonic conditions.</p>	<ul style="list-style-type: none"> The oxygen saturation values significantly different with the various saline volumes ($p=0.02$), and the times to oxygen saturation recorded ($p=0.0006$) with the patients, but there was interaction between saline volume and suction time ($p=0.002$). SaO₂ did not fall below 96% for any suction volume 	<ul style="list-style-type: none"> Patient consent not mentioned. Sample size calculation not mentioned/not attended. Blinding not mentioned Clinical meaningful outcome
<p>Lasocki, S, Lu, Q, Sartorius, A, Fouillat, D, Remterand, F and Rouby, J. (2006) Open and closed-circuit endotracheal suctioning: efficiency and effects on gas exchange. <i>Anesthesiology</i>, vol 104, np 1, pp. 39-47.</p> <p>Level of Evidence III-1</p>	<p>Cross over study</p> <p>Ventilated adults with acute lung injury (ie patients PF ratio less than 300, no evidence of LFF as demonstrated by PAOP and LVEF). Head injuries excluded.</p>	<p>18 adult mechanically ventilated patients with acute lung injury of a direct pulmonary origin.</p>	<ul style="list-style-type: none"> Open suctioning resulted in a significantly greater decline in PaO₂ than closed suctioning. The volume of secretions suctioned from the ETT was less with the closed suction technique. The volume of tracheal aspirate with closed suction could be increased by increasing the suction to 400 mmHg from 200 mmHg without any deterioration in oxygenation. 	<ul style="list-style-type: none"> Small sample size. The authors tend to use mmHg and cms of H₂O interchangeably. Therefore it is not clear whether they used 200 and 400 mmHg or cms H₂O of suction in their study. The inflection points were not included for all patients. PaO₂ was only monitored for 16 mins.

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<p>Leur, J., Zwaveling, J., Loef, B., Schans, C. (2003) Endotracheal suctioning versus minimally invasive airway suctioning in intubated patients: a prospective randomised controlled trial, Intensive Care Medicine, 29, 426-432</p>	<p>RCT Routine endotracheal suction (RES) or Minimally invasive airway suction (MIAS) Exclusion intubated elsewhere required closed suction (?) lung transplant non-regular ETT ARDS RES – tds - pre O2 manual - disconnect hyperventilation - suction 200/400 3 secs + saline + - manual hyperventilator - x 3 cycles - 49 cm catheter MIAS – audible or visible secretions 29 cm catheter suction without pre oxygenation, manual hyperinflation or saline</p>	<p>N (M/F) RES - 197 (72/28) MIAS - 186 (71/29) Equal distribution for age, Apache II, smoking Hx of Pulm PA, Emergency admission Trauma/medical/surgical patients</p>	<ul style="list-style-type: none"> No difference on primary/2nd outcomes in intention to treatment <table border="1"> <thead> <tr> <th colspan="4">Adverse events (intention to treat)</th> </tr> <tr> <th></th> <th>RES</th> <th>MIAS</th> <th>P value</th> </tr> </thead> <tbody> <tr> <td>N of interventions</td> <td>7 827</td> <td>7 395</td> <td></td> </tr> <tr> <td>Decrease in SpO2(%)</td> <td>2.7</td> <td>2.0</td> <td>0.010</td> </tr> <tr> <td>Bradycardia (%)</td> <td>0.1</td> <td>2.0</td> <td>0.240</td> </tr> <tr> <td>Arrhythmia (%)</td> <td>6.6</td> <td>7.9</td> <td>0.002</td> </tr> <tr> <td>Increase SBP(%)</td> <td>24.5</td> <td>16.8</td> <td><0.001</td> </tr> <tr> <td>Increase in PPR(%)</td> <td>1.4</td> <td>0.9</td> <td>0.007</td> </tr> <tr> <td>Blood in mucus(%)</td> <td>3.3</td> <td>0.9</td> <td><0.001</td> </tr> <tr> <td>Protocol violation</td> <td>RES 32%(63)</td> <td>MIAS 56%(105)</td> <td></td> </tr> </tbody> </table>	Adverse events (intention to treat)					RES	MIAS	P value	N of interventions	7 827	7 395		Decrease in SpO2(%)	2.7	2.0	0.010	Bradycardia (%)	0.1	2.0	0.240	Arrhythmia (%)	6.6	7.9	0.002	Increase SBP(%)	24.5	16.8	<0.001	Increase in PPR(%)	1.4	0.9	0.007	Blood in mucus(%)	3.3	0.9	<0.001	Protocol violation	RES 32%(63)	MIAS 56%(105)		<ul style="list-style-type: none"> Limited or no description of some confounding variables including actual diagnosis, haemodynamic status and use of vasoactive drugs, sedation and sedation levels, patient position and physio Questionable homogeneity of groups especially diagnosis Clinical significance of Adverse Events such as BP & PPR & SaO2 is questionable Volume of protocol violation Data Collection
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<p>Lorente L. Lecuona M. Martin M. Garcia C. Mora M. Sierra A. (2005) Ventilator-associated pneumonia using a closed versus open tracheal suction system. Critical Care Medicine; 33:1: 115-119</p>	<p>Prospective randomised study. Throat swab on admission to ICU; twice weekly thereafter & at discharge. Tracheal aspirate on intubation, twice weekly thereafter & at extubation. Sampling in this way was to identify endogenous (bacteria colonising the throat) vs. exogenous (bacteria not found in throat swabs) VAP. VAP incidence put into category of time it developed: 1-2, 3-4, 5-9, 10-14, 15-19, 19-24, & ≥ 25days.</p>	<p>Total 443 patients 210 – closed tracheal suction system 233 – open tracheal suction system. All humidified using HME – changed 48hrly. Open suction, single catheter each time, sterile gloves, mask. Closed suction system changed 24hrly No routine change of resp. circuit, Semirecumbent body position, Continuous enteric feeding with periodic residual gastric volumes. Ranitidine (stress ulcer prophylaxis) Oral care with chlorhexidine No cont. subglottic aspiration</p>	<ul style="list-style-type: none"> No significant differences were found in either the percentage of patients who developed VAP (20.47% CS to 18.02% OS) or in the number of VAP cases per 1000 mechanical ventilation days (17.59 CS vs. 15.84 OS) No differences for VAP incidence for duration of mech. vent. between groups. No difference in the two groups for exogenous VAP. No differences in causal micro-organisms between the two groups. Cost for closed vs. open suction more expensive p<0.001. 	<ul style="list-style-type: none"> Strong. Risk factors for VAP were accounted for and practices to avert these used as described in the "sample description" box; previous studies have not used these measures. Numbers required exceeded requirements to power the study. As with all studies related to diagnosis of VAP, controversy exists. 																																								
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<p>Maggiore, SM, Lellouche, F., Pigeot, J., Taille, S., Deye, N., Durrmeyer, X., Richard, J., Mancebo, J., Lemaire, F., and Brochard, L. (2003) Prevention of Endotracheal Suctioning- induced Alveolar Derecruitment in Acute Lung Injury, <i>American Journal of Respiratory and Critical Care Medicine</i>; 167: 1215-1224</p> <p>Level of Evidence: III-1</p>	<p>Prospective randomised crossover design</p> <p>Suction performed by</p> <ol style="list-style-type: none"> 1. disconnection 2. via swivel mount 3. closed 4. swivel & PSV 40cm 5. closed & PSV <p>Suction methods performed in random order at least 30 minutes apart</p> <p>Size 14 gauge catheter</p> <p>Suction manoeuvre 25-30 seconds</p> <p>Negative pressure -200cmH2O</p>	<p>9 patients sedated/paralysed & mechanically ventilated by volume control Inclusion</p> <p>Fulfil ALI/ARDS criteria</p> <p>Exclusion</p> <p>Leaking chest tube, CI to sedation/paralysis, resp or CN instability last 6 hrs.</p>	<table border="1"> <thead> <tr> <th></th> <th>1</th> <th>2</th> <th>3</th> <th>4</th> <th>5</th> </tr> </thead> <tbody> <tr> <td>EELV</td> <td>-1466 ±586</td> <td>-733 ±406</td> <td>-531 ±228</td> <td>-168 ±176</td> <td>-284 ±317</td> </tr> <tr> <td colspan="6">Differences 1-3 p<0.001 Not significant between 4 and 5 Positive correlation between external PEEP and LV fall ($\rho = 0.7$, p<0.05)</td> </tr> <tr> <td>SaO2 %</td> <td>-9.2 ±7.6</td> <td>-1.7 ±0.9</td> <td>-2.2 ±2.7</td> <td>-1.5 ±0.6</td> <td>-1.3 ±0.6</td> </tr> <tr> <td colspan="6">Fall was significant (p<0.001) Positive correlation between decrease and alveolar recruitment ($\rho = 0.44$, p<0.01) Positive correlation between decrease and EELV ($\rho = 0.43$, p<0.01)</td> </tr> </tbody> </table>		1	2	3	4	5	EELV	-1466 ±586	-733 ±406	-531 ±228	-168 ±176	-284 ±317	Differences 1-3 p<0.001 Not significant between 4 and 5 Positive correlation between external PEEP and LV fall ($\rho = 0.7$, p<0.05)						SaO2 %	-9.2 ±7.6	-1.7 ±0.9	-2.2 ±2.7	-1.5 ±0.6	-1.3 ±0.6	Fall was significant (p<0.001) Positive correlation between decrease and alveolar recruitment ($\rho = 0.44$, p<0.01) Positive correlation between decrease and EELV ($\rho = 0.43$, p<0.01)						<p>Measurement bias</p> <ul style="list-style-type: none"> • Only 30 mins between interventions • 2 patients, 1 day vent, 1 day ALI & survived? • heterogeneity of sample • sample size not calculated • Length of suction procedure is excessive compared to Australian practice
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<p>Rabitsch W. Kostler J. Fiebiger W. Dielacher C. Losert H. Sherif C. Staudinger T. Seper E. Koller W. Daxbock F. Schuster E. Knobl P. Burgmann H. & Frass M. (2004) Closed suctioning system reduces cross-contamination between bronchial and gastric juices. <i>Anesth Analg</i>: 99: 886-892.</p> <p>Level of Evidence: III-1</p>	<p>Prospective randomised study.</p> <p>Antibiograms of aspirates from the VETT (visualised endotracheal tube) and feeding tube on days 1 & 3 were performed for genetic identity.</p> <p>Oxygen saturations (SaO2) were recorded pre & post suctioning.</p> <p>Assessment of quantity of mucous visualised via VETT.</p>	<p>N = 24 consecutive patients.</p> <p>Randomised to OS n=12 or CS n=12.</p> <p>All on controlled ventilation or bilevel.</p> <p>CS catheters changed 24hrly.</p> <p>Inclusion: estimated length of ventilation ≥ 3 days; >18 yrs of age.</p> <p>Exclusion: bleeding diathesis; participation in another study; severe respiratory distress not allowing replacements of ETT with visualised ETT (VETT).</p>	<p>Open suction group - 5 cross-contaminations on day 3 vs day 1 the 5 strains shared common genotypes.</p> <ul style="list-style-type: none"> • VAP = 5 • SpO2 – significant decrease with suctioning. <p>Closed suction group- no cross-contamination.</p> <ul style="list-style-type: none"> • VAP = 0 • SpO2 – significantly higher than OS group. 	<ul style="list-style-type: none"> • Confounding variables 40cm • Reintubation • Open suction technique may be flawed due to the large numbers of VAP in that group. • “flushes” ? instillation of saline. If so this is not possible in Closed suctioning, yet data collected claims no difference for this between groups. This may be a translation (from German) problem which can lead to confusion. • Small numbers – room for bias. 																														

Short Reference	Design/Method	Sample Description	Outcomes/Findings	Methodological Quality
<p>Stoller J.K. Orens D.K. Fatica C. Elliot M. Kester L. Woods J. Hoffman-Hogg L. Karafa M.T. Arroliga A.C. (2003) Weekly versus daily changes of in-line suction catheters: Impact on rates of ventilator-associated pneumonia and associated costs. Respiratory Care; 48 (5): 494-499.</p> <p>Level of Evidence: III-3</p>	<p>Observational cohort study. Control period (daily change) vs treatment period (weekly change) Study periods conducted during the same seasons each year to discount seasonal effects. Vent. tubing changes 7th daily. Humidifiers same over study periods. P-Bennett 7200. Standard sedation and weaning protocols No use of sub-glottic suction.</p>	<p>Total recruited n=289 Pre-intervention adult intubated patients study period n=146. Treatment study period n=143.</p>	<ul style="list-style-type: none"> Control period - VAP n=2 Treatment period VAP n=0 (p=0.50) Secondary outcomes – trend toward shorter ICU LOS p=0.42; fewer ICU readmissions within 24 hrs p=0.53; episodes of bacteraemia equal. Cost of in-line suction catheter control period \$US6,026, vs treatment period \$US1,330 P<0.001. 51% of pts had the same catheter for >3 days (4-9 days) ±SD 3.8-0.8 days. 	<ul style="list-style-type: none"> Short study periods reduce the power of the study. Numbers to treat not calculated. Nursing staff not able to be blinded, room for change in practice and thus bias. Small VAP numbers, ? relates to use of criteria to diagnose VAP.
<p>Topeli A et al (2004) Comparison of the effect of closed versus open endotracheal suction systems on the development of ventilator-associated pneumonia Journal of Hospital Infection, 58(1): 14-9.</p> <p>Level of Evidence: III-1</p>	<p>A prospective, randomised, controlled trial. Open versus closed suction Outcome: VAP Inclusion mechanical ventilation for more than 48 hrs between 1/4/2000 & 31/8/2001. Exclusion: Terminally ill patients with malignancy, documented nosocomial pneumonia at admission, patients intubated more than 48 hrs prior to admission</p>	<p>Closed suction N=41 Open suction N=37 Cultures taken from ventilator tubing of 42 patients.</p>	<ul style="list-style-type: none"> 13 patients in open suction & 16 patients in closed suction became colonised. No difference between the groups in frequency of development of VAP, mobility or length of stay & duration of mechanical ventilation. 	<ul style="list-style-type: none"> Randomisation is questionable Multivariate analysis: development of VAP & high APACHE II score.
<p>Zeitoun, S, Barros, A, Diccini, S, (2003) A prospective, randomised study of ventilator-associated pneumonia in patients using a closed vs open suction system. Journal of Clinical Nursing, vol 12, pp 484-489. - Reviewer 3</p> <p>Level of Evidence III-1</p>	<p>RCT Patients older than 13 who were mechanically ventilated for more than 48 hours. Patients were excluded if they were intubated at another hospital, pulmonary infection at the time of admission, HIV or neutropenia, and required early reintubation.</p>	<p>N=47 Open suctioning = 24 Closed suctioning = 23</p>	<p>Open suction VAP 11 Closed suction VAP 7</p>	<ul style="list-style-type: none"> Selection bias Measurement bias Randomisation method open to bias Unknown if those measuring outcomes were blinded Control of confounders is not described

Review Name	Review Question / Outcomes	Search Strategy	Findings	Limitations																											
Thompson, L, (2000) "Suctioning adults with an artificial airway" The Joanna Briggs Institute for evidence based nursing and midwifery, Adelaide, South Australia. <i>Population</i> patients > 15 years within the acute care setting with either an endotracheal or tracheostomy tube insitu. The studies included both spontaneously breathing and / or artificially ventilated patients.	Which methods of suctioning reduce the prevalence of mucosal trauma or mucosal dysfunction and promote the removal of respiratory secretions? Which techniques / methods are effective in reducing the occurrence of suctioning-induced hypoxaemia, during or following the suctioning procedure? Which techniques/methods are effective in minimising the haemodynamic or pulmonary complications associated with the suctioning procedure?	<i>Keyword/s (list)</i> Respiration, artificial, ventilation, mechanical, intubation, endotracheal, intratracheal, tracheostomy, tracheotomy, artificial airway, suction <i>Databases:</i> CINAHL 1982-March 1999 Medline 1966-1999 Embase 1980 – March 1999 Cochrane – March 1999 Ovid databases issues available to March 1999 Sliverplatter databases March 1999 No hand search	<ol style="list-style-type: none"> Suction when clinical indicated – Grade C Aseptic technique should be considered an essential component for hospitalised patients – Grade D Suction catheter diameter should not occlude more than half of the internal diameter of the artificial airway – Grade C Duration of suctioning should be limited to <10-15 seconds – Grade D Hyper oxygenation can minimise hypoxia – Grade C Allow for washout time on ventilators – Grade C If possible the ventilator should be used to provide hyper oxygenation/hyperinflation – Grade C Hyperinflation sequences should be limited to two per session to limit adverse haemodynamic effects – Grade B For patients with a raised ICP consider paced rather than consolidated care activities – Grade C Limiting the suctioning to only 2 passes with duration of 10 seconds or less plus adequate preoxygenation in patients with cerebral hypertension. - Grade C 	<ul style="list-style-type: none"> Review of potential harmful effects of 100% oxygen to cause absorption atelectasis not included. No discussion / review of the effects of suction on alveolar recruitment and the effect on ventilatory strategies such as the "open lung" approach 																											
Level of Evidence: I				<table border="1"> <thead> <tr> <th>Grade of rec</th> <th>Level of evidence</th> <th>Therapy/Prevention Aetiology / Harm</th> </tr> </thead> <tbody> <tr> <td rowspan="3">A</td> <td>1a</td> <td>Systematic review (with homogeneity of RCT)</td> </tr> <tr> <td>1b</td> <td>Individual RCT (narrow CI)</td> </tr> <tr> <td>1c</td> <td>All or none</td> </tr> <tr> <td rowspan="5">B</td> <td>2a</td> <td>SR (with homogeneity of cohort)</td> </tr> <tr> <td>2b</td> <td>Individual cohort (incl low quality RCT)</td> </tr> <tr> <td>2c</td> <td>'Outcomes' research</td> </tr> <tr> <td>3a</td> <td>SR (with homogeneity of casecontrol)</td> </tr> <tr> <td>3b</td> <td>Individual casecontrol</td> </tr> <tr> <td>C</td> <td>4</td> <td>Case-series (poor quality cohort or casecontrol)</td> </tr> <tr> <td>D</td> <td>5</td> <td>Expert opinion without explicit critical appraisal or based on physiology, bench research or 'first principles.</td> </tr> </tbody> </table>	Grade of rec	Level of evidence	Therapy/Prevention Aetiology / Harm	A	1a	Systematic review (with homogeneity of RCT)	1b	Individual RCT (narrow CI)	1c	All or none	B	2a	SR (with homogeneity of cohort)	2b	Individual cohort (incl low quality RCT)	2c	'Outcomes' research	3a	SR (with homogeneity of casecontrol)	3b	Individual casecontrol	C	4	Case-series (poor quality cohort or casecontrol)	D	5	Expert opinion without explicit critical appraisal or based on physiology, bench research or 'first principles.
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Table 10: Summary of Research not included

Paper Name	Reasons for Non Inclusion
Babcock H.M. Zack J.E. Garrison T. Trovillion E. Jones M. Fraser V.J. & Kollef M. H. (2004) An educational intervention to reduce ventilator-associated pneumonia in an integrated health system: A comparison of effects. <i>Chest</i> : 125: 2224-2231. Reviewer 5	Not about suctioning
Donald, K., Robertson, V., and Tsebelis, K. (2000) Setting safe and effective suction pressure: the effect of using a manometer in the suction circuit, <i>Intensive Care Medicine</i> , 26, pp 15- 19. Reviewer 1	Not applicable to PICO
Celik SS and Elbas NO (2000) The standard of suction for patients undergoing endotracheal intubation. <i>Intensive and Critical Care Nursing</i> , 16 (3): 191-198	Poor quality RCT conducted in a context dissimilar to Australia.
Day T., Farnell S., Haynes, S. Wainwright S., Wilson-Barnett J. (2002) Tracheal suctioning an exploration of nurses knowledge and competence in acute and high dependency ward area. <i>Journal of Advanced Nursing</i> 39 (1) 35-45. Reviewer 7	Does not apply to guideline population
Freytag C. C. Thies F.L. König W. & Welte T. (2003) Prolonged application of closed in-line suction catheters increases microbial colonisation of the lower respiratory tract and bacterial growth on catheter surface. <i>Infection</i> : 31: 31-37.	Small sample size with complex methodology High risk of measurement bias Clinical practices stated incongruent
Girou G et al (2004) Airway colonisation in long-term mechanically ventilated patients. Effect of semi-recumbent position & continuous subglottic suctioning. <i>Intensive Care Med</i> 30: 225-233	Sub glottic suction excluded after reviews done
Glass C, Grap MJ & Sessler CN. (1999) Endotracheal tube narrowing after closed-system suctioning: prevalence and risk factors. <i>American Journal of Critical Care</i> . Mar; 8(2): 93-100.	Small Convenience sample No comparison with ETT using open suction
Hess, D, Kallstrom, T, Mottram, C, Myers, T, Sorenson, H, and Vines, D. (2003) Care of the ventilator circuit and its relation to ventilator-associated pneumonia. <i>Respiratory Care</i> , September, vol. 48, No. 9, pp 869-879.	Unable to apply recommendations to this guideline
Jongerden, I. P., Rovers, M. M., Grypdonck, M. H. and Bonten, M. J. M. (2007) Open and closed endotracheal suction systems in mechanically ventilated intensive care patients: a meta-analysis. <i>Critical Care Medicine</i> , 35(1), 260-270.	Heterogeneity of studies
Kollef MH, Nikolaos J. Skubas and Thoralf M. Sundt (1999) A randomised clinical trial of continuous aspiration of subglottic secretions in cardiac surgery patients. <i>Chest</i> 116: 1339-1346.	Sub glottic suction excluded after reviews done
Leone, M., Rousseau, S., Avidan, M., Delmas, A., Viviand, X., Guyot, L. and Martin, C. (2004) Target concentrations of remifentanyl with propofol to blunt coughing during intubation, cuff inflation and tracheal suctioning, <i>British Journal of Anaesthesia</i> , 93(5) pp. 660-3.	Scope of document does not include sedation
McKillop, 2004, "Evaluation of the implementation of a best practice information sheet: tracheal suctioning of adults with an artificial airway" <i>JBI Reports</i> , pp293-308.	About implementation
McNarry, A.F. and Goldhill D.R (2004) Evaluation of the Blue Line Ultra™ Suctionaid™ tracheostomy tube. <i>Care of the Critically Ill</i> , 20(3).	Specifically about a particular tracheostomy tube
Oh, H. and Whasook, S. (2003) A meta - analysis of the effects of various interventions in preventing endotracheal suction - induced hypoxemia, <i>Journal of Clinical Nursing</i> 12: 912-924.	Question not clearly stated No report on validity criteria
Pogson DG & Shirley PJ (2002) Hypoxaemia during tracheal suctioning: comparison of closed versus open techniques at varying PEEP CCForum: downloaded from http://ccforum.com/supplements/6/S1 July 17 2006	Study published as abstract only
Shah, S., Fung, K., Brim, S. & Rubin, B.K. (2005). An in vitro evaluation of the effectiveness of endotracheal suction catheters. <i>Chest</i> , 128 (5), 3699-3704.	Bench test of no value
Shorr A. & O'Malley P. (2001) Continuous subglottic suctioning for the prevention of ventilator associated pneumonia: potential economic implications. <i>Chest</i> : 119: 228-235.	Sub glottic suction excluded after reviews done
Smulders et al. (2002) A randomised clinical trial of intermittent subglottic secretion drainage in patients receiving mechanical ventilation. <i>CHEST</i> , 121: 858-862.	Sub glottic suction excluded after reviews done
Sole (2003) A multisite survey of suctioning techniques and airway management practices. <i>AMJ of Crit Care</i> 11 (2) 141-149.	Did not observe practice
Sole, ML et al. (2002a). Bacterial growth in secretions and on suctioning equipment of orally intubated patients: a pilot study. <i>Am. J. Critical Care</i> 11 (2) 141-149.	Small study
Sole, ML et al. (2002b). Suctioning Techniques and airway management practices; a pilot study. <i>Am J Critical Care</i> 11 (4) 364-368.	Did not observe practice
Stenquist O. Lindgren S. Karason S. Sondergaard S. and Lundin S. (2001) Warning! Suctioning. A lung model evaluation of closed suctioning systems. <i>Acta Anaesthesiol Scand</i> ; 45: 167-172	Animal model that did not represent complex lung physiology
Vonberg, R., Eckmans, T., Welte, T. and Gastmeier, P. (2006) Impact of the suctioning system (open vs. closed) on the incidence of ventilation-associated pneumonia: meta-analysis of randomized controlled trials. <i>Intensive Care Medicine</i> , 32, 1329-1335.	Heterogeneity of studies

Reviews – systematic and narrative

- Use one per article which is a review of the literature.
- Please be brief. Cell size is locked so add text; use a smaller font size to fit your conclusions in.
- Where yes/no is asked for, text can be added to flesh out answer.
- Where a number exists, please refer to the expanded question.
- For the databases searched please add a tick and describe the hand search strategy.

1. Is there an explicit review plan documented? Was an explicit search strategy documented?
2. Was an explicit article review method used?
3. Were points 1-3 covered adequately?
4. Does the summary of each reviewed study reflect the essential components of the study design, research process and analysis techniques?
5. Is the organisation of the reviewed studies chronological and logical?
6. Does the organisation of the reviewed studies lead the reader to the same conclusions as the authors?

Full Reference ⇨			
1 - Review Plan - yes/no		3 - Review Method - yes/no	
Clinical Question -		What was the article review method?	
→ Population -		Are all the relevant concepts and variables included? yes/no	
→ Intervention/s		5 - Summary yes/no	
→ Outcome/s		6 - Organisation chronological/logical? yes/no	
2 - Search Strategy		4 Quality of the review –	
Keyword/s (list)		Limits (list)	
Search Time Line		Are the conclusions of the authors warranted? Yes/no & discuss	
Data Bases – adequate? Y/N		Please tick list below <input checked="" type="checkbox"/>	
CINAHL	Pubmed	Embase	Cochrane
Psych info	DARE	Hand search	Other
		7- Organisation ⇨ Conclusions? yes/no	
		What are the key findings of the Review?	

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