Abstract of thesis entitled

Implementation and evaluation of evidence-based practice guidelines for open endotracheal suctioning in mechanically-ventilated adult patients

Submitted by

Tang Alvin Siu Ting

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at The University of Hong Kong in July 2013

Endotracheal suctioning is a procedure performed on a daily basis in hospitals, and is mostly take place in intensive care units (ICUs). (Annapoorna, 2005; Day et al, 2009). It helps removing sputum or secretion out from patients’ trachea. For patients who are under mechanical ventilation, this procedure is vital to maintain their airway patency when they are intubated with endotracheal tube or tracheostomized (Finucane & Santora, 2003). However, the procedure has its own risk and complications such as hypoxaemia, atelectasis, cardiovascular instability and more (Thomson, 2000). There are in general two types of endotracheal suctioning: open and closed system. As disconnection of mechanical ventilation from patients is needed for open endotracheal suctioning (OES), it has a higher risk of complications. However, the cost for OES is much cheaper compared to the closed system. Although OES is widely used in Hong Kong, there is no evidence-based guideline for nurses to follow. The guideline developed by American Association of Respiratory Care (2010) is lack of specificity on the target population and its recommendations were based on mixed literatures
targeting on adult and infant patients. Therefore, the aim of this dissertation is to
develop an evidence-based guideline for OES in adult patients under mechanical
ventilation in ICU.

To develop a guideline for OES, search was performed in multiple electronic
databases (British Nursing Index, CINAHL, Cochrane Library, Ovid MEDLINE, and
PubMed) with keywords related to OES and its complications. A total of 457 studies
fulfilled the inclusion criteria and 11 of them were selected. The selected studies were
evaluated by quality appraisal checklists, which are developed by Scottish
Intercollegiate Guidelines Network (SIGN). Data were extracted for developing the
guideline.

Evidence have shown that the incidence of post-OES hypoxemia can be reduced
by performing hyperoxygenation with 100% oxygen for 4-6 breaths prior and after
each open endotracheal suction, accompanying with hyperinflation with 150% of
patient’s tidal volume at most 8 breaths/40 seconds delivered by ventilator and
prohibiting normal saline instillation into trachea for diluting the sputum. The grades
of the recommendations in the guideline were rated with using of the SIGN grading
system. The implementation potential was analyzed by the patients’ characteristics,
transferability of the findings, feasibility of implementation and cost-benefit ratio.

A 12-month implementation program was developed including communication
with stakeholders, 4-week pilot testing, and training of ICU staffs, and implementation of OES guideline. The effectiveness of the guideline will be evaluated based on the primary outcome (i.e. oxygen level in blood) for detecting the incidence of hypoxemia. Also, the acceptability of the guideline, compliance of the guideline, financial cost reduction and better quality of service will be used as other evaluation indicators.
Implementation and evaluation of evidence-based practice guidelines for open endotracheal suctioning in mechanically-ventilated adult patients

by

Tang Alvin Siu Ting

A thesis submitted in partial fulfilment of the requirement for the Degree of Master of Nursing at The University of Hong Kong.

July 2013
Declaration

I declare that this thesis represents my own work, except where due acknowledgement is given and that it has not been previously included in a thesis, dissertation or report submitted to this University or to any other institution for a degree, diploma or other qualifications.

Signed …………………………………………………

Tang Alvin Siu Ting
Acknowledgments

I would like to give a big thank my supervisors, Dr. Marie Tarrant, Dr. Noel Chan, for guiding me throughout most of the dissertation process in the past one and a half year. Also, I would like to thank Dr. Sharon Leung, who guided me for the first half year of my dissertation and then left The University of Hong Kong. Without their sincere helps with invaluable insights, suggestions and supports, I could not have finished this dissertation on my own.
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<table>
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<th>Acronym used</th>
<th>Full Term</th>
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<tbody>
<tr>
<td>APN</td>
<td>Advanced Practice Nurse</td>
</tr>
<tr>
<td>BNI</td>
<td>British Nursing Index</td>
</tr>
<tr>
<td>CO₂</td>
<td>Carbon dioxide</td>
</tr>
<tr>
<td>COS</td>
<td>Chief-of-service</td>
</tr>
<tr>
<td>DOM</td>
<td>Department Operation Manager</td>
</tr>
<tr>
<td>ETS</td>
<td>Endotracheal suctioning</td>
</tr>
<tr>
<td>ETT</td>
<td>Endotracheal tube</td>
</tr>
<tr>
<td>HCO₃</td>
<td>Hydrogen bicarbonate</td>
</tr>
<tr>
<td>ICU</td>
<td>Intensive care unit</td>
</tr>
<tr>
<td>ICP</td>
<td>Intracranial pressure</td>
</tr>
<tr>
<td>MHI</td>
<td>Manual hyperinflation</td>
</tr>
<tr>
<td>MRB</td>
<td>Manual rebreathing bag</td>
</tr>
<tr>
<td>MAP</td>
<td>Mean arterial pressure</td>
</tr>
<tr>
<td>NSI</td>
<td>Normal saline instillation</td>
</tr>
<tr>
<td>NC</td>
<td>Nursing Consultant</td>
</tr>
<tr>
<td>NO</td>
<td>Nursing Officer</td>
</tr>
<tr>
<td>NS</td>
<td>Nursing Specialist</td>
</tr>
<tr>
<td>OES</td>
<td>Open endotracheal suction</td>
</tr>
<tr>
<td>PYNEH</td>
<td>Pamela Youde Nethersole Hospital</td>
</tr>
<tr>
<td>PaCO₂</td>
<td>Partial pressure of blood carbon dioxide</td>
</tr>
<tr>
<td>PaO₂</td>
<td>Partial pressure of blood oxygen</td>
</tr>
<tr>
<td>RCT</td>
<td>Randomized controlled trial</td>
</tr>
<tr>
<td>RCO</td>
<td>Randomized crossover trial</td>
</tr>
<tr>
<td>SaO₂</td>
<td>Saturation of oxygen in arteriole</td>
</tr>
<tr>
<td>SvO₂</td>
<td>Saturation of oxygen in venuole</td>
</tr>
<tr>
<td>SIGN</td>
<td>Scottish Intercollegiate Guidelines Network</td>
</tr>
<tr>
<td>VHI</td>
<td>Ventilator hyperinflation</td>
</tr>
<tr>
<td>WM</td>
<td>Ward Manager</td>
</tr>
</tbody>
</table>
Chapter 1: Statement of the Problem

**Background**

When patients experience airway obstruction or respiratory failure a, intubation of endotracheal tube would be done in order to maintain or regain patency of the airway (Finucane & Santora, 2003). The intubated patients may encounter inadequate effort in coughing out sputum from trachea, especially when patients are under mechanical ventilator support. The sputum or secretion retained inside the trachea may block the airway even though endotracheal tube is inserted. Endotracheal suctioning thus plays an important role in maintaining clearance of sputum and secretion from the airway, and so avoiding inadequate ventilation or suffocation among the patients, which are lethal.

Mechanical ventilation is widely used among the intensive care units (ICUs) in Hong Kong. In Pamela Youde Nethersole Eastern Hospital, there were 1591 patients admitted into the ICU in 2012, and 730 of them were intubated with mechanical ventilation for ventilatory support (Pamela Youde Nethersole Eastern Hospital registry, 2012). In other words, there are around 46% of the ICU patients were intubated, and endotracheal suctioning is needed to maintain the patency of their airway.

Endotracheal suctioning is performed on a daily basis in hospitals and it is one of the most frequent practices for patients with endotracheal tubes inserted (Annapoorna,
2005). It is an invasive procedure with risks and complications, including tracheal injury, chest infection, ventilator-associated pneumonia, atelectasis, hypoxemia, and cardiovascular instability (Thomson, 2000; Finucane & Santora, 2003). However, to date there is few evidence-based guidelines or protocols from the Hong Kong Hospital Authority or from the Pamela Youde Nethersole Eastern Hospital for guiding the endotracheal suctioning procedure. According to Annapoorna (2005) and Day et al (2009), if there is no well-developed guidelines or protocols, nurses would perform the procedures based on conventional practices. However, performing endotracheal suctioning without evidence-based guidelines/protocols may potentially cause harm to patients. It is because patients who require ventilator support are frailer, as their respiratory support is compromised, and prone to have complications.

The American Association of Respiratory Care (2010) have a clear illustration of their suggestions guidelines and standards of endotracheal suctioning in the protocol with evidence supported. However, the process of critical appraisal and data synthesis was not shown in the guideline. In addition, the estimated effect size was not reported. The protocol did not provide the underpinning of the recommendations and failed to address the strength of the recommendations. Therefore, a much detailed work on the clinical practice guidelines have to be done, and so to develop guidelines with sufficient evidence and a clearer illustration.
There are in general two different types of endotracheal suction: open and closed suctioning. In order to perform open endotracheal suctioning, disconnection of patient’s airway from mechanical ventilation is needed. Compared to the closed suctioning, open suctioning is more likely to prone patients with post endotracheal suctioning complications. However, despite of the mentioned disadvantages, open endotracheal suctioning is still widely used because of the cheaper cost (Lorente et al, 2006), with similar incidence rate of ventilator-associated pneumonia (Jongerden et al, 2007; Zeitoun et al, 2003). Therefore, this dissertation is intended to develop an evidence-based practice protocol on open endotracheal suctioning for intubated patients with ventilator support in order to minimize its adverse effects.

**Research question**

The aim of this dissertation is to develop an evidence-based guideline for open endotracheal suctioning (OES), in order to reduce its potential complications. The research question was formulated using the PICO format. PICO refers to patients population, intervention, comparison and outcome of interested topic.

Patient population (P) – Adult patients under mechanical ventilation

Intervention (I) – An evidence-based OES practice

Comparison (C) – Conventional OES practice
Outcome (O) – Reduction of the incidence rate of potential complications

With reference to the endotracheal suctioning guidelines developed by American Association of Respiratory Care (2010), there are four aspects in general to be related to reduce the complications brought by OES. They are: assessment of patients’ needs or indications for OES, size of suction catheter being used, hyperoxygenation and hyperinflation delivery, and normal saline instillation.

**Definitions**

*Open endotracheal suctioning (OES):*

The procedure involves disconnection of mechanical ventilation from patient’s artificial airway, i.e. endotracheal tube (ET tube) or tracheostomy. Then, insert sterile suction catheter into the artificial airway and apply negative pressure. The aim of the procedure is to clear secretion and mucous from the airway, and to maintain the patency of patient’s airway (Finucane & Santora, 2003).

*Hyperoxygenation:*

It is the use of high concentration of inspired oxygen before and after endotracheal aspiration (Pedersen et al, 2009).

*Hyperinflation:*

It is a procedure to achieve excessive inflation or expansion of the lungs.
(Pedersen et al, 2009).

**Normal saline instillation (NSI):**

Sterile normal saline is applied into ET tube or tracheostomy tube to enhance the removal of copious secretion inside. The theory behind is that secretion and mucous are diluted with normal saline, and hence loosen the secretion (Roberts, 2009).

OES is a procedure that nurses perform frequently. It is an invasive procedure associated with a number of complications such as hypoxaemia. Yet there is no evidence-based guidelines or protocols to safeguard the quality of this nursing procedure. The aim of this dissertation is therefore to develop an OES evidence-based guideline for patients under mechanical ventilation to prevent post-OES hypoxaemia. The focus of the guideline is on hyperoxygenation, hyperinflation and normal saline instillation.
Chapter 2: Review of Evidence

In this chapter, examination of various strategies to reduce incidence of complications brought by OES was done through literature review on published research studies. Reviewing the significance, internal validity; and the strengths and limitations of the identified studies is included. The research strategies, data extraction, critical appraisal, quality assessment, summary and synthesis of the data is also explained in the chapter. Then, the chapter draws nursing practice implications from the synthesized data.

Searching strategies

Search of evidence was done in the five electronic databases including British Nursing Index (BNI), CINAHL Plus, Cochrane Library, Ovid MEDLINE and Pubmed. The used keywords are ‘endotracheal’, ‘suction’, ‘mechanical ventilation’, ‘indication’, ‘intensive care’, ‘hyperoxygenation’, ‘hyperventilation’, ‘hyperinflation’, ‘normal saline instillation’. Constraints added in the search are ‘adult samples over 18 years old’ and studies published within the past 15 years, i.e. 1997-2012. Included studies are clinical trials subjected on human, systematic reviews and meta-analysis. On the other hand, excluded articles are literature reviews, seminar papers, and studies of non-mechanically ventilated samples, neonatal or paediatric patients, closed
endotracheal suctioning, oral suction, and subglottic suction. Also, articles that are not available in English were also excluded.

**Search results**

457 research articles were yielded from the search, and 419 of them were screened out based on the exclusion criteria mentioned above. 38 potentially relevant results were left: 7 from BNI, 3 from CINAHL Plus, 8 from Cochrane Library, 10 from MEDLINE, and 10 from Pubmed. Excluding 8 duplicated results and 2 which only available in Spanish, 28 studies remained for further assessment. After reading the abstracts, 13 studies were screened out, as 10 were related to closed endotracheal suctioning, 2 were on animal experiments and 1 was an in-vitro experiment, leaving 15 studies matched the inclusion criteria. One additional study was later selected from the reference lists of the 15 studies. In view of the insufficient evidence for developing guidelines on the aspects of ‘indication of OES’ and ‘size of suction catheter’, 4 studies on these two aspects were also excluded. Exclusion of the two aspects left 11 studies to be included in this dissertation. The selection process is shown in the flow chart below.
Among the selected studies, there is one randomized controlled trial (RCT) (Celik & Elbas, 2000), two randomized crossover trials (RCOs) (Berney & Denehy,
2002; Ji et al, 2002), two non-randomized controlled trials (Akgul & Akyolcu, 2002; Kinloch, 1999), two quasi-experimental studies (Glakoumidakis et al, 2011; Kerr et al, 1997), one meta-analysis (Oh & Seo, 2003) and three systematic reviews (Brooks et al, 2001; Overend et al, 2009; Thompson, 2000).

**Data extraction**

Data extraction from the selected studies was performed by developing tables of evidence. The evidence tables were made (Table 1) based on the format of Scottish Intercollegiate Guidelines Network (SIGN) as follow.
<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Participants/Setting</th>
<th>N</th>
<th>Intervention (I)</th>
<th>Control (C)</th>
<th>Outcome measures</th>
<th>Effect size (p value)</th>
</tr>
</thead>
</table>
| Kerr et al (1997) | Quasi-experimental design | • Patients ≥ 16 yrs old in ICU  
• Suffered from severe head injury  
• Intubated and on a Pruritan-Bennett ventilator  
• ICP monitoring available to the patients | Total: 66  
I(a): 29  
I(b): 37 | I(a)  
• 8 breaths/40 s of hyperventilation prior to ETS  
• Delivered by manual sigh control of ventilator, set at 135% of tidal volume with 100% oxygen  
• Suction catheter was inserted twice for 10s | I(b)  
• All patients served as their own control  
• 4 breaths/20s of hyperventilation prior to ETS  
• Delivery mode and suction procedures same as I(a) | 1) ICP  
2) MAP  
3) Cerebral perfusion pressure  
4) Heart rate  
5) SaO2  
6) Partial pressure of end-tidal carbon dioxide | 1) I(a): 0.412 (0.200)  
I(b): 0.615 (0.001)  
2) I(a): 0.174 (0.824)  
I(b): 0.457 (0.016)  
3) I(a): 0.129 (0.942)  
I(b): 0.573 (0.004)  
4) I(a): 0.27 (0.31)  
I(b): 0.453 (0.017)  
5) I(a): 0.398 (0.342)  
I(b): 0.225 (0.555)  
6) I(a): 0.311 (0.227)  
I(b): 0.714 (<0.001) |
<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Participants/Setting</th>
<th>N</th>
<th>Intervention (I)</th>
<th>Control (C)</th>
<th>Outcome measures</th>
<th>Result</th>
</tr>
</thead>
</table>
| Celik & Elbas (2000) | Randomized controlled trial | ● Patients with ET tube in Cardiovascular Surgery ICU in Turkey  
● Undergone CABG/open heart valve surgery  
● Normal serum electrolytes level | Total: 60  
I: 30  
C: 30 | ● Hand washing prior OES  
● Hyperoxygenation prior and after suctioning for 4-5 breaths with 100% O₂, delivered by MRB/ventilator  
● Intermittent suctioning with less than 10 sec at a time | ● No hand washing  
● No hyperoxygenation  
● Suctioning >10 sec at a time | Measured in no. normal/abnormal cases | 1) –20 cases (-83%)  
2) –21 cases (-91%)  
3) –13 cases (-37%)  
4) –11 cases (-78.5%)  
5) –12 cases (-80%) |
<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Participants/Setting</th>
<th>N</th>
<th>Intervention (I)</th>
<th>Control (C)</th>
<th>Outcome measures</th>
<th>Result</th>
</tr>
</thead>
</table>
| Berney & Denehy (2002) | Randomized crossover design | * Intubated and ventilated patients in ICU  
* Receive hyperinflation as part of their physiotherapy treatment | Total: 20            | I(a)  
  * 6 sets of 6 manual hyperinflation (MHI) breaths given by using manual rebreathing bag with 10L/min O2  
  * Ventilator hyperinflation (VHI) 2 hours after MHI with 6 breaths/min in VC mode, 20L/min O2 until peak airway pressure reached 40cmH2O  
  * ETS was done after each hyperinflation methods  
  * Reverse the sequence in Day 2  
  * Each subjects act as their own control with baseline data prior any interventions | I(b)  
  * Reverse sequences of MHI & VHI in I(a)                                                                 | 1) Improvements in static pulmonary compliance (%)  
  2) Sputum wet weight | +9.75 to 11.5% in MHI vs +9.8% to 11.58% in VHI  
  6.53g in MHI vs 6.01g in VHI (p=0.11) |
<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Participants/Setting</th>
<th>N</th>
<th>Intervention (I)</th>
<th>Control (C)</th>
<th>Outcome measures</th>
<th>Result</th>
</tr>
</thead>
</table>
| Kinloch (1999)| Non-randomized control trial | - Patients ≥18 yrs old in cardiovascular ICU  
- Undergone heart surgery CABG  
- Oximetrix fiber-optic pulmonary artery catheter was inserted  
- Orally intubated with cuffed ETT                                                                                                           | Total: 35                | - Stop mechanical ventilation and 5ml of normal saline was instilled into patients’ ETT  
- Hyperoxygenation and hyperinflation with 100% O2 for 5 breaths  
- OES done afterwards  
- Hyperoxygenation and hyperinflation for 5 breaths again  
- OES was done again  
- Hyperoxygenation and hyperinflation with restart of mechanical ventilation | - No NSI was done  
- Hyperoxygenation prior ETS was done                                                                                                   | 1) Lowest SvO2 after ETS  
2) Venous saturation of oxygen (SvO2) recovery time | Mean differences  
1) −6.1% (p=0.07)  
2) +3.8 min. (p=0.05) |
<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Participants/Setting</th>
<th>N</th>
<th>Intervention (I)</th>
<th>Control (C)</th>
<th>Outcome measures</th>
<th>Result</th>
</tr>
</thead>
</table>
| Akgul & Akyolcu  | Non-randomized control trials | Patients under mechanical ventilation in ICU of an university hospital in Turkey due to:  
- pulmonary problems  
- cardiovascular problems  
- trauma  
- All patients were suctioned twice at 2-hour intervals, with normal saline instillation (NSI) prior to suctioning and no NSI | Total: 20  
Male: 11  
Female: 9 | ● Hyperoxygenation with 100% O₂ for 1 minute  
● 5 ml of normal saline was instilled  
● Reconnect ventilator and give 5 breaths of hyperoxygenation  
● OES was done for 10 seconds with 14 Fr catheter | ● Same procedures as intervention group except no normal saline instillation was done | 1) Bloods gases  
- pO₂  
- pCO₂  
- HCO₃  
- pH | 1) Blood gases  
- pO₂  
- +25.37 of control vs −13.01 of NSI  
- pCO₂  
- −0.06 of control vs +0.25 of NSI  
- HCO₃  
- +0.01 of control vs +0.01 of NSI |
|                  |                             |                                                                                      |           |                                                                                  |                                                                              | 2) Heart rate  
- Control: No increase  
- NSI: Increase with statistically significant (p<0.05)  
- SpO₂ from monitors | 2) Heart rate  
- Control: No increase  
- NSI: Increase with statistically significant (p<0.05)  
- SpO₂ from monitors |
<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>Participants/Setting</th>
<th>N</th>
<th>Intervention</th>
<th>Control</th>
<th>Outcome measures</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ji et al</td>
<td>Randomized crossover trial</td>
<td>Patients over 18 years old with tracheostomy</td>
<td>17</td>
<td>Baseline SaO₂ was recorded prior to experiment</td>
<td>Subjects as their own control with their baseline data</td>
<td>1) SaO₂ level</td>
<td>1) Range:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Under the care of neuro-surgical ICU</td>
<td></td>
<td>No NSI, 2mL or 5 mL of NSI were done to tracheostomy tube of the subjects</td>
<td></td>
<td>2) Recovery time</td>
<td>0mL: -0.75</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Total: 17</td>
<td>Mean age: 65.1</td>
<td>Oxygen supplied for 15 seconds before and after ETS</td>
<td></td>
<td></td>
<td>+0.03</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td>SaO₂ was recorded immediately after ETS, at 15, 30, 45 seconds, and then at</td>
<td></td>
<td></td>
<td>2mL: -1.32</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1, 2, 3, 4, 5 minutes</td>
<td></td>
<td></td>
<td>-0.23</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Repeat all 3 methods of NSI with 80 minutes rest in between</td>
<td></td>
<td></td>
<td>5mL: -2.35</td>
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<td></td>
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<td>-1.47 (p=0.02)</td>
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<td></td>
<td></td>
<td>2mL: 45sec</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>(p=0.06)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5mL: no return of SaO₂</td>
</tr>
<tr>
<td>Study</td>
<td>Design</td>
<td>Participants/ Setting</td>
<td>N</td>
<td>Intervention (I)</td>
<td>Control (C)</td>
<td>Outcome measures</td>
<td>Effect size</td>
</tr>
<tr>
<td>-----------------------</td>
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<td>-----------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Glakoumidakis et al (2011)</td>
<td>Quasi-experiment</td>
<td>Patients &gt;18 yrs old in ICU of two hospitals with mechanical ventilation by an ET tube or tracheostomy tube ❗ No application of muscle-relaxation medications ❗ No chronic pulmonary or kidney disease</td>
<td>Total: 103</td>
<td>Hyperoxygenation with 100% O₂ for 1 minute prior to NSI ❗ 5ml of normal saline was instilled to patients’ ETT prior succioning ❗ SaO₂ was recorded 1 minute and 15 minutes after ETS</td>
<td>Patients act as their own control ❗ No NSI was done ❗ Hyperoxygenation prior OES was done</td>
<td>1) Mean secretion weight (gram) 2) Changes in SaO₂ level compared to baseline</td>
<td>+1.00 (p&lt;0.001) 1 min (p=0.692) I: -6.4 to +7.5 C: -4.1 to +5.00 15Min (p=0.316) I: -5.2 to +17.1 C: -2.8 to +5.3</td>
</tr>
<tr>
<td>Study</td>
<td>Design</td>
<td>No. of studies</td>
<td>Types of studies</td>
<td>Database searched</td>
<td>Main conclusion</td>
<td></td>
<td></td>
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<tr>
<td>---------------</td>
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<td>---------------------------------------------------------------------------------------------------</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
| Oh & Seo (2003) | Meta-analysis     | 10 studies on intervention to reduce ETS-related hypoxemia                    | ● 9 randomized control trails (RCT)  
● 6 Prospective experimental study                                                                 | Medline (1970 - 2003) | 1) Hyperoxygenation and hyperinflation, with FiO$_2$ of 1 and 150% tidal volume of 3-6 breaths respectively, can reduce suction-induced hypoxaemia 55%, with effect size 1.33 (95%CI: 0.92-1.73)  
2) Preoxygenation only can reduce 32% incidence rate of post suctioning hypoxaemia, with effect size 0.68 (95% CI: 0.14-1.21)  
3) Pre- and post-OES hyperoxygenation can reduce 49% of suction-induced hypoxaemia  
4) No effect or significant negative effect on patients’ oxygen level if hyperinflation was done alone  
5) FiO$_2$ of 0.2 above maintenance level of mechanical ventilation would be enough for patients with COPD for hyperoxygenation |
| Brooks et al (2001) | Systematic Review | 162 experimental articles related to suctioning to intubated and non-intubated patients in all range of ages | ● 59 RCTs or RCOs  
● 28 non-randomized crossover or comparative cohorts  
● 49 observational studies  
● 26 animal or in vitro studies | Medline  
EMBASE  
CINAHL  
Cochrane Library | 1) Hyperoxygenation should be provided before OES  
2) Hyperinflation should not be applied for severely head-injured patients because it may raise ICP  
3) Ventilator is more effective for delivery of oxygen than manual rebreathing bag for hyperoxygenation and hyperinflation  
4) Insufficient evidence to support or defy NSI |
<table>
<thead>
<tr>
<th>Study</th>
<th>Design</th>
<th>No. of studies</th>
<th>Types of studies</th>
<th>Database searched</th>
<th>Main conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overend et al (2009)</td>
<td>Systematic Review</td>
<td>28 papers related to suctioning of adult patients</td>
<td>● 15 RCTs&lt;br&gt;● 13 randomized crossover studies (RCO)</td>
<td>● Medline&lt;br&gt;● CINAHL&lt;br&gt;● EMBASE&lt;br&gt;● Cochrane Library</td>
<td>1) Hyperoxygenation before and after OES is recommended&lt;br&gt;2) The significance of hyperinflation alone is unclear&lt;br&gt;3) NSI may cause decrease in SaO₂ with no clinical significance</td>
</tr>
</tbody>
</table>
Review of studies

Sample characteristics:

All the experimental studies targeted on adult patients with endotracheal tube being treated in intensive care units. Patients in these studies suffered from a variety of diseases. Two studies included patients who underwent heart surgery (Celik & Elbas, 2000; Kinloch, 1999); Kerr et al (1997) included patients suffered from severe head injury. Akgul and Akyolcu (2002) included patients suffered from pulmonary, cardiovascular and trauma problems. Glakoumidakis et al (2011), Ji et al (2002), and Berney and Denehy (2002) did not designate what diseases the patients suffered from. For the meta-analysis and systematic reviews, they all included studies on both closed system and open system endotracheal suctioning. As they did the analysis separately in the content, their recommendations do fit the inclusion criteria of this review.

Sample size:

The sample sizes of the experimental studies ranged from 17 patients in a randomized crossover trials (RCO) (Ji et al, 2002), to 103 patients in a quasi-experiment (Glakoumidakis et al, 2011). The reasons of the small sample size in some of the studies was because the interventions had to be standardized among the OES providers. The standardization had to be done by training the care providers. Yet
small sample size might affect the generalizing ability of the guidelines developed.

**Interventions:**

Two interventions are focused in this dissertation: ‘hyperoxygenation and hyperinflation’ and ‘NSI’.

For hyperoxygenation, both Celike and Elbas (2000) and Kerr et al (1997) used 100% oxygen, and hyperoxygenated the patients for 4-5 breaths (around 30 seconds to 1 minute). This rate of hyperoxygenation was also recommended by Oh and Seo (2003). For hyperinflation, Berney and Denehy (2002) delivered 6 sets of manual hyperinflation with manual resuscitating bag (MRB) with 6 breaths per set, and compared it with 6 breaths/min of ventilator hyperinflation; Kerr et al (1997) tested 4 breaths/20s, 8 breaths/40s and 30 breaths/60s of ventilator hyperinflation and set at 135% of tidal volume. In Oh and Seo’s study (2003), they recommended that the setting of hyperinflation should be 150% of tidal volume. No recommendation on level of oxygen or setting of hyperoxygenation and hyperinflation was provided in the three systematic reviews.

For NSI, 5 ml of normal saline instillation into endotracheal tube was applied as intervention in three studies (Akgul & Akyolcu, 2002; Glakoumidakis et al, 2011; Kinloch, 1999). In Ji et al’s study (2002), 2 ml and 5 ml of normal saline were tested
against no NSI, in order to test the relationship between the amount of normal saline
instilled and the oxygen level of patients.

**Outcome:**

For hyperoxygenation, Celik & Elbas (2000) and all three systematic reviews (Thompson, 2000; Overend et al, 2009; Brooks et al, 2001) suggested that hyperoxygenation is effective on reducing post-OES hypoxemia. According to Celik and Elbas (2002), the reduction rate of abnormal cases in mean arterial pressure (MAP), heart rate, and carbon dioxide level is significant when pre-OES hyperoxygenation is applied. Oh & Seo (2003) reported a 32% and 49% reduction in incidence of OES induced hypoxaemia when pre- and peri-OES (pre- and post-) hyperoxygenation were applied respectively.

Overend et al (2009), Brooks et al (2001) and Oh & Seo (2003) argued that hyperinflation should not be used for improving oxygenation, as there is no statistical difference in oxygen level between applying hyperinflation alone and without hyperinflation. However, they all showed that applying both hyperoxygenation and hyperinflation simultaneously prior to OES is beneficial in reducing the incidence rate of hypoxaemia. It may be due to the fact that hyperinflation might improve static pulmonary compliance of patients to mechanical ventilators (Berney & Denehy, 2002).
According to Oh & Seo (2003), the reduction rate was 55%. For the rate of hyperinflation, the more frequent the hyperinflation rate, the higher the increase in intracranial pressure (ICP), heart rate and partial pressure of end-tidal carbon dioxide (Kerr et al, 1997). The SaO$_2$ level, however, has no statistically significant increase upon the change from 8 breaths/40s to 30 breaths/60s of hyperinflation. The study also showed that there was statistically insignificant increase in ICP after hyperinflation. The cause of the increase was suggested to be the mild vasconstricting nature of oxygen.

Studies done by Akgul and Akyolcu (2002) and Ji et al (2002) showed there are significant decrease in blood oxygen level and SaO$_2$ level after applying NSI respectively. However, Glakoumidakis et al (2011) showed that there is no significant decrease in SaO$_2$ level upon NSI. The differences of outcome suggested by Akgul & Akyolcu (2002) were because of the change in SaO$_2$ level may not be clinically significant. However the potential risk of decrease in blood oxygen level which may lead to compensated hypoxaemia should not be neglected. NSI leads to a longer recovery time of oxygen level (Glakoumidakis, 2011; Kinloch, 1999; Ji et al, 2002). Only Glakoumidakis et al’s study (2011) measured the sputum weight, and it showed that more sputum was yielded after NSI. Although the sputum weight increased, the researchers doubted the increase was due to the normal saline instilled. Taken together,
NSI is not recommended by the four clinical trials (Akgul and Akyolcu, 2002; Glakoumidakis, 2011; Ji et al, 2002; Kinloch, 1999). All three systematic reviews reached similar conclusion as they showed NSI has potential negative effect on patients’ oxygenation level with no significant beneficial effect (Brooks et al, 2001; Overend, 2009; Thompson, 2000).

**Critical appraisal of studies**

The critical appraisals of the selected studies are shown in Table 2, which were compiled according to the appraisal checklist developed by SIGN as shown in Appendix A and Appendix B.
### Table 2 – Table of Internal Validity of Included Studies

#### Table 2a: Systematic Review and Meta-analysis

<table>
<thead>
<tr>
<th>Study</th>
<th>Clearly focused question</th>
<th>Methodology description</th>
<th>Sufficient Literature Search</th>
<th>Assessment of studies’ quality</th>
<th>Similarity between studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oh &amp; Seo (2003)</td>
<td>+++</td>
<td>+++</td>
<td>+</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Thompson (2000)</td>
<td>+++</td>
<td>++</td>
<td>++</td>
<td>+++</td>
<td>++</td>
</tr>
<tr>
<td>Overend et al (2009)</td>
<td>+++</td>
<td>+++</td>
<td>++</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Brooks et al (2001)</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

**Legends:**
- Well covered (+++);
- Adequately Addressed (++)
- Poorly Addressed (+)
- Not Addressed (-)
- Not Reported (NR)
- Not Applicable (NA)

<table>
<thead>
<tr>
<th>Study</th>
<th>Bias Minimized</th>
<th>Direction of Bias</th>
<th>Overall Quality Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oh &amp; Seo (2003)</td>
<td>+</td>
<td>Only one database was searched</td>
<td>High (+++)</td>
</tr>
<tr>
<td>Thompson (2000)</td>
<td>+</td>
<td></td>
<td>High (+++)</td>
</tr>
<tr>
<td>Brooks et al (2001)</td>
<td>++</td>
<td></td>
<td>High (+++)</td>
</tr>
<tr>
<td>Overend et al (2009)</td>
<td>++</td>
<td></td>
<td>High (+++)</td>
</tr>
<tr>
<td>Study</td>
<td>Clearly Focused Question</td>
<td>Random Allocation</td>
<td>Adequate Allocation Concealment</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>--------------------------</td>
<td>-------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>Celik &amp; Elbas (2000)</td>
<td>++</td>
<td>NR</td>
<td>-</td>
</tr>
<tr>
<td>Berney &amp; Denehy (2002)</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td>Glakoumidakis et al (2011)</td>
<td>+++</td>
<td>NA</td>
<td>NR</td>
</tr>
<tr>
<td>Akgul &amp; Akyolcu (2002)</td>
<td>+++</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Kinloch (1999)</td>
<td>+++</td>
<td>NR</td>
<td>+</td>
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<tr>
<td>Kerr et al (1997)</td>
<td>++</td>
<td>++</td>
<td>NR</td>
</tr>
<tr>
<td>Ji et al (2003)</td>
<td>+++</td>
<td>NR</td>
<td>NR</td>
</tr>
</tbody>
</table>

Legends:
Well covered (+++); Adequately Addressed (++); Poorly Addressed (+); Not Addressed (-); Not Reported (NR); Not Applicable (NA)
Table 2c: Bias minimization of experimental studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Bias Minimized</th>
<th>Direction of Bias</th>
<th>Effect Due to Intervention</th>
<th>Results Applicable to Target Group</th>
<th>Overall Quality Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Celik &amp; Elbas (2000)</td>
<td>++</td>
<td>Homogeneous sampling with patients undergone heart</td>
<td>Yes</td>
<td>Yes</td>
<td>Fair (+)</td>
</tr>
<tr>
<td>Berney &amp; Denehy (2002)</td>
<td>++</td>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td>High (++)</td>
</tr>
<tr>
<td>Akgul &amp; Akyolcu (2002)</td>
<td>+</td>
<td>Spectrum bias may occur as limited causes of MV</td>
<td>Yes</td>
<td>Yes</td>
<td>Fair (+)</td>
</tr>
<tr>
<td>Ji et al (2002)</td>
<td>+</td>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td>Fair (+)</td>
</tr>
<tr>
<td>Kinloch (1999)</td>
<td>+</td>
<td>Homogeneous sampling of patients undergone CABG</td>
<td>Yes</td>
<td>Yes</td>
<td>High (++)</td>
</tr>
<tr>
<td>Kerr et al (1997)</td>
<td>++</td>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td>Fair (+)</td>
</tr>
<tr>
<td>Glakoumidakis et al (2011)</td>
<td>++</td>
<td></td>
<td>Yes</td>
<td>Yes</td>
<td>High (++)</td>
</tr>
</tbody>
</table>

Legends:
Well covered (+++); Adequately Addressed (++); Poorly Addressed (+); Not Addressed (-); Not Reported (NR); Not Applicable (NA)
**Meta-analysis and systematic reviews**

The meta-analysis done by Oh & Seo (2003) has a high rating. Although the authors searched and obtained literatures from the MEDLINE only, its research question, methodology, assessment of studies were clearly described. Rather than relying on one single database, their analysis may be more comprehensive if additional databases were searched. For the three systematic reviews, all of them have clearly focused research questions. In the reviews by Thompson (2000) and Overend (2009), the focus was not only on OES but also on closed system suctioning. The systematic review by Brooks et al (2001) even included literatures on non-intubated subjects. Also, they reviewed literatures which included both adults and infants subjects. Inclusion of a variety of literatures in the three systematic reviews reduces the focus of their research questions, but they categorized the reviewed studies based on intubated or non-intubated; adults or infants; OES or CES. Categorizing the studies into various subgroups helps maintaining the specificity of their recommendations extracted. Therefore, there is no need to downgrade the quality of their recommendations towards OES.

**Clinical trials**

All the clinical trails had clearly stated the research questions either on
hyperoxygenation and hyperinflation (Berney & Denehy, 2002; Celik & Elbas, 2000; Kerr et al, 1997), or NSI (Akgul & Akyolcu, 2002; Glakoumidakis et al, 2011; Ji et al, 2002; Kinloch, 1999). All the trials treated the samples equally, except the interventions under test, among experimental and control groups. The measurements of the outcomes are mostly on blood gases (Celik & Elbas, 2000; Akgul & Akyolcu, 2002) and SaO₂ level (Kerr et al, 1997, Ji et al, 2002; Galkoumidakis et al, 2011), which are valid and is recognized as the most direct way to measure the effect of interventions on participants’ oxygenation. There was no double blinding for all trials, because the differences in the interventions can be differentiated by the researchers or even the participants themselves instantly, once the interventions were applied. The sample sizes of the trials were generally small. By power analysis, 20 subjects is the minimum sample size to obtain a 80% statistical power to detect a 0.5 population correlation. Only Ji et al’s study (2003) could not reach the minimum sample size and it may undermine the generalizability of their study.

RCOs have a slightly better generalizability than RCTs on testing outcome measurements such as oxygen level of patients. It is because the baseline oxygen levels and their reactions towards interventions are different among patients. Thus, RCOs can offset the difference in the reactions, as all samples were their own control.
Homogenous sampling was found in two trials (Kinloch, 1999; Celik & Elbas, 2000). The reason of this sampling may be because the ICUs (where the studies took place) might receive patients with cardiovascular problems only. This may limit the generalizability of the studies. In Kinloch (1999), more smokers were in the experimental group (60% vs. 15%). This may lead to a sampling bias. But the covariance test was performed and no covariance problem was shown statistically.

Dropouts existed in Kinloch’s (1999) and Ji et al’s (2003) studies, but no intention-to-treat analysis was done. Plausible rationale of the absence of intention-to-treat may include fluctuation of oxygen level towards stress, and one assumed result may have great effect on the small sample sizes. Therefore, the intention of the absence of the intention-to-treat maybe to keep the collected data more reliable.

The methodology of random allocation of sample was described in Berney & Denehy (2002) and Kerr et al (1997). Kerr et al (1997) used coin toss before intervention for allocating the samples into the two intervention groups and one control group. Berney & Denehy (2002) used sealed envelopes to determine the treatment sequences on Day 1. Although Celik & Elbas (2000) and Ji et al (2002) claimed that their studies were RCT and RCO respectively, there is no description on how the samples were randomly allocated. Allocation concealment methodology was
clearly stated in the studies by Kerr et al (1997) and that by Berney & Denehy (2002).

The methods they used were mentioned above. The researchers in the study by
Kinloch (1999) told the primary care nurse for NSI or not only the moment before
suctioning procedure.

**Summary and Synthesis**

*Characteristics of interventions and effectiveness*

From the extracted data, the interventions can be classified into 3 categories:

hyperoxygenation, hyperinflation, and NSI.

**Hyperoxygenation**

Two clinical trials (Kerr et al, 1997; Celik & Elbas, 2000;), one meta-analysis
(Oh & Seo, 2003) and three systematic reviews (Thompson, 2000; Brooks et al, 2001;
Overend et al, 2009) support the pre- and post-OES hyperoxygenation. According to
Oh & Seo (2003), pre- and peri-OES hyperoxygenation with 100% oxygen can reduce
32% and 49% incidence rate of post-OES hypoxaemia. The effect size of
preoxygenation is 0.68 (p=0.001, 95% confidence interval: 0.14 – 1.21). According to
Celik & Elbas (2000), pre-oxygenation with 100% oxygen for 4-5 times can reduce
83% of incidence rate of abnormal MAP, 91% of abnormal heart rate, 78.5% and 80%
of abnormal partial CO₂ and HCO₃ level in blood gases. Therefore, hyperoxygenation with 100% oxygen in both pre- and post-OES is recommended. For patients with chronic obstructive pulmonary disorder, 100% oxygen should not be applied due to the possibility of bronchospasm. Oh & Seo (2003) suggested that FiO₂ 0.2 above the maintenance oxygen level should be enough for preventing post-OES hypoxaemia. However, there is no recent research on this level of oxygen supporting the hypothesis.

Hyperinflation

One RCO (Berney & Denehy, 2002), one quasi-experiment (Kerr et al, 1997), one meta-analysis (Oh & Seo, 2003) and two systematic reviews (Brooks et al, 2001; Overend, 2009) mentioned the significance of hyperinflation. There is no evidence to supporting the significance of applying hyperinflation alone (Oh & Seo, 2003; Overend et al, 2009). However, Berney and Denehy (2002) suggested that, instead of improving oxygen level of patients directly, hyperinflation actually improves the static pulmonary compliance of patients towards mechanical ventilation. Moreover, in the five studies where it is applied with hyperoxygenation, positive results were reported. The combination can reduce the incidence rate of post-OES hypoxaemia by 55%, with the effect size of 1.33 (p<0.001, 95% confidence interval: 0.92 – 1.73) (Oh
& Seo, 2003). Therefore, hyperoxygenation plus hyperinflation together is strongly related to the prevention of post-OES hypoxaemia. There are 2 delivery methods of hyperinflation, by ventilator or MRB. Berney & Denehy (2002) and Brooks et al (2001) suggested that, although there is no statistical indication on one is more superior than the other, ventilator delivery of hyperinflation is better than MRB because it does not require disconnection from mechanical ventilator. Without the disconnection, drop of positive end-expiratory pressure (PEEP) can be avoided. Hence, nurses can have a better control on airway pressure. However, hyperinflation may increase intracranial pressure (ICP) among patients with severe head injury, as suggested by Kerr et al (1997). In their study, ICP and cerebral perfusion pressure increased with the increase in frequency and duration of hyperinflation. The increases indicate that hyperinflation may cause neurotrauma to patients with head injuries, and therefore should be avoided for this type of patients.

The frequency and settings for hyperinflation varies among studies. Berney & Denehy (2002) used 6 breaths/min with 20L/min O₂ for ventilator delivery of hyperinflation, and 6 breaths/min with 10L/min for MRB delivery. Although there is no statistical significant differences on pulmonary compliance and sputum weight yielded between the two methods, Berney & Denehy suggested that ventilator delivered hyperinflation is preferred, as the pressure it provided is much more stable
than by MRB. Kerr et al (1997) tested 4 breaths/20s, 8 breaths/40s and 30 breaths/60s with 135% of tidal volume as hyperinflation. They argued that 8 breaths/40s is more preferable as it causes the least increase in heart rate and ICP while being effective on enhancing patients' oxygenation after OES, while Oh & Seo (2003) suggested 150% tidal volume of 3-6 breaths. Therefore, hyperinflation should be done with not more than 150% of tidal volume at the rate of 8 breaths/40s by ventilator, in order to avoid the increase of ICP and heart rate.

*Normal saline instillation*

One RCO (Ji et al, 2002), one quasi-experiment (Glakoumidakis et al, 2011), two non-randomized control trials (Kinloch, 1999; Akgul & Akyolcu, 2002), and three systematic reviews (Brooks et al, 2001; Overend, 2009; Thompson, 2000) have studied the significance of NSI. The clinical trials showed different degree of statistically significant declines in SaO₂ (Ji et al, 2002; Glakoumidakis et al, 2011), and pO₂ in blood gases (Akgul & Akyolcu, 2002). However, Akgul & Akyolcu (2002) and Glakoumidakis et al (2011) stated that the declines were not clinically significant. On the other hand, NSI may lead to a longer recovery time of oxygen level in patients after OES, ranging from 3.8 minutes (Kinloch, 1999) to no return of SaO₂ after 5 minutes (Ji et al, 2002, Glakoumidakis et al, 2011). Therefore, NSI can possibly cause
or prolong post-OES hypoxaemia. The systematic reviews by Thompson (2000) and Brooks et al (2001) stated that there is insufficient evidence to support or defy NSI’s significance. On the other hand, Overend et al (2009) suggested that NSI may cause a decrease of SaO₂, but no clinical significance for the intervention. Glakoumidakis et al (2011) showed that there is a 100% increase in sputum weight yielded by OES when NSI was applied. However, the investigators stated that they did not analyze on the content of the sputum yielded nor the net sputum weight. However, such analysis would have tell whether the increase is caused by the normal saline instilled only. As a result, NSI is still not recommended to be used as a routine procedure as all the 7 studies suggested (Akgul and Akyolcu, 2002; Glakoumidakis, 2011; Ji et al, 2002; Kinloch, 1999; Brooks et al, 2001; Overend, 2009; Thompson, 2000). When patient is under mechanical ventilation, instead of applying NSI, adequate humidification of the artificial airway and the hydration status of the patients should rather be focused for dealing with copious sputum (Akgul & Akyolcu, 2002).

**Summary of the evidence**

Among the eleven selected studies, the patient populations were generally homogeneous, as all of them focused on adult patients with endotracheal tube and require OES. They covered a spectrum of patients in medical and surgical ICUs.
Among them, two of the studies used Acute Physiology and Chronic Health Evaluation II (APACHE II) to measure the severity of illness among the samples (Glakoumidiks, 2011; Kerr et al, 1997), whereas Celik and Elbas (2000) used some of the components in APACHE II as inclusion and exclusion criteria.

Hyperoxygenation before and after OES can significantly reduce the incidence of rise in heart rate, rise in MAP, and post-OES hypoxaemia (Celik & Elbas, 2000). Hyperinflation by either MRB or ventilator can improve static pulmonary compliance of the patients by around 9% - 11% (Berney & Denehy, 2002), but on the other hand it may cause rise in ICP (Kerr et al, 1997). Evidence supports that the use of hyperoxygenation and hyperinflation together, and they can reduce the incidence rate of post-OES hypoxaemia up to 55% (Oh & Seo, 2003). The recommended setting of hyperoxygenation would be 100% oxygen, i.e. FiO₂ 1.0, for 4-6 breaths. For hyperinflation, not more than 150% of tidal volume should be set in the rate of 8 breaths/40s. Moreover, NSI is not recommended as it may lead to decrease of oxygen level in blood with no sufficient proof of its beneficial effect (Akgul & Akyolcu, 2002; Brooks et al, 2001; Glakoumidakis et al, 2011; Ji et al, 2002; Kinloch, 1999; Overend et al, 2009; Thompson, 2000). The implementation plan and recommendations are discussed in the next chapter of this dissertation.
Based on the findings, hyperoxygenation and hyperinflation before and after OES and prohibition of NSI would reduce the incidence rate of post-OES hypoxaemia.
Chapter 3: Evidence-based Practice Guideline

With the synthesis of nursing research outcomes developed in the previous chapter, the OES evidence-based practice recommendations is developed in this chapter.

Overview of the evidence-based practice guideline

Title

A guideline of open endotracheal suctioning for patients under mechanical ventilation for preventing post-OES hypoxaemia.

Aim

The aim of the guideline is to improve the effectiveness of open endotracheal suctioning (OES) on patients under mechanical ventilation.

Objectives

The objectives are to provide recommendations for practice in the areas listed below:

(1) Hyperoxygenation prior to OES

(2) Hyperinflation

(3) Prohibition on bolus instillation of normal saline into trachea
**Target setting**

Intensive Care Unit

**The intended target users**

Nurses, physicians and physiotherapists working in intensive care units.

**Target group**

For patients aged 18 or above under mechanical ventilation in an intensive care unit.

**Target procedures**

The target procedures included in the guideline focus on (1) concentration of oxygen used and duration for hyperoxygenation; (2) tidal volume delivered and duration for hyperinflation; (3) avoid bolus instillation of normal saline into trachea.

**Recommendations**

The recommendations are based on the eleven reviewed studies. The recommendations can be categorized into the three aspects. The key to the evidence and grades of the recommendations below are based on the system designed by The
Hyperoxygenation

Recommendation 1.1

Hyperoxygenation should be performed prior to and after each OES [Grade A]

Rationale

Endotracheal suctioning causes drop in oxygen level in blood. Hyperoxygenation prior to OES can temporarily increase blood oxygen level, and therefore ameliorates the reduction of blood oxygen level after OES. After OES, hyperoxygenation helps reducing the drop in patients’ blood oxygen level and time for returning it to normal range, and thus preventing hypoxaemia. With less reduction on oxygen level, the chance of increase in both heart rate and mean arterial pressure (MAP) after OES for compensating the oxygen depletion is therefore decreased. (Celik & Elbas, 2000; Oh & Seo, 2003) [1+] (Brooks et al, 2001; Kerr et al, 1997) [2++] (Thompson, 2000; Overend et al, 2009) [2+]

Recommendation 1.2

Hyperoxygenation should be performed with 100% oxygen, i.e. FiO$_2$ 1.0, for 4-6 breaths. [Grade A]
Rationale

Hyperoxygenation with 100% oxygen has been universally adapted. However, prolonged exposure of 100% oxygen may lead to barotraumas. With limiting to 4-6 breaths, hyperoxygenation is adequately effective and the chance of inducing adverse effect is low. (Celik & Elbas, 2000; Oh & Seo, 2003) [1+]

Recommendation 1.3

For patients with chronic obstructive pulmonary disease, 20% higher than maintenance level of oxygen should be used for hyperoxygenation instead of 100%, in 4-6 breaths. [Grade A]

Rationale

For patients suffering from chronic obstructive pulmonary disease, persistent exposure of high concentrations of oxygen may lead to decreased ventilation, accumulation of CO₂ and then respiratory acidosis. (Berney & Denehy, 2002) [1++] (Oh & Seo, 2003) [1+]

Hyperinflation

Recommendation 2.1

Hyperinflation should be done in 150% of patients’ tidal volume, at most 8
breaths/40 sec. [Grade A]

*Rationale*

Excessive hyperinflation may lead to barotraumas and decreased cardiac output. 150% of tidal volume is an effective setting and is most commonly used. As excessive breaths of hyperinflation given to patients may lead to increase in ICP, MAP and cerebral perfusion pressure without significant increase of blood oxygen level, 8 breaths/40 sec is set as the limit to prevent the complications. (Kerr et al, 1997) [2++]

**Recommendation 2.2**

Ventilator-delivered hyperinflation is more preferable than the manual rebreathing bag. [Grade A]

*Rationale*

Although research showed that there is no significant difference of static pulmonary compliance to mechanical ventilation with the two different modes of delivery, there is no disconnection from the mechanical ventilator when using ventilator-delivered hyperinflation and thus is more preferable. On the contrary, manual rebreathing bag delivered hyperinflation may lead to poor control of airway pressure and decrease in positive end-expiratory pressure, which may reduce the efficacy of hyperinflation. (Berney & Denehy, 2002) [1++] (Brooks et al, 2001) [2++]
**Recommendation 2.3**

Hyperinflation should be used with hyperoxygenation in 100% oxygen with 4-6 breaths, rather than applied alone. [Grade B]

**Rationale**

Hyperinflation prior to OES can improve static pulmonary compliance of patients to mechanical ventilation, and prevent atelectasis. The reason behind is that hyperinflation helps expansion of the alveoli in lungs. However, there is no significant evidence proving the improvement of blood oxygen saturation level, when it is applied alone. The combined use of hyperinflation and hyperoxygenation has a synergistic effect in improving post OES oxygen level in blood and is therefore preferred. (Oh & Seo, 2003) [1+] (Overend et al, 2009) [2+]

**Recommendation 2.4**

Hyperinflation should not be given to patients with severe head injury or whose intracranial pressure (ICP) have to be stabilized. [Grade B]

**Rationale**

Hyperinflation increases intrathoracic pressure of the patient, which may lead to an increase in ICP. For the patients with severe head injuries, increase in ICP may be lethal. Therefore, we should never apply hyperinflation in head injured patients. (Kerr

Prohibition of normal saline instillation into trachea prior OES

Recommendation 3

Never instill normal saline into trachea prior OES. [Grade A]

Rationale

Normal saline has been widely used prior to OES, as it is assumed that it can loosen the tenacious mucus or sputum, and hence facilitate the removal of mucus or sputum by coughing or endotracheal suctioning. Based on the evidence, normal saline and mucus are actually not soluble for each other. Also, NSI is irritating and it may lead to a drop in oxygen saturation, prolonged recovery of oxygen saturation after OES, and a significant increase of heart rate. (Ji et al, 2002) [1+] (Brooks et al, 2001; Glakoumidakis et al, 2011) [2++] (Akgul & Akyolcu, 2002; Kinloch, 1999; Overend et al, 2009; Thompson, 2000) [2+]

In short, the proposed OES guidelines consists of 1) Hyperoxygenation should be performed prior and after OES in 1.0 FiO₂ for 4-6 breaths; 2) Hyperinflation should be used with hyperoxygenation in 150% of patient’s tidal volume in at most 8 breaths/40 sec delivered by ventilator; 3) Never perform NSI into trachea prior OES.
Chapter 4: Implementation Potential

Before implementing the guideline in a local clinical setting, implementation potential has to be assessed. The assessment includes the transferability of the research findings, the feasibility of the implementation, and the cost-benefit ratio of the guidelines (Polit & Beck, 2008).

**Sufficient clients to benefit**

The target hospital is an acute hospital in the Eastern Cluster of Hong Kong Island. The general adult ICU of the hospital is composed of twelve intensive care beds and eight high dependency beds. From January 2012 to December 2012, there were 730 patients under mechanical ventilation in the ICU (Pamela Youde Nethersole Eastern Hospital registry, 2012). The statistics show that there will be a considerable number of patients being benefited by the guideline.

**Transferability of the findings**

*Similarity of research population and setting to target group*

Among the clinical trails (Akgul & Akyolcu, 2002; Berney & Denehy, 2002; Celik & Elbas, 2000; Glakoumidakis et al, 2011; Ji et al, 2002; Kinloch, 1999), they all have the ICU patients under mechanical ventilation with age 18 or above, except
the quasi-experiment done by Kerr et al (1997). The trial conducted by Kerr et al (1997) set the age limit to 16 or above instead, but it still fits the admission criteria of the targeted hospital ICU. For the meta-analysis and systematic reviews (Brooks et al, 2001; Oh & Seo, 2003; Thompson, 2000) except the systematic review done by Overend et al (2009), they recruited patients from all age with the need of endotracheal suctioning. But during the analysis and review, adult and paediatric patients were separately analyzed to minimize the heterogeneity of the samples for recommendations making. In the review by Overend et al (2009), the population is limited to adult patients only. Therefore, the targeted populations across all reviewed studies are homogeneous to the targeted hospital ICU.

For ethnicity, the majority of the clinical studies were done in western countries. These studies were conducted in America (Kerr et al, 1997; Kinloch, 1999), Greece (Glakoumidakis, 2011), Australia (Berney & Denehy, 2002), Turkey (Akgul & Akyolcu, 2002; Celik & Elbas, 2000) and Korea (Ji et al, 2002). On the other hand, Chinese is the main users of the local ICU. The differential effect of performing OES on patients with various ethnicities seems to be insignificant, as the results obtained are congruent among the studies despite the variation of ethnicity.
**Philosophy of care**

The mission of the targeted ICU is to provide patient-focused quality service in critical care medicine, with highest quality achievable for patients in order to maximize health outcome, patient safety and comfort (PYNEH Intensive Care Unit, 2010). It is congruent to the Guidelines for Specialty Nursing Services by Hospital Authority (2009), which stated that intensive care nursing is a holistic care of patients with maintaining professional competence of intensive care nurses based on a board base of knowledge and experience, through evidence-based research and continuous education.

The aim of the guideline is to enhance the effectiveness of OES, and it is to maximize the health outcome and patient safety of the patients. Thus, the philosophy of care of the guideline is similar to both the reviewed studies and the targeted local setting.

**Length of implementation and evaluation period**

In the eleven reviewed articles, the length of the clinical trials ranged from five months to three and forty-two year, but most of them were completed within one year. Therefore, the proposed guideline could be implemented and evaluated within one year. For the detailed time frame, a pilot study will be conducted in the ICU. The
sample size of the pilot study will be calculated to detect the feasibility of the proposed guidelines and its evaluation plan. After the pilot study, group training with several identical sessions for briefing will be conducted within one month. Another eight months would be used for the implementation and evaluation of the guideline in the clinical setting. The length of analysis on the evaluation would be approximately two months.

**Feasibility**

The feasibility of implementing the guideline should be considered in several aspects. According to Polit & Beck (2008), the aspects include the nursing autonomy, resources availability and organizational culture towards the new innovation.

**Freedom to implement**

Nurses have the full autonomy and responsibility on when and how to provide endotracheal suctioning to the patients in ICU. Therefore, nurses have the freedom to implement the proposed evidence-based guideline to improve patient care quality, as well as the freedom to terminate if any undesirable outcome exist.
**Interference with current staff functions**

The proposed guideline is supposed to act as a standardization or modification of the current practices in performing OES. As providing OES is already an everyday basis for ICU nurses, the interference is minimal.

**Consensus among staff**

It is widely known that OES can induce hypoxaemia. The proposed evidence-based guideline could help reducing the incidence of hypoxaemia and enhance the effectiveness and quality of OES. Moreover, there is no additional workload on implementing the guideline.

**Administration support**

The administrators and the hospital are generally supportive to guidelines or protocols that are proposed to standardize current practice, and to enhance the quality of nursing care. The organizational climate encourages evidence-based practices to be brought into clinical setting for performance improvement. As the proposed guideline is evidence-based and is aimed at standardizing the quality of nursing care, getting administration support is highly possible.
**Potential friction encountered**

The implementation of the guideline is unlikely to cause friction among clinical staff, as it is congruent with the current OES practice. The risks brought by over hyperoxygenation and hyperinflation would be barotraumas and decreased cardiac output (Kerr et al, 1997; Oh & Seo, 2003), but it is preventable as nurses have the autonomy to terminate the hyperoxygenation and hyperinflation. Also, as mentioned before, OES is already performed in ICU on daily basis.

**Skills involved**

All ICU nurses should have induction program on providing OES to patients prior to practice. The required skill of OES in the proposed OES guideline is basically identical to the existing practice. For facilitating the implementation of the guideline, training sessions for introducing the recommendations to nurses are needed to ensure their understanding of the recommendations.

**Resources needed**

To implement the guideline, there is no need to purchase any additional equipments or materials, since ventilators and suctioning equipments are readily available in the targeted ICU. However, half-hour training workshops would be
provided to ensure their compliance to the guideline. In total, there will be four identical lectures held on every Monday. It is to ensure all ICU nurses can be released to attend the training workshops. Also, equipments for monitoring $\text{SaO}_2$ and tests for blood gases are required.

**Evaluation tools**

To evaluate the effectiveness of the guideline, incidence rate of post-OES hypoxaemia will be recorded. Thus, $\text{SaO}_2$, blood gases and blood oxygen recovery time of the patients have to be measured as primary evaluation tools. Heart rate, ICP of the patients, and the lengths of ICU stay are the secondary evaluation tools. Also, feedbacks from nurses will be evaluated via questionnaires and semi-structured focus group interviews during pilot testing and implementation period.

**Cost/benefit ratio**

It is essential to analyze the cost and benefit that the proposed guideline would bring. The analysis is to ensure the innovation has the lowest possible cost with maximum health care benefit. (Polit & Beck, 2008) The analysis of the guideline is shown below.
**Potential risk**

All the eleven studies have indicated that there is no adverse event with the recommended interventions. For the prohibition of NSI, there may have a risk of tenacious mucus occluding the endotracheal tubes. However, it should be prevented by ensuring adequate humidification by humidification circuit instead of NSI (Glakoumidakis et al, 2011), since NSI may exaggerate post-OES hypoxaemia.

**Potential benefits**

The potential benefits of implementing the guideline can be categorized into patients’ and nurses’ aspects.

For patients benefits, there would be reduction of the hypoxaemia incidence after performing OES (Celik & Elbas, 2000; Berney & Debeh, 2002; Oh and Seo, 2003), reduction on oxygen level recovery time (Ji et al, 2002; Glakoumidakis et al, 2011) and better static pulmonary compliance (Kerr et al, 1997).

For nursing staffs, they will have more confidence in providing OES if the procedures are standardized (Annapoorna, 2005). Therefore, quality of patient care and effectiveness of OES can be maintained.
**Risk of maintaining current practice**

As the absence of high quality evidence-based guideline and standardized care on OES for the target population, maintaining the current practice may lead to a higher rate of post-OES hypoxaemia and so the morbidity and mortality rate.

**Cost**

As no additional equipments are needed for the implementation of the guideline, there is no material cost for the implementation.

The man-hour for nursing staff to take the training workshops, which is estimated to be half an hour per nurse, is the non-material cost. As there are 85 nurses with mean wage of HK$174.4 per hour, the estimated total cost would be HK$174.4/2 x 85 ICU nurses, i.e. HK$7412. The lecture rooms for the workshops are open for staff. In the long run, the workshops would be included into the existing ‘new ICU staff training program’, and so there is no long run cost for sustaining the implementation.

**Cost saving**

The reduction of the post-OES hypoxaemia incidence may lead to a reduction of various complications such as dysrhythmia, laryngospasm, trauma, and
microatelectasis (Oh & Seo, 2003). Therefore the cost saved from implementing the guideline will be the cost of treating the complications listed, and so lowering the morbidity and mortality.

**Cost of not implementing intervention**

If the guideline is not implemented, there would be a higher incidence rate of post-OES hypoxaemia, and therefore we may have to treat the complications brought by it.

The proposed OES guideline has a high implementation potential, as the supporting evidence is transferable to the targeted setting; has high feasibility of implementation in the clinical setting of the targeted ICU; and has a low cost with high benefit.
Chapter 5: Implementation Plan

To implement the guideline, plans of communication, pilot study and evaluation plan are essential. They are included in this chapter. Also, the details on how to initiate, guide and sustain the implementation are discussed. The time frame of implementation illustrated with the Gannt Chart is shown in Table 3.
<table>
<thead>
<tr>
<th>Task</th>
<th>Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication with stakeholders and seek approval</td>
<td>✓</td>
</tr>
<tr>
<td>Train the steering committee</td>
<td>✓</td>
</tr>
<tr>
<td>Program designing and preparation</td>
<td>✓     ✓</td>
</tr>
<tr>
<td>Pilot testing</td>
<td>✓</td>
</tr>
<tr>
<td>Amendments on guidelines, training sessions, and evaluations</td>
<td>✓</td>
</tr>
<tr>
<td>Training of ICU nurses</td>
<td>✓     ✓</td>
</tr>
<tr>
<td>Implementation of OES guidelines</td>
<td>✓     ✓ ✓ ✓ ✓ ✓ ✓</td>
</tr>
<tr>
<td>Evaluation: system outcomes</td>
<td>✓     ✓     ✓     ✓     ✓ ✓</td>
</tr>
<tr>
<td>Evaluation: healthcare provider outcomes</td>
<td>✓     ✓     ✓     ✓     ✓     ✓</td>
</tr>
<tr>
<td>Evaluation: patient outcomes</td>
<td>✓     ✓     ✓     ✓     ✓     ✓     ✓</td>
</tr>
</tbody>
</table>

Table 3 - Gannt chart on Implementation and Evaluation plan
Communication plan

To promote the implementation of the guideline, communications with stakeholders have to be made in order to initiate, sustain and evaluate the implementation.

Stakeholders

Stakeholders are the parties that are interested in the proposed guidelines and are also capable to affect the existing practice, either directly or indirectly (Polit & Beck, 2008). The stakeholders included in the proposed open endotracheal suctioning guideline are the ICU nurses, Advanced Practice Nurses (APNs), Nursing Specialists (NS), Nursing Officers (NOs), Physiotherapists, Ward Manager (WM), Nursing Consultant (NC), Department Operation Manager (DOM), ICU physicians and Chief-of-service (COS).

Communication with Stakeholders and potential users

The aim of communicating with stakeholders is to gain support and cooperation from them. It is done so by introducing the guideline and the changes it may bring. To do so, a bottom-up approach will be used in prioritizing the order of stakeholders to be communicated.
The NS will be the first stakeholder to be communicated with by email and in person. It is because the NS is the nurse who promotes and initiates evidence-based practices with the purpose of improving the quality of care to patients in ICU care. Explanation on the importance of the guideline will be discussed with the NS with the supporting evidence. Also, assistances will be sought from the NS for modifying the guidelines, in both searching for evidence and setting guidelines on the basis of it.

After obtaining the support from the NS, the proposed guidelines will be presented to the APNs, NOs, WM and DOM for obtaining their support in a meeting. The meeting will be held before seeking the approval from the COS of ICU, which will be initiated and held by the NS. The reason for inviting them is that they are the gatekeepers of any new guidelines or policies, who possess the authority to adopt the guidelines with financial support. In the meeting, the guideline and its significance will be introduced along with the implementation plan, resources and manpower required, estimated expenditure and timetable for implementation.

After obtaining the approval from the gatekeepers, explanations on the proposed guideline will be given to the ICU nurses through ward meeting and internal emails, with details of the guideline and links to the evidence.

If the proposed guideline is rejected during the arranged meeting, further
review and modifications of the guideline will be made with the aids from the NS. Then, the modified guidelines will be raised in another meeting. The communication flow chart is shown in Figure 2.

![Figure 2 – Communication Flowchart](image)

**Initiating the practice**

After obtaining the approval, a steering committee will be established for implementing the proposed OES guidelines. The committee will be composed of the author, NS, senior nurses with experience over 6 years and WM. The committee members will participate in preparation, implementation and evaluation of the guideline.

To commence and facilitate the implementation of the OES guideline, it is
essential to assure the ICU nurses understand the guideline. A 30-minutes training workshop will be designed for them, which is an introductory program explaining the OES guideline and its importance. The explanation of the guideline will take around 10 minutes. Then, the workshop will be held for 20 minutes. In the workshop, participants can have a trial on the OES techniques mentioned in the guidelines on a dummy (e.g. manikin or SimMan).

As it is impossible for all ICU nurses to attend to the OES workshop at the same time, the steering committee will design a supplementary information notice and post it on the staff notice boards. Also, ‘read-and-sign’ approach will be used in order to ensure all nursing staffs are acknowledged. Then, 4 identical OES workshops will be arranged with one in every week for 4 weeks. This is to provide flexibility for all 85 frontline nurses to join the workshop when they are available. In each training workshop, a power-point presentation of the guideline, with OES demonstrations and skill practice, directed by steering committee member on hyperoxygenation and hyperinflation prior to and after OES, will be provided. At the end of the workshop, questions and ideas from nurses on the OES guidelines will be encouraged.
Guiding the practice

Despite the workshop, nurses may still encounter difficulties when implementing the guideline in the clinical setting. Therefore, ‘train-the-trainers’ approach and recording the problems will be used as a measure to tackle the problem. Trainers will be assigned among the steering committee members. These trainers are assigned as a resource person for the frontline nurses to facilitate feedbacks and feelings from the nurses. Also, they will record the encountered problems and raised in the committee meeting, which will be held bi-weekly. Notices will be posted for addressing the questions and providing possible solutions.

Sustaining the practice

To sustain the change of the OES practice among the frontline staff, the steering committee members will involve in the daily practice as auditors. The audit will include the compliance of nurses to the proposed guidelines, and evaluate its effects on patients. Also, the frontline staff will be encouraged to approach the committee members if they encounter any problems. The committee members will search for new and strong evidences on OES in order to tackle the problems and update the proposed guideline.
**Pilot study plan**

A pilot study is a preliminary study to detect the weaknesses of the proposed guidelines or protocol prior to full implementation (Polit & Beck, 2008). The aim is to determine the adequacy of the training, the feasibility of implementing the proposed OES guideline and that of the evaluation plan. The pilot study will be carried out in the ICU of the designated hospital, after getting the ethical approval from the Ethical Board for Researches and before the full-scale implementation of the guideline in the clinical setting. The pilot study is estimated to be held for one month.

**Adequacy of trainings**

Ten ICU nurses will be invited to participate in the workshop during the pilot study. The training program will be in the same design and setting as planned. All participants will be given a 15-minute power-point presentation and discussion. Then the workshop on hyperoxegenation and hyperinflation prior OES will take place. During the workshop, participants’ questions and feedbacks on the OES guidelines will be recorded. After the workshop, participants will be required to complete an evaluation questionnaire (Appendix D), in order to investigate staff’s understanding, skills and satisfactions upon the proposed OES guidelines. And thus,
the effectiveness of the training workshop can be evaluated. The ‘train-the-trainer’
and the pilot training will be held for one week in estimation before the training
workshops for all ICU nurses as shown in Table 3.

**Feasibility of OES guidelines**

In the pilot study, 10 patients who meet the inclusion criteria will be recruited.
Eligible participants are patients under mechanical ventilation in intensive care unit
and they will be enrolled by using convenience-sampling method. The patients
included in the pilot study will be assessed by medical officers to see whether they
are fit to participate. Patients’ relatives will be informed for obtaining their consents
of allowing patients to participate in the pilot study. With referring the data from the
Pamela Youde Nethersole Eastern Hospital ICU registry in 2012, the estimated
timeframe for recruiting patient for implementing the guideline will be done in two
weeks. Nurses’ opinions and perceptions on the guideline will be obtained by the
steering committee, and modifications will be done if there is any identified problem
recorded from the pilot study, e.g. the materials used in the training workshops on
explaining the guideline or the interventions to enhance nurses’ compliance to the
guideline.
**Feasibility of evaluation plan**

To assess the feasibility of the evaluation plan during the pilot study, all the procedures of sampling recruitment, outcome measurements, data collection and analysis will be observed and recorded. All the participating staff and patients who are conscious during the pilot study will be invited to participate in meeting for evaluation. The aim of the assessment is to identify the weaknesses and limitations of the evaluation plan that will be used when implementing the OES guideline. The assessment of evaluation plan will be commenced at the beginning of the pilot study, and the discussion on the weaknesses and limitations with refining the evaluation plan will be done in the week after the pilot study.

The implementation plan of the proposed OES guideline starts with communicating with the stakeholders in ICU for approval. Then, a steering committee will be established to initiate and guide the change of practice. Training workshops will be designed to explain and demonstrate the suggested practices in the guidelines. A pilot study will be held in order to detect the weaknesses of the guidelines. During the implementation of the guideline, evaluation of the effectiveness will be performed and nurses’ perceptions will be collected.
Chapter 6: Evaluation Plan

The aim of evaluation plan is to determine the effectiveness of the proposed OES guideline. Specifically, the expected and the actual outcomes of the implementation will be compared. The expected outcomes include the patient outcomes, health care provider outcomes and organizational outcomes. It will be carried out during the implementation of the guideline as indicated in Table 3.

Outcomes

Patient outcomes

The aim of developing the evidence-based OES guideline is to improve the effectiveness of OES on patients under mechanical ventilation by reducing the incidence of hypoxemia. Therefore, the primary patient outcomes are the blood oxygen level and oxygen saturation in arterioles (SaO₂). After the implementation of the proposed OES guideline, it is expected to have a reduction in the incidence of hypoxemia. The blood gas oxygen level and SaO₂ were used as outcome measurements by Kerr et al (1997), Celik & Elbas (2000), Akgul & Akyolcu (2002). Blood oxygen level lower than 60mmHg (or 8kPa) or SaO₂ lower than 90% is considered as hypoxemia (Mason et al, 2010).

The secondary patient outcome is the duration of oxygen level recovery. As
mentioned by Ji et al (2002), restriction on NSI can shorten the oxygen level recovery time, and helps reducing the duration of patient under hypoxemia. If the oxygen level does not recover to the baseline level within one minute, it is considered to be lengthened time of oxygen level recovery (Glakoumidakis, 2011; Ji et al, 2002)

Static pulmonary compliance to mechanical ventilation will also be the secondary outcome measurements, by calculating the change in volume divided by the change in pleural pressure. As suggested by Berney & Denehy (2002), a better static pulmonary compliance to mechanical ventilation after OES implies a lesser chance of patients acquiring atelectasis.

**Healthcare provider outcomes**

As there is no standard guidelines on minimizing the unsatisfactory effects brought by OES such as hypoxemia, the proposed OES guidelines may help nurses in ICU to do so. With evidence-based guideline to support their practice on OES, they may find themselves having more skills and confidence to perform OES. To evaluate their levels of confidence on performing OES, questionnaire shown in Appendix E will be handed out for ICU nurses to fill in. The questionnaires will be collected and analyzed by the steering committee.
Also, staff’s compliance is an important indication of their acceptance towards the new practice. Members of the steering committee will record and assess their compliance rate and determine the cultural and behavioral changes brought by the implementation of the proposed OES guideline.

**Organizational outcomes**

The organizational outcomes will be the improvement of the quality of nursing care and the financial savings from the increased usage of OES. With the evidence-based guideline, there is likely to have a reduction in post-OES hypoxaemia. Additionally, ICU nurses will have a higher confidence in performing OES when compared to the conventional practice previously adopted. The higher confidence in performing OES will result in greater chance of choosing OES over the closed system suctioning. The difference of the cost between OES and closed system ones is the potential financial savings. The potential financial saving will be the reduced cost of patient care due to the reduction post-OES hypoxaemia and related complications. (Overend et al, 2009)

**Nature and number of clients involved**

To evaluate the effectiveness of the OES guideline during the implementation, evaluation will be carried out as mentioned above. The details of the evaluation are
discussed below.

**Eligibility criteria**

Based on the reviewed evidence for formulating the evidence-based OES guideline, the target subjects will be adult patients aged 18 or over and are under mechanical ventilation in ICU. The exclusion criteria are patients with pneumonia or history of airway problem such as atelectasis or chronic obstructive airway disease.

The target health care population will be the 75 ICU nurses of all grades in the ICU, as 10 ICU nurses had participated in the pilot study.

Prior to recruiting nurses and patients into the evaluation study, the plan of the evaluation will be submitted to the Ethic Board of PYNEH for ethical approval. Consents from all nurses and patients’ relatives will be obtained after the approval of the evaluation study.

**Design**

The evaluation study will be carried out in pre- and post- manner. The reason of using this study design is to obtain baseline data of each patient for direct comparison of the difference before and after the implementation. This within-subject study design can help taking into account the diverse individual
difference among the subjects.

All subjects will receive OES with/without guideline implemented and without it, and their SaO$_2$ and oxygen level in blood gases will be recorded before and after each suction. First, all nurses will perform 5 times of OES in conventional practice on patients before attending any training workshops on the proposed OES guidelines, and the SaO$_2$ and oxygen level in blood gases of the patients will be recorded. Then, training workshops on the proposed guidelines will be held for the nurses to participate. After that, the nurses will perform 5 times of OES in accordance with the recommendations of the proposed guideline on the same group of patients, with recording SaO$_2$ and oxygen level in blood gases of the patients. Based on the within-subject approach, all patients’ data will be compared with their own readings in pre- and post-guideline implementation. Comparing the differences of the incidence rate of hypoxaemia and oxygen recovery time before and after the implementation of the guideline, its effectiveness can then be evaluated. As it is suggested to perform OES only when necessary, it is estimated that two to four days will be needed for data collection of each patients.

For the evaluation on nurses’ confidence level and acceptance on the proposed OES guideline, evaluation questionnaires (Appendix D and Appendix E) and compliance checklist (Appendix F) will be given to nurses to fill in. In addition,
focus group interview of 6-10 nurses per session for 30 minutes will be held to collect opinions and ideas on the proposed guidelines.

**Sample size calculation**

The design of the evaluation is in pre- and post-intervention design. The sample size is calculated according to the design and the primary outcomes of the guideline. Among the literature previously reviewed, the reduction in incidence of post-OES hypoxemia ranged from 37% (Celik & Elbas, 2000) to 55% (Oh & Seo, 2003), and an effect size of 1.33 (Oh & Seo, 2003). To achieve a larger sample size, the decrease in post-OES hypoxemia of 37% is adopted. The sample size is obtained with an online computer program developed by Lenth (2006). Statistical significance is set as 0.05 and power at 80%. On the basis of these assumptions, 103 patients will be required as calculated with the test for one proportion. With assuming 10% dropout rate due to critical condition of patients, a total of 114 patients will be recruited.

**Sample recruitment**

Convenience sampling will be adopted for recruiting samples. With reference to the Pamela Youde Nethersole Eastern Hospital statistics, there were around 730 patients to be admitted into ICU and required to have mechanical ventilation during
their stay in 2012. Assuming there will be 20% of the patients under mechanical ventilation are ineligible, such as having atelectasis. The estimated period of time to recruit 114 patients will be around two and a half months. Detailed calculation is shown in Table 4.

Table 4 - Calculation on sample recruitment of evaluation study

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Newley admitted patients under MV per month</td>
<td>730/12 = 60 patients</td>
</tr>
<tr>
<td>No. of ineligible patients per month (20%)</td>
<td>60x20% = 12 patients</td>
</tr>
<tr>
<td>Total eligible patients under MV per month</td>
<td>60-12 = 48 patients</td>
</tr>
<tr>
<td>Time to recruit</td>
<td>114/48 = 2.375 months</td>
</tr>
</tbody>
</table>

Data collection

An OES checklist will be developed by the steering committee (Appendix F), and will be distributed to case nurses of the patients under mechanical ventilation. The checklist aims to collect data such as compliance to the guideline, blood oxygen level and SaO₂ of the patients pre-and-post OES, time for oxygen level recovery, and the static pulmonary compliance to mechanical ventilation. Also, subjects’ demographic data will be collected from their medical records in the computer system for detecting potential gender or race difference of the guidelines’ effectiveness. The checklists will be collected by the members of steering committee every day during the implementation period.

Staffs’ reactions to the guideline will be collected from the evaluation forms.
and in the 30-minutes semi-structured focus group interviews with audio recording as qualitative data after the implementation period. Each focus group involves 6-10 staff and a member of steering committee as moderator. Comments and obstacles that came across during the implementation will be covered in the focus group meetings. Category scheme will be developed and the data will be coded according to their categories and themes.

**Data analysis**

Both the quantitative and qualitative data collected will be analyzed by the steering committee.

The primary outcome of the guideline is the incidence rate of post-OES hypoxemia, and it will be analyzed by a two-tailed paired t-test to test for significance of difference before and after implementing the guideline.

Patients’ demographics and characteristics, and nurses’ data (e.g. year of experience and their ranks) will be presented in descriptive statistics. The two-tailed t-test on the incidence rate of post-OES hypoxemia will be computed using the computer software Statistical Package for Social Sciences (SPSS). Sample size and the significance level will be set to ≥60 and at 0.05 respectively (Bruce & Patten, 2009).
**Criteria of effectiveness**

The success of the guidelines is determined by whether the patients, health care providers and organizational outcomes have achieved. As mentioned, the primary patient outcome is the reduction in incidence of post-OES hypoxemia. If the absolute reduction of incidence rate reaches 37% (Ji et al, 2002), the guideline will be considered as effective.

For health care provider outcome, the acceptance of the guidelines, compliance rate and higher knowledge and confidence levels are the indicators of the success of the guideline. If there is a 70% ‘agree’ results of above with at least 60% response rate for the evaluation questionnaires from the training session (Appendix D) and nurses’ evaluation on knowledge, satisfaction and acceptance level on the guidelines (Appendix E), the nurses’ evaluation of acceptance and confidence level will then seen to be achieved (SurveyMonkey, 2011). If the competency in return demonstration during the training workshop is 100%, the aim of the training workshops will then seen to be achieved.

For the organizational outcome, the reduction in financial cost and better quality of service will demonstrate the effectiveness of the guideline.
Conclusion

The proposed OES guideline has great implementation potential as it is evidence-based, having good transferability into target setting, and with low cost-benefit ratio. The guideline can reduce the incidence rate of post-OES hypoxemia; enhance nurses’ confidence and knowledge level on performing OES; and reduce the financial cost. The implementation of the evidence-based guideline on OES for mechanically ventilated patients will succeed in the target ICU with its detailed communication and evaluation plans, and the participation of ICU staffs.
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# Methodology Checklist 1: Systematic Reviews and Meta-analyses

## Section 1: Internal validity

**In a well conducted systematic review:**

<table>
<thead>
<tr>
<th></th>
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<th>Does this study do it?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>The study addresses a clearly defined research question.</td>
<td>Yes</td>
</tr>
<tr>
<td>1.2</td>
<td>At least two people should select studies and extract data.</td>
<td>Yes</td>
</tr>
<tr>
<td>1.3</td>
<td>A comprehensive literature search is carried out.</td>
<td>Yes</td>
</tr>
<tr>
<td>1.4</td>
<td>The authors clearly state if or how they limited their review by publication type.</td>
<td>Yes</td>
</tr>
<tr>
<td>1.5</td>
<td>The included and excluded studies are listed.</td>
<td>Yes</td>
</tr>
<tr>
<td>1.6</td>
<td>The characteristics of the included studies are provided.</td>
<td>Yes</td>
</tr>
<tr>
<td>1.7</td>
<td>The scientific quality of the included studies is assessed and documented.</td>
<td>Yes</td>
</tr>
<tr>
<td>1.8</td>
<td>The scientific quality of the included studies was assessed appropriately.</td>
<td>Yes</td>
</tr>
<tr>
<td>1.9</td>
<td>Appropriate methods are used to combine the individual study findings.</td>
<td>Yes</td>
</tr>
<tr>
<td>1.10</td>
<td>The likelihood of publication bias is assessed.</td>
<td>Yes</td>
</tr>
<tr>
<td>1.11</td>
<td>Conflicts of interest are declared.</td>
<td>Yes</td>
</tr>
</tbody>
</table>

## SECTION 2: OVERALL ASSESSMENT OF THE STUDY

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>What is your overall assessment of the methodological quality of this review?</td>
<td>High quality (++)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Acceptable (+)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unacceptable – reject 0</td>
</tr>
<tr>
<td>2.2</td>
<td>Are the results of this study directly applicable to the patient group targeted by this guideline?</td>
<td>Yes</td>
</tr>
</tbody>
</table>
## Methodology Checklist 2: Controlled Trials

### Section 1: Internal validity

**In a well conducted RCT study...** | **Does this study do it?**
---|---
1.1 The study addresses an appropriate and clearly focused question. | Yes | No □
1.2 The assignment of subjects to treatment groups is randomised. | Yes | No
1.3 *An adequate concealment method is used.* | Yes | No
1.4 Subjects and investigators are kept ‘blind’ about treatment allocation. | Yes | No
1.5 The treatment and control groups are similar at the start of the trial. | Yes | No
1.6 The only difference between groups is the treatment under investigation. | Yes | No
1.7 All relevant outcomes are measured in a standard, valid and reliable way. | Yes | No
1.8 What percentage of the individuals or clusters recruited into each treatment arm of the study dropped out before the study was completed? | | |
1.9 All the subjects are analysed in the groups to which they were randomly allocated (often referred to as intention to treat analysis). | Yes | No
1.10 Where the study is carried out at more than one site, results are comparable for all sites. | Yes | No

**SECTION 2: ** OVERALL ASSESSMENT OF THE STUDY
|   | **How well was the study done to minimise bias?** | **High quality (++)**  
|   |                                                | **Acceptable (+)**  
|   |                                                | **Unacceptable – reject 0**  
| 2.2 | **Taking into account clinical considerations, your evaluation of the methodology used, and the statistical power of the study, are you certain that the overall effect is due to the study intervention?** |   
| 2.3 | **Are the results of this study directly applicable to the patient group targeted by this guideline?** |   
| 2.4 | **Notes.** Summarise the authors’ conclusions. Add any comments on your own assessment of the study, and the extent to which it answers your question and mention any areas of uncertainty raised above. |   

## Appendix C - Key to Evidence Statements and Grades of Recommendations

### Levels of Evidence

<table>
<thead>
<tr>
<th>Level of Evidence</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1++</td>
<td>High quality meta-analyses, systematic reviews of RCTs, or RCTs with a very low risk of bias</td>
</tr>
<tr>
<td>1+</td>
<td>Well-conducted meta-analyses, systematic reviews, or RCTs with a low risk of bias</td>
</tr>
<tr>
<td>1-</td>
<td>Meta-analyses, systematic reviews, or RCTs with a high risk of bias</td>
</tr>
<tr>
<td>2++</td>
<td>High quality systematic reviews of case control or cohort or studies with a very low risk of confounding or bias and a high probability that the relationship is causal</td>
</tr>
<tr>
<td>2+</td>
<td>Well-conducted case control or cohort studies with a low risk of confounding or bias and a moderate probability that the relationship is causal</td>
</tr>
<tr>
<td>2-</td>
<td>Case control or cohort studies with a high risk of confounding or bias and a significant risk that the relationship is not causal</td>
</tr>
<tr>
<td>3</td>
<td>Non-analytic studies, e.g. case reports, case series</td>
</tr>
<tr>
<td>4</td>
<td>Expert opinion</td>
</tr>
</tbody>
</table>

### Grades of Recommendation

<table>
<thead>
<tr>
<th>Grade</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>At least one meta-analysis, systematic review, or RCT rated as 1++, and directly applicable to the target population; or A body of evidence consisting principally of studies rated as 1+, directly applicable to the target population, and demonstrating overall consistency of results</td>
</tr>
<tr>
<td>B</td>
<td>A body of evidence including studies rated as 2++, directly applicable to the target population, and demonstrating overall consistency of results; or Extrapolated evidence from studies rated as 1++ or 1+</td>
</tr>
<tr>
<td>C</td>
<td>A body of evidence including studies rated as 2+, directly applicable to the target population and demonstrating overall consistency of results; or Extrapolated evidence from studies rated as 2++</td>
</tr>
<tr>
<td>D</td>
<td>Evidence level 3 or 4; or Extrapolated evidence from studies rated as 2+</td>
</tr>
<tr>
<td>✓</td>
<td>Recommended best practice based on the clinical experience of the guideline development group</td>
</tr>
</tbody>
</table>
Appendix D: Evaluation questionnaires for training workshop

Section A (Please circle the most appropriate number on the rating scales)

<table>
<thead>
<tr>
<th>Items</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Powerpoint presentation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1 The content of presentation is clear</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>1.2 The content of presentation is easy to understand</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>1.3 Information on open endotracheal suctioning skills are useful</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>1.4 The content of presentation meets your expectation</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2. Hand-on workshop</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1 Instructions are clear during demonstration</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2.2 Instructors are helpful during practice</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2.3 Experience in hand-on workshop is good</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3. Overall</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1 The venue is appropriate</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3.2 Timing of the workshop is appropriate</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>3.3 The contents of presentation and workshop are relevant</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Section B

1. What are the things about the training workshop you appreciate MOST?

2. What things could the training workshop be improved?

3. Other comments

______________________________
Appendix E: Evaluation questionnaire on satisfaction and acceptance level after the OES guidelines implementation

Section A (Please circle the most appropriate number on the rating scale)

<table>
<thead>
<tr>
<th>Items</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Knowledge level</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1 I understood the complications brought by open system suctioning (OES)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2 I was clear about the significant of OES guidelines</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.3 The risk and benefit of the OES guidelines were understood</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.4 The method of hyperoxygenation was clear</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5 The method of hyperinflation was clear</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.6 The reasons for inhibition of normal saline instillation was clear</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Self-perceived skills and confidence</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1 I had developed adequate skills to implement the OES guidelines</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.2 I am confident to perform hyperoxygenation prior OES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.3 I am confident to perform hyperinflation prior OES</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Satisfaction level</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1 I was clear about the content of the guideline</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.2 The content of the guidelines were well-organized to implement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.3 The guidelines have clear instruction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.4 I was able to cope with the workload and problems encountered during implementation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.5 I had fulfilled what the guideline required</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Section B

1. What difficulties have you faced during the implementation?

2. What are the best things about the guidelines?

3. What thing of the guidelines can be improved?

Other comments:
**Appendix F: OES Guidelines Checklist**

**OES Guidelines Checklist**

<table>
<thead>
<tr>
<th>Patient Name:</th>
<th>Admission Date:</th>
<th>ICU bed number:</th>
<th>Nurse’s name:</th>
</tr>
</thead>
</table>

- Please complete the checklist in every shift
- Please ‘√’ the appropriate boxes if the item is completed; use ‘N/A’ for Not applicable
- Please return the checklist to the steering committee members when patient is discharged from ICU

<table>
<thead>
<tr>
<th>Items</th>
<th>Date</th>
</tr>
</thead>
</table>

### 1. Hyperoxygenation

1.1 Hyperoxygenation was done prior to OES
1.2 Hyperoxygenation was done after OES
1.3 Hyperoxygenation was done for 4-6 breaths
1.4 Hyperoxygenation was done with 100% oxygen
1.5 Hyperoxygenation with oxygen level 20% higher than maintenance level for patient with COPD

### 2. Hyperinflation

2.1 Hyperinflation was done prior to OES WITH hyperoxygenation
2.2 Hyperinflation was done after OES WITH hyperoxygenation
2.3 Hyperinflation was done in 150% of patient’s tidal volume
2.4 Hyperinflation was done at rate of 8 breaths/40secs
2.5 Hyperinflation was delivered by ventilator
2.6 Hyperinflation was NOT given to patients with head injury or high ICP

### 3. Normal saline instillation

3.1 NO normal saline was instilled into trachea for easier sputum clearance