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# Comparison of open and closed suction on safety, efficacy and nursing time in a paediatric intensive care unit

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ABSTRACT

*Background:* Endotracheal suctioning (ETS) is one of the most common procedures performed in the paediatric intensive care. The two methods of endotracheal suctioning used are known as open and closed suction, but neither method has been shown to be the superior suction method in the Paediatric Intensive Care Unit (PICU).
*Purpose:* The primary purpose was to compare open and closed suction methods from a physiological, safety and staff resource perspective.
*Methods:* All paediatric intensive care patients with an endotracheal tube were included. Between June and September 2011 alternative months were nominated as open or closed suction months. Data were prospectively collected including suction events, staff involved, time taken, use of saline, and change from pre-suction baseline in heart rate (HR), mean arterial pressure (MAP) and oxygen saturation ($SpO_2$). Blocked or dislodged ETTs were recorded as adverse events.
*Findings:* Closed suction was performed more often per day (7.2 vs 6.0, $p < 0.01$), used significantly less nursing time (23 vs 38 min, $p < 0.01$) and had equivalent rates of adverse events compared to open suction (5 vs 3, $p < 0.23$). Saline lavage usage was significantly higher in the open suction group (18% vs 40%). Open suction demonstrated a greater reduction in $SpO_2$ and nearly three times the incidence of increases in HR and MAP compared to closed suction. Reductions in MAP or HR were comparable across the two methods.
*Conclusions:* In conclusion, CS could be performed with less staffing time and number of nurses, less physiological disturbances to our patients and no significant increases in adverse events.


## 1. Introduction

Endotracheal suctioning (ETS) is one of the most common procedures performed in the intensive care setting, and the procedure has specific significance and risk in paediatric and neonatal patients. The endotracheal tube (ETT) requires regular clearance of mucous to prevent complications such as blocked ETTs, atelectasis and alveolar collapse.[1,2] In infants and children the smaller diameter ETT further increases the risk of blockage. ETS has many serious complications and risks including hypoxaemia, cardiovascular instability, infection, pain and elevated intracranial pressure.[3–6] Neonates and children can be particularly prone to

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complications due to physiological immaturity and lower functional residual capacity.[6]

There are two methods of ETS commonly used known as open and closed suction. The open suctioning (OS) system is performed by disconnecting the ventilator circuit from the ETT to insert the suction catheter. In the closed suctioning (CS) system, ETS is performed without disconnecting the ventilator circuit and uses in-line catheters that are enclosed in a sheath and attached to the ETT. Several randomised controlled trials (RCTs) that compared CS and OS failed to show a superiority of one type of ETS over the other; furthermore several meta-analyses, mostly in adults, were not able to demonstrate any clinically significant differences between the two methodologies.[7–10] Open suctioning has been reported to be associated with arterial desaturation, inability to maintain PEEP, increased heart rate and blood pressure and cardiac arrhythmias, particularly in patients with cardiorespiratory instability.[11–15] In addition, the open system places staff at an increased risk of exposure to infectious patient secretions and the patient at increased risk of microbial contamination of their artificial airway.[16,17] CS has been shown in some adult studies to demonstrate fewer physiological disturbances compared to OS.[13,18] In neonates and children evidence is limited, with CS showing less lung volume loss and some physiological benefit although not in all studies.[6,11,14,19] Animal studies have demonstrated less secretions are removed using the closed system versus the open system,[20,21] however clinical evidence has been limited to mostly anecdotal reports.[18,22,23] Nursing time for CS has been shown to be less than OS.[10]

Our aim in performing this audit was to compare open and closed suction methods from a physiological, safety and staff resource perspective. A secondary objective was to make an informed decision about our suction practice as we moved from our old hospital with 4–5 bed multi-patient rooms into a new hospital where the PICU was an entirely single room environment.

## 2. Methods

The audit was conducted over a four month period from June 2011 to September 2011 at The Royal Children's Hospital, Melbourne PICU. This is a 19 bed multi-disciplinary unit admitting 1400 patients per year aged from 0 to 18 years. Each month of the audit was alternatively designated as an OS or CS month. Both methods of ETS were practised in the unit, although the CS technique was used less frequently. All patients with an ETT were included in the audit on admission to PICU or on intubation in the PICU. ETS was performed as per the pre-existing guideline within the PICU. Staff were permitted to change the catheter type at any point after allocation if deemed clinically necessary. The suction catheters used for OS were Y-suction catheters (Unomedical or Pacific Hospital Supply Co.), and CS was performed with the Kimberly-Clark™ 'Kimvent™' closed ballard suction system for neonates/paediatrics. An ETS event was defined as a discrete episode of ETS that may involve several passes of the suction catheter. After each ETS event was completed the bedside nurse recorded the number of staff involved, the length of time of the ETS event, use of saline lavage, as well as change from pre suction baseline in heart rate (HR), mean arterial pressure (MAP) and oxygen saturation ($SpO_2$) during the ETS episode. Time was recorded in minutes and was estimated by nursing staff using clocks on the wall in each room. Saline lavage consisted of 0.9% saline and less than 0.5 ml was instilled. The HR was measured from the displayed 3 lead ECG, MAP was measured from an intra-arterial line and the arterial oxygen saturation from pulse oximetry. The researchers calculated if the change in HR, MAP, and $SpO_2$ was 20% or more above or below the patient's pre-suction baseline, and entered this in the data. Nursing time was calculated by number of staff multiplied by time involved, that is 2 staff for 2 min = 4 min of nursing time. No data were collected regarding nursing experience or qualifications. Staff could also write free comments on the data sheet, and this information was collated for identification of common themes. The bedside nurse noted on the data sheet if any adverse event (blocked ETT or dislodged ETT) or intervention associated with the ETT occurred (re-strapping or re-positioning of the ETT). Data were entered by a single person into an excel spreadsheet. Statistical tests used were Fisher's exact test and chi square test, and continuous parametric variables were compared with the *t* test.

A *p*-value of <0.05 was considered statistically significant. The data were analysed by suction method the patient was allocated to, even if their suction method was changed after allocation. Approval to conduct the clinical audit as a quality improvement initiative was granted by the Director of the Unit and Nurse Unit Manager.

## 3. Results

Over the four month period of the study, 6691 ETS events were documented by the bedside nurses from 229 unique patient admissions (Table 1). Some patients were present during the cross over period and received both forms of ETS hence total patients $n = 258$. The CS method resulted in more suction events per day compared to OS (7.2 vs 6.0, $p < 0.01$). The overall count of ETS events for the OS section of the audit was higher than the CS section as it involved more audit days (65 vs 53 days). Saline lavage usage differed significantly between the two groups (1397 vs 572, $p < 0.01$). Adverse events of blocked or dislodged ETT were compared and showed no significant difference between the two groups. Adverse events in the OS group was all dislodged ETTs (3), whilst for CS was blocked ETT (4) and dislodged ETT (1). No patient had more than one adverse event. When looking at patient categories, the cardiac subgroup accounted for five of the eight adverse events, with two adverse events occurring in the respiratory infection subgroup and one in the direct from theatre (non cardiac) subgroup.

The average ETS time per day for each beside nurse was statistically significantly less for CS compared to OS as seen in Table 2 (23 min vs 38 min, $p < 0.01$). This was due to a reduction in the average length of time for each ETS event, in addition to less staff were required to carry out the suction procedure. The number of staff involved with ETS showed a significant reduction in the average number of staff required for CS compared to OS (1.2 vs 2.0, $p = 0.000$). This translates to a clinically significant difference of one versus two nurses. There was also a significantly greater proportion of non-nursing staff involved with performing ETS in the single patient room compared to multi-patient room for the OS method (3.8% vs 2.2%, $p < 0.01$).

Comparison of the effect of OS and CS on physiological parameters can be seen in Table 3. Variation by more than 20% was chosen as our cut off as this was considered a significant clinical change. Overall the OS method produced a greater frequency of

**Table 1**
Summary of ETS data.

| | Patients ($n$=) | Patient days | ETS events | ETS events per patient per day | Saline lavage use (per ETS event) | Adverse events |
|---|---|---|---|---|---|---|
| Open | 150 | 583 | 3501 | 6 | 1397 | 3 |
| Closed | 108 | 441 | 3190 | 7.2 | 572 | 5 |
| *p* value | | | | <0.01 | <0.01 | =0.23 |