Clinical practice guidelines for suctioning the airway of the intubated and nonintubated patient

Authors’ objectives
To provide physicians, physiotherapists, nurses and respiratory therapists with guidelines for the application of airway suctioning.

Searching
MEDLINE; (from 1966 to 1998), EMBASE (from 1974 to 1996) and CINAHL (from 1982 to 1997) were searched for publications in the English language. The keywords were 'trachea', 'pharynx', 'tracheostomy', 'suction', 'artificial airway', 'inflation' and 'endotracheal'. The Cochrane Database of Systematic Reviews was also searched. The reference lists from both included and excluded studies were examined. Only abstracts with sufficient information to allow judgement of the methodology and interpretation of data were included. No attempts were made to locate unpublished material. Reviews, guidelines, protocols and other descriptive articles were excluded.

Study selection
Study designs of evaluations included in the review
Randomised controlled trials (RCTs), randomised and non-randomised crossover studies, and comparative cohort studies were eligible. Case series and animal studies were not included in providing evidence for recommendation. One retrospective chart review was also included.

Specific interventions included in the review
The inclusion criteria were not defined a priori in terms of the interventions. Studies that used interventions that were irrelevant to the questions or that were reports of diagnostic tests, were excluded. The following techniques used in airways suctioning were included:

preoxygenation, hyperventilation, and combinations of preoxygenation and hyperventilation;
different frequencies of suctioning;
drugs for muscle paralysis (vercuronium, atacurium, and succinylcholine);
drugs for pain relief during suctioning;
instillation of saline;
use of adaptors (modified Wye, modified endotracheal intubation, and positive end expiratory pressure adaptor);
hyperventilation and hyperoxygenation;
methods of delivery (manual resuscitator bag versus ventilator);
open versus closed systems;
catheters of different design and types (DeLee, bulb catheter, straight catheter, Coude catheter, double and single lumen endotracheal tube);
clean and sterile technique;
drugs to prevent increased intracranial pressure (ICP) or cerebral perfusion pressure (CCP), i.e. intravenous and topical
lidocaine, alfentanil, fentanyl, and thiopental; 
drugs to minimise or decrease bradycardia during suctioning (nebulised, intravenous, and intramuscular atropine); and jet ventilation.

Participants included in the review
Intubated and nonintubated adults and children were eligible. The following groups of participants were included: nonintubated neonates with and without evidence of meconium aspiration syndrome (MAS); intubated neonates, pre-term and full-term infants; post-operative adults including those who had undergone cardiac surgery or lung resection; adults with head injuries or trauma; and adults with chronic obstructive pulmonary disease and respiratory distress syndrome.

Outcomes assessed in the review
The inclusion criteria were not defined a priori in terms of the interventions. The measures of benefit and complications of suctioning assessed were ICP, CPP, heart rate, oxygen saturation, blood-pressure, and the rates of mortality, MAS, and pneumonia. The data extractors set priorities when there were multiple outcome measures.

How were decisions on the relevance of primary studies made?
Initially, broad subject-related criteria were used to identify articles for more intensive examination. At least two researchers reviewed each retrieved article and agreed on its inclusion or exclusion.

Assessment of study quality
The review focused on RCTs and comparative cohort studies. Some aspects of validity were discussed in the text of the review, although no formal validity assessment was performed. At least two researchers assessed study type.

Data extraction
At least two researchers extracted the data into a specially designed data extraction form. The data extracted were: the author and year of publication; study type; allocation method; participant inclusion and exclusion criteria; when the study was conducted; adequacy of follow-up; baseline comparison of treatment groups; specific intervention; outcome measures; and whether the outcomes of physiological status were appropriate, valid and reliable. If the study was not specifically described as randomised, it was assumed to be non-randomised.

Methods of synthesis
How were the studies combined?
Meta-analyses were not conducted due to heterogeneity in the patient populations, differences in the intervention techniques and outcome measures. The studies were grouped according to the characteristics of the participants (infants and children versus adults), then categorised on the basis of the suction technique used. A narrative synthesis was then undertaken.

How were differences between studies investigated?
Differences were discussed in the text of the review.

Results of the review
Eighty-seven studies were used to inform the recommendations: 59 RCTs (approximately 1,765 patients) and 28 non-randomised crossover studies, comparative studies, or retrospective chart reviews (approximately 1,616 patients).

There were no studies on the following: the optimum route for suctioning when the patient is not intubated (nasal versus oral); the use of airway (nasal or oral); catheter size; frequency of suctioning, suction pressure, duration of suction, and landmark for applying suction; intermittent versus constant suctioning; rotation of catheter; and the use of lubrication.

Infants and children.
Nonintubated neonates with MAS.

DeLee versus bulb methods: one RCT and one comparative cohort found no difference in the rates of MAS or mortality between the DeLee and bulb methods. Both studies lacked statistical power to detect a difference.

Oropharyngeal suctioning versus tracheal suctioning: one RCT and one comparative cohort found no difference between the treatments. The cohort study reported stridor associated with tracheal suctioning. Nonintubated neonates without MAS (one comparative cohort study): in view of the lack of evidence, no recommendations were made.

Intubated neonates, pre-term and full-term infants. Preoxygenation: all 3 studies (1 RCT and 2 non-randomised crossover studies) showed improved oxygenation with preoxygenation. None of the studies examined the potentially negative effects of hyperventilation of a pre-term infant. Combination of preoxygenation and hyperventilation (2 non-randomised studies): neither study used a control group of no preoxygenation and hyperventilation. No recommendations were made. Frequency of suctioning: one RCT found no statistically-significant difference between suction applied 6-hourly versus 12-hourly. No recommendations were made.

Drugs for muscle paralysis: one non-randomised crossover study found muscle paralysis (using pancuronium) in ventilated pre-term infants reduced the increase in intracranial pressure during suction. Drugs for pain relief during suctioning: 3 studies (2 RCTs and one non-randomised crossover study) provided no clear evidence of benefit or harm of analgesic use (alfentanil, meperidine, phenobarbital) during suctioning.

Instillation: 2 crossover RCTs reported differences over time but did not compare outcomes between the groups. No recommendations were made. Adaptor: 2 RCTs and 2 non-randomised crossover studies found increased oxygenation when an adaptor was used. Hyperventilation and hyperoxygenation: the studies (2 crossover RCTs) compared several protocols using combinations of hyperventilation and hyperoxygenation. Neither study compared groups. A pre-post suction analysis of both studies showed no oxygen desaturation during suction with hyperventilation or hyperoxygenation, or combinations of these methods. There was insufficient evidence to make recommendations.

Adults.

Preoxygenation: all 4 studies (2 RCTs and 2 comparative cohort studies) showed an increase in oxygen saturation with preoxygenation.

Hyperoxygenation and hyperinflation (5 crossover RCTs): hyperoxygenation helped to maintain oxygen levels in mechanically-ventilated medical and surgical patients (4 RCTs). The additional effect of hyperinflation was unclear. For patients with head injury, there were no differences between hyperoxygenation alone and the combination of hyperventilation and hyperoxygenation on intracranial pressure, arterial blood-pressure, heart rate or saturation (1 RCT).

Insufflation (5 RCTs): in general, insufflation was associated with the maintenance of oxygen levels throughout suctioning at flow rates of 10 to 15 L/minute.

Hyperinflation alone (7 RCTs): 5 RCTs on postcardiac surgery patients reported inconsistent effects on oxygen levels, but an increase in blood-pressure associated with hyperinflation was noted. Two RCTs in head injury patients suggested that an increase in the volume of air delivered may be associated with an increase in intracranial pressure.

Methods of delivery (4 crossover RCTs and 1 comparative cohort study): 4 of the 5 studies reported improved oxygenation with the use of a ventilator, compared with the manual resuscitator bag. In 3 RCTs it was not confirmed whether the manual resuscitator bag actually delivered hyperventilation and an oxygen concentration of 100%. Use of adaptors (3 crossover RCTs): 2 of the 3 RCTs reported that adaptor use was associated with a decreased change in oxygenation during suctioning. Positive end expiratory pressure adaptor (1 crossover RCT and 1 non-randomised crossover study): the results were inconsistent.

Open versus closed suctioning systems (11 studies): the results on oxygenation were inconsistent.

Clean versus sterile technique (1 retrospective comparative cohort study): the methodological flaws included a lack of
standardisation of the techniques, a lack of control for confounders, and the use of a nonvalidated tool.

Straight versus Coude catheter (4 comparative cohort studies): the Coude catheter was more effective than a straight catheter in direct cannulation of the left bronchus in patients with a tracheostomy (1 study), and in intubated patients after surgery (1 study). There was insufficient evidence to make recommendations on the best catheter design for the prevention of mucosal injury.

Catheter design: a double lumen endotracheal tube used to assist drainage of subglottic secretions was associated with a reduced risk of pneumonia (2 RCTs), but no reduction in hospital mortality (1 RCT). There was insufficient evidence from 3 studies (2 crossover RCTs and 1 cohort study) to make recommendations on the relative effectiveness of single and double lumen catheters for instillation. Instillation (1 RCT and 2 crossover RCTs): most of the studies found no difference in oxygenation, gas exchange, heart rates, or blood-pressure. There was insufficient evidence to make recommendations.

Drugs to prevent increased ICP or CPP (5 studies): vecuronium (0.12 mg/kg), atacurium (0.4 mg/kg) and succinylcholine (1 mg/kg) prevented a rise in ICP (2 studies). Intravenous lidocaine had no effect on ICP during suctioning (3 studies), whereas intratracheal lidocaine was more effective in suppressing cough reflex but was associated with an initial rise in ICP due to coughing. Thiopental did not prevent a rise in ICP associated with suctioning (1 study). Alfentanil decreased CPP (1 study), while fentanyl had no effect on ICP (1 study). Drugs to minimise or decrease bradycardia during suctioning (1 crossover RCT): bradycardia was prevented with either parenteral atropine (1 mg intramuscularly or slow intravenous) or nebulised atropine (0.05 mg/kg) (p<0.001). Tachycardia occurred in all patients receiving the parenteral form.

Jet ventilation (1 small non-randomised study): there was insufficient evidence to make recommendations.

**Authors' conclusions**

There were no studies on the optimal route for suctioning when the patient is not intubated (nasal versus oral); the use of airway (nasal or oral); catheter size; frequency of suctioning, suction pressure, duration of suction, and landmarks for applying suction; intermittent versus constant suction; rotation of catheter; and the use of lubrication.

**CRD commentary**

The aims were stated and the inclusion criteria were broadly defined in terms of the study design and participants. Several relevant sources were searched, and the methods used to select the studies were described. Restricting the included studies to those published in the English language may have resulted in the omission of other relevant studies. In addition, the lack of attempts to locate unpublished material raises the possibility of publication bias.

The included studies were limited to controlled trials (either randomised controlled studies or comparative cohort studies) and while some aspects of study validity were discussed in the text, no formal validity assessment was performed. Relevant data were extracted and the methods used to extract the data were described. The studies were grouped appropriately according to the participants and type of intervention, and the narrative synthesis was presented clearly. Most of the studies had a small sample size with limited power to detect a difference between the treatment groups, and recommendations were only made when the evidence was judged as adequate. Condensing such a large volume of diverse studies into a readable publication is no mean achievement.

The evidence presented supports the authors' recommendations, though the strength of the evidence would have been increased by including a formal assessment of the quality of the studies on which the evidence was based.

**Implications of the review for practice and research**

Practice: The authors state that in children the DeLee and bulb methods are equally effective in the aspiration of meconium when suctioning nonintubated infants with MAS. The DeLee method is not recommended due to the risks to the operator. Individualised preoxygenation should be applied in intubated and ventilated pre-term and full-term infants to improve oxygenation. Adaptors should be used to mechanically ventilate pre-term and full-term infants with respiratory distress syndrome.
The authors state that mechanically-ventilated adults should receive additional oxygen before suctioning. For mechanically-ventilated trauma, cardiac and chronic obstructive airways patients, hyperoxygenation should be used during suction. For severely head-injured patients, where intracranial pressure is of concern, hyperinflation, before, during and/or after suctioning should not be added to hyperoxygenation.

The use of oxygen insufflation (at 10 to 15 L/minute) is recommended for relatively stable patients who are mechanically ventilated. The use of hyperinflation by any method is not recommended in preoxygenated patients who undergo coronary artery bypass graft surgery. In other populations, caution is required when using hyperinflation because of the risks of increasing the ICP. A ventilator is more effective than a manual resuscitator bag and should be used when oxygen delivery is a concern. Suctioning through an adaptor in mechanically-ventilated surgical and medical patients may be as effective as disconnecting the ventilator circuit and hyperoxygenating before and after suctioning.

A curved catheter is more successful than a straight one in tracheotomised or intubated patients in entering the left main bronchus. There is some evidence to support the use of a modified endotracheal tube with the capacity for subglottic suctioning. Intravenous vecuronium (0.12 mg/kg), atacurium (0.4 mg/kg) or succinylcholine (1 mg/kg) may be considered in head-injured patients to prevent an increase in ICP associated with suctioning. Intravenous lidocaine (1.5 mg/kg) does not appear to prevent a rise in ICP. Nebulised atropine (0.05 mg/ kg) may prevent bradycardia in patients with bradycardia induced by suctioning.

Research: The authors state that further research is required. This should address the following: the use of muscle paralysing agents; the cost-effectiveness of double lumen tubes to assist with subglottic drainage and its use in high-risk groups; and instillation in patients with marginal gas exchange.

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**Bibliographic details**

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**Other publications of related interest**
This additional published commentary may also be of interest. Taylor-Piliae R. Review: several techniques optimise oxygenation during suctioning of patients. Evid ased Nurs 2002;5:51.

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