Comparison between open and closed suction systems. A systematic review

Comparação entre os sistemas aberto e fechado de aspiração. Revisão sistemática

INTRODUCTION

Tracheal suction is a rather frequent and essential procedure in patients under mechanical ventilation. There are reports that each patient undergoes suction from 8 to 17 times a day. (1-7) During the procedure tracheal secretion is removed to assure adequate oxygen supply and to avoid obstruction of the tube lumen, resulting in increased respiratory work, atelectasias and pulmonary infections. However, there are also adverse effects such as alteration of the heart rate, hypoxemia and ventilator associated pneumonia (VAP). (8) Furthermore, it must be remembered that this is an uncomfortable and invasive procedure. (9)

Two suction systems are available on the market: an open suction sys-
tem (OSS) and a closed suction system (CSS). The OSS is only used once and requires that the ventilator be disconnected. Whereas the CSS use is multiple and permits suction without disconnection. It is positioned between the tracheal tube and the mechanical ventilator circuit and cannot remain in the patient for more than 24 hours. In the United States the CSS has become very popular in the last decade and in the intensive care units (ICU) it is exclusively used in 58% of cases, while the OSS is used exclusively in only 4% of the centers.

In some studies, the OSS seems to have some advantages such as a lower incidence of pneumonia, less physiological changes during the procedure, less bacteria contamination and lower costs. In an international guide on prevention of VAP, published in 2004, there are recommendations regarding cost reduction with the use of CSS, however this recommendation is only based upon a single study. Those that defend CSS advocate that during suction with OSS the ventilator is disconnected, which, together with the negative vacuum pressure, lead to intense loss of pulmonary volume and subsequent hypoxemia. Until now, there are no concrete evidences off one system being better than the other. Therefore the decision was made to carry out this study and conclude it with a flowchart to orient the choice of the system to be used.

As such, the objective of this study was to compare the closed suction system with the open suction system in relation to the hemodynamic, blood gas exchange, ventilator associated pneumonia, pulmonary volume, secretion removal variables by means of a systematic review and in this way propose a flowchart for the rational utilization of these resources.

METHODS

The systematic review was carried out by a search for scientific articles in the MedLine (International Literature on Health and Science), LILACS (Latin America and the Caribbean Literature on Health and Science) and Cochrane databases encompassing the period from 1997 to August 2007. Keywords used were: endotracheal suction and closed suction.

Articles that compared the open and closed suction systems used in adult humans and that were randomized-controlled trials were included. Pediatric and experimental studies were excluded.

The articles found were assessed by two different, independent reviewers that followed the scientific method appraisal card (Appendix). Studies that had only one reply, yes, on the card were approved by the reviewers and described in this study. Based upon these results, an effort will be made to present a flowchart to orient choice of the suction system best suited for each situation.

RESULTS

Figure 1 particularizes the selection process of articles for this study. Of the 78 studies initially identified, 58 were excluded because they were not relevant, did not compare the two suction systems, dealt with pediatrics or were experimental. Of the 20 remaining articles, four were excluded because they were systematic reviews or meta-analyses, as the studies were the same as those already analyzed here. Only one was excluded from these 16 studies because it did not comply with the appraisal card criteria (attachment). The 15 studies included were controlled and randomized trials comparing open and closed systems for use in human adults.

Figure 1 - Diagram showing the process for selection of studies.
Ventilator associated pneumonia

Nine articles were found comparing incidence of VAP, which was defined as presence of fever, appearance of a new or worse pulmonary infiltrate at chest X-ray and leukocyto-
sis (≥ 10000/mm³) and purulent tracheal secretion (Table 1). The CSS induced a decrease of VAP in only two studies and in the remaining, no difference was found.

Mortality, intensive care length of stay and duration of mechanical ventilation

A study including 78 clinical and surgical patients was found, comparing mortality among patients suctioned us-
ing OSS and CSS, which did not disclose any statistically
significant differences. Two studies compared ICU length of stay and two compared duration of MV in which no signifi-
cant differences were found. Table 2 shows the profile of the studies.

Blood gas exchange variables (oxygen and carbon
dioxide arterial pressure)

Only two studies related changes in oxygen arte-
Table 1 – Studies found comparing the open and closed suction systems in relation to incidence of pneumonia

<table>
<thead>
<tr>
<th>Studies</th>
<th>N</th>
<th>Categories</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lorente et al. (2)</td>
<td>443</td>
<td>Clinical-surgical</td>
<td>No difference</td>
</tr>
<tr>
<td>Rabitsch et al. (5)</td>
<td>24</td>
<td>Clinical-surgical</td>
<td>CSS ↓ incidence of VAP ↓</td>
</tr>
<tr>
<td>Adams et al. (6)</td>
<td>20</td>
<td>Liver transplant</td>
<td>No difference</td>
</tr>
<tr>
<td>Zeitoun et al. (10)</td>
<td>20</td>
<td>Clinical-surgical</td>
<td>No difference</td>
</tr>
<tr>
<td>Lee et al. (15)</td>
<td>70</td>
<td>Clinical-surgical</td>
<td>CSS ↓ incidence of VAP ↓</td>
</tr>
<tr>
<td>Topeli et al. (16)</td>
<td>78</td>
<td>Clinical-surgical</td>
<td>No difference</td>
</tr>
<tr>
<td>Zeitoun et al. (17)</td>
<td>47</td>
<td>Clinical-surgical</td>
<td>No difference</td>
</tr>
<tr>
<td>Combes et al. (18)</td>
<td>104</td>
<td>Neurosurgical</td>
<td>No difference</td>
</tr>
<tr>
<td>Lorente et al. (19)</td>
<td>457</td>
<td>Clinical-surgical</td>
<td>No difference</td>
</tr>
</tbody>
</table>

N – number; CSS – closed suction system; VAP – ventilator associated pneumonia; MV – mechanical ventilation

Table 2 – Studies found comparing the open suction system to the closed suction system for mortality, length of stay in intensive care unit and time of mechanical ventilation

<table>
<thead>
<tr>
<th>Studies</th>
<th>N</th>
<th>Categories</th>
<th>Results</th>
<th>Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topeli et al. (16)</td>
<td>78</td>
<td>Clinical-surgical</td>
<td>No difference</td>
<td>Mortality and length of stay in ICU</td>
</tr>
<tr>
<td>Combes et al. (18)</td>
<td>104</td>
<td>Neurosurgical</td>
<td>No difference</td>
<td>Length of stay in ICU</td>
</tr>
<tr>
<td>Lorente et al. (19)</td>
<td>457</td>
<td>Clinical-surgical</td>
<td>No difference</td>
<td>Time of MV</td>
</tr>
</tbody>
</table>

N – number; ICU – intensive care unit; MV – mechanical ventilation

Table 3 – Studies found related to changes in oxygen and carbon dioxide arterial pressure

<table>
<thead>
<tr>
<th>Studies</th>
<th>N</th>
<th>Categories</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lasocki et al. (14)</td>
<td>18</td>
<td>Acute pulmonary injury</td>
<td>↓PaO₂ and ↑PaCO₂ with OSS</td>
</tr>
<tr>
<td>Bourgault et al. (20)</td>
<td>18</td>
<td>Clinical – surgical</td>
<td>Not significant decrease of PaO₂</td>
</tr>
</tbody>
</table>

N – number; OSS – open suction system; PaO2 – partial oxygen pressure; PaCO₂ – partial pressure of carbon dioxide
significant difference of SpO2 between the two systems, with hyperoxygenation at 100% of FiO2 before aspiration, as well as without this procedure. In the first five studies hyperoxygenation is recommended before suction to avoid excessive decrease of SpO2 (Table 4).

In four studies the variables considered were mean arterial pressure (MAP) and heart rate (HR). In two of these studies, no important differences were found when comparing the OSS and the CSS.

In the article by Cereda et al., suction with OSS brought about a significant increase of the MAP and maintenance of the HR, that continued 2 minutes after the procedure. Another study reported increase of HR and MAP with the OSS and, furthermore, cited a statistically higher incidence of dysrhythmias (Table 5).

**Pulmonary volume**

Three studies compared changes in pulmonary volume during suction with OSS and CSS. In all plethysmography was used to measure expiratory pulmonary volume before and after the procedure. A statistically higher reduction of the pulmonary volume was found when OSS was used. This is justified because of disconnection of the patient from the mechanical ventilator as well as by the presence of a negative pressure caused by aspirator vacuum (Table 6).

**Removal of secretion**

Two studies compared the quantity of suctioned secretion with the OSS and the CSS. A larger mass of secretion suctioned with the OSS was reported in the first. This article further compared the suction for two different intensities of negative pressure (~200 and ~400 cmH2O). When the more negative pressure was used (~400 cmH2O) more secretion was removed. Another study did not find differences in the volume of suctioned secretion between the two suction systems (Table 7).

**Costs**

Four studies comparing costs between use of the OSS and the CSS were found. In the first two, cost of using CSS was higher than that of OSS. In the third study cost of using CSS was lower and in the fourth.

---

**Table 4 – Studies found comparing peripheral oxygen saturation between the open and closed suction systems**

<table>
<thead>
<tr>
<th>Studies</th>
<th>N</th>
<th>Categories</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rabbits et al.</td>
<td>24</td>
<td>Clinical-surgical</td>
<td>Decrease of SpO2 with OSS</td>
</tr>
<tr>
<td>Lee et al.</td>
<td>14</td>
<td>Clinical-surgical</td>
<td>Decrease of SpO2 with OSS</td>
</tr>
<tr>
<td>Maggiore et al.</td>
<td>9</td>
<td>Clinical-surgical</td>
<td>Decrease of SpO2 with OSS</td>
</tr>
<tr>
<td>Creedal et al.</td>
<td>10</td>
<td>Clinical-surgical</td>
<td>Decrease of SpO2 with OSS</td>
</tr>
<tr>
<td>Lee et al.</td>
<td>14</td>
<td>Clinical-surgical</td>
<td>Decrease of SpO2 with OSS</td>
</tr>
<tr>
<td>Fernandez et al.</td>
<td>10</td>
<td>Clinical-surgical</td>
<td>No statistical difference</td>
</tr>
</tbody>
</table>

N – number; OSS – open suction system; SpO2 – peripheral oxygen saturation

**Table 5 – Studies citing changes in mean arterial pressure and heart rate between the open and closed suction systems**

<table>
<thead>
<tr>
<th>Studies</th>
<th>N</th>
<th>Categories</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bourgault et al.</td>
<td>18</td>
<td>Clinical-surgical</td>
<td>No difference</td>
</tr>
<tr>
<td>Fernández et al.</td>
<td>10</td>
<td>Clinical-surgical</td>
<td>No difference</td>
</tr>
<tr>
<td>Cereda et al.</td>
<td>10</td>
<td>Clinical-surgical</td>
<td>OSS: ↑ MAP and keeps HR</td>
</tr>
<tr>
<td>Lee et al.</td>
<td>14</td>
<td>Clinical-surgical</td>
<td>OSS: ↑ HR and MAP</td>
</tr>
</tbody>
</table>

N – number; OSS – open suction system; MAP – mean arterial pressure; HR – heart rate

**Table 6 – Studies relating pulmonary volume changes during suction with the open and closed suction systems**

<table>
<thead>
<tr>
<th>Studies</th>
<th>N</th>
<th>Categories</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fernández et al.</td>
<td>10</td>
<td>Clinical-surgical</td>
<td>OSS: Decrease of pulmonary volume</td>
</tr>
<tr>
<td>Cereda et al.</td>
<td>10</td>
<td>Clinical-surgical</td>
<td>OSS: Decrease of pulmonary volume</td>
</tr>
<tr>
<td>Maggiore et al.</td>
<td>23</td>
<td>Clinical-surgical</td>
<td>OSS: Decrease of pulmonary volume</td>
</tr>
</tbody>
</table>

N – number; OSS – open suction system
DISCUSSION

During the development of this study difficulties for comparison of studies were found, because there were many discrepancies between methods. Furthermore, the populations studied were quite heterogeneous.

In relation to MAP, seven of the nine studies did not disclose differences between both systems. In 2 other studies (5, 15) there was a decrease of MAP with CSS, and Rabitsch et al. (5) also found less cross contamination between gastric juice and tracheal secretion.

In their study Topeli et al. (16) reported that even though there were no significant differences between the two suction systems, appearance of multiresistant bacteria such as *Acinetobacter spp* and *Pseudomonas aeruginosa* was more common in the CSS.

Adams et al. (6) also reported that there was no significant difference regarding incidence of VAP, however stressing that with the CSS more suction are performed because of the procedure’s ease and a lesser efficacy of the method, according to reports of the team.

In the study by Lorente et al. (19) the OSS and CSS were compared, however without a daily change of the closed circuit, as recommended by the manufacturer. The outcome was that there was no increased incidence of VAP as long as it is used for no more than 4 days.

Five of the six studies showed a decrease of SpO₂ when the OSS was utilized. This result leads to a belief that in patients who may be severely affected by short periods of hypoxemia, such as those hemodynamically unstable, CSS should be preferred. It must be emphasized that the data collection moment varied from study to study (ranging from immediately after and up to 2 minutes after suction) and that may have interfered in the results. This because, if in all work, collection had been made 5 minutes after suction, it is possible that saturation would have already returned to its initial values.

Likewise, pulmonary volumes presented a decrease in the three studies found, however measurement was also made at different moments, ranging from prior to suction to immediately afterwards and before suction to 10 minutes after the procedures. In the latter, pulmonary volume had already returned to the initial state. (21)

Among the fours studies comparing costs between both systems, two inferred that the CSS has a higher cost, (2, 6) one that it has a lower cost (15) and another that it has a higher cost if the same equipment is used for less than four days. (19) It should be remembered that when the CSS is used, the common suction probe must also be used to aspirate the nose and mouth to reduce incidence of ventilator associated pneumonia. And when suction is performed the traditional way, the same probe is used for the tracheal tube, nose and mouth, in this order.

Therefore in CSS the same material is used in the OSS, in addition to the closed system itself. In the universe of intensive care some of the most important outcomes are: decrease of mortality, length of stay in ICU and time of mechanical ventilation. In
the studies found there was no difference in any of these items, disclosing that one as well as the other may be used.

These results are congruent with those of three meta-analyses found on the subject. (8,25,26)

Jorgenden et al. (8) analysed mortality, cardiopulmonary variables, bacterial contamination, secretion volume and costs; Peter et al. (25) compared ventilator associated pneumonia and mortality and in Vonberg et al. (26), only pneumonia. None was able to conclude anything about superiority of one of those methods.

No sufficient scientific evidence was found to prepare a flowchart with guidelines for the choice of one or the other systems, as proposed in the objective of this work.

CONCLUSION

Based upon the systematic review carried out, it was concluded that there is no difference regarding the compared variables: incidence of VAP, mortality, length of stay at ICU, time of MV, PaCO2, PaO2, MAP and HR and removal of secretion when using OSS and CSS. However, there was always a decrease of SpO2 and of pulmonary volumes with use of the OSS; and higher costs in the majority of studies with the use of the CSS.

As such, CSS seems to increase the risk of colonization, but has the advantage of not reducing the pulmonary volumes and not entailing a drop of saturation, especially in patients with severe respiratory failure and in the use of higher levels of positive end expiratory pressure. New studies on the subject are suggested in an effort to prepare the flowchart initially proposed.

REFERENCES

7. Zielmann S, Grote R, Sydow M, Radke J, Burchard H. [Endotracheal suctioning using a 24-hour continuous sys-
Comparison between open and closed suction systems


APPENDIX

Appraisal card of the scientific study method for systematic review

Appraiser: ___________________________ Date: __________

Level of evidence: _______________________

I) Study title
Suitable for the subject ( ) Yes ( ) No
Close to the research objective ( ) Yes ( ) No

II) Introduction:
Places the reader to the subject ( ) Yes ( ) No
History of the subject ( ) Yes ( ) No
Definition and concept ( ) Yes ( ) No
Pertinent literature and Yesilar ( ) Yes ( ) No
Justification for research ( ) Yes ( ) No

III) Objective:
Correctly formulated hypothesis ( ) Yes ( ) No
Clear and concise ( ) Yes ( ) No

IV) Scientific method:
Adequate description of type/design ( ) Yes ( ) No ( ) Not applicable
Adequate casuistry ( ) Yes ( ) No ( ) Not applicable
Sample characteristics ( ) Yes ( ) No ( ) Not applicable
Number of subjects ( ) Yes ( ) No ( ) Not applicable
Control group ( ) Yes ( ) No ( ) Not applicable
Adequate randomization ( ) Yes ( ) No ( ) Not applicable
Adequate inclusion criteria ( ) Yes ( ) No ( ) Not applicable
Adequate exclusion criteria ( ) Yes ( ) No ( ) Not applicable
Description of adequate material ( ) Yes ( ) No ( ) Not applicable
Description of procedures ( ) Yes ( ) No ( ) Not applicable
Statistical analysis ( ) Yes ( ) No ( ) Not applicable

V) Adequate results:
( ) Yes ( ) No

VI) Adequate bibliographic references:
Provides new reference that can be included in this systematic review: ( ) Yes ( ) No

APPROVED: ( ) Yes ( ) No