Level of dyspnoea experienced in mechanically ventilated adults with and without saline instillation prior to endotracheal suctioning

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Abstract:

The purpose of this study was to compare the level of dyspnoea with and without the use of 5-cc saline instillation prior to endotracheal suctioning of mechanically ventilated adults. A crossover, quasi-experimental design was used. Seventeen alert, mechanically ventilated adults were asked to rank their level of dyspnoea using the vertical visual analogue scale at specific time intervals surrounding two suctioning events. Saline was randomly assigned to be instilled prior to one of two suctioning episodes. Dyspnoea was ranked immediately after suctioning, and at 10-, 20-, and 30-minute intervals. Data were analyzed using repeated measures analysis of variance with time of measure (immediately after suctioning, 10-, 20-, and 30-minute intervals) and treatment type (with saline versus without saline instillation). The level of dyspnoea based on treatment type (with or without saline) was non-significant. Treatment type by age group interaction was significant ($F(1, 15) = 5.41$, $P = 0.034$). The nature of the interaction revealed that older patients (<60 years of age) experienced less dyspnoea without saline prior to suctioning and greater dyspnoea with saline instillation as compared to the younger subjects (<60 years of age). This study documented no beneficial effects of saline. However, it did demonstrate that saline instillation might precipitate a significantly increased level of dyspnoea for up to 10 minutes after suctioning in patients older than 60 years of age. Recommendations based on the results of this study would be to avoid the use of saline instillation prior to suctioning.

Article:

Patients who are intubated require suctioning. Because having an endotracheal tube (ETT) inserted through the mouth to the trachea interrupts the first-line defence mechanism, one is unable to naturally remove foreign debris or intrinsic mucus by coughing. In order to facilitate secretion removal, endotracheal suctioning (ETS) is performed. There is controversy in clinical practice as to whether to perform ETS with or without saline instillation prior to suctioning. Many research studies have analysed the effect of saline instillation prior to suctioning on secretion removal, oxygen saturation, dislodgment of bacteria, physiologic variables and other factors (Ackerman et al. 1996; Chatila et al. 1995; Hagler & Traver 1994; Gray et al. 1990; Raymond 1995; Hagler & Traver 1993; Glass & Grap 1995; Briening 1996; Celik & Elbas 2001). Thus far, no study has documented any consistent benefit of using saline: nevertheless, in some institutions, saline continues to be used routinely in clinical practice. Further research is needed to evaluate benefits of the common practice of using saline prior to suctioning.

Although studies have evaluated the effect of saline on external parameters, no study has examined the effect saline instillation may have on a patient's level of dyspnoea. This study measured the patient's level of dyspnoea surrounding two suctioning conditions: with saline instillation and without saline instillation prior to suctioning.

INTRODUCTION

Dyspnoea

Dyspnoea is a subjective sensation of difficulty in breathing, which mechanically ventilated patients may experience (Carrieri et al. 1984). Dyspnoea has been associated with physiological and environmental variables that affect mechanically ventilated patients (Gift 1991; Thompson et al. 1993; Tice 1990; Bostick & Wendelgass 1987). Although other studies have explored various variables, dyspnoea was observed to decrease 10–20 minutes post suctioning when saline was instilled in awake, alert, mechanically ventilated patients (Sheppard et al. 1993; Thompson & Tice 1990). These two studies did not compare ETT suctioning with and without the use of saline instillation. Further studies are needed to understand the level of dyspnoea experienced post suctioning with and without the use of saline in mechanically ventilated patients. Nurses and respiratory therapists are key individuals responsible for providing the 'best' practice to mechanically ventilated patients. Currently, the 'best' practice regarding ETT suctioning with and without the use of saline and the consequential level of dyspnoea in mechanically ventilated patients is unknown.

Endotracheal suctioning

Dyspnoea may be associated with increased amounts of mucus, which can cause narrowing of the radius of the airway and contribute to increased anxiety. Endotracheal suctioning is required to remove secretions, prevent obstruction, and maximize oxygenation and ventilation. When an ETT or tracheostomy tube is present, the patient's mucociliary transport system is interrupted (Gray et al. 1990; Lush et al. 1988). Anytime this natural transport system is disrupted, an alternative method of removing secretions such as suctioning has to be employed. Although suctioning is a justified practice, complications can occur. Complications associated with suctioning may include bacterial growth, hypoxaemia, shortness of breath, cardiac arrhythmias, damage to the cilia and epithelium, atelectasis, and vagal stimulation (Bostick & Wendelgass 1987; Johnson & Sexton 1990; Knipper 1986; Rindfleisch & Tyler 1983; Shim et al. 1969; Chang 1995). Knowing that complications from suctioning are possible, the need to suction should outweigh the risks of suctioning. One benefit of suctioning is that dyspnoea is reduced (Tice 1990; Thompson & Tice, 1990).

Saline instillation

The issue of using saline prior to suctioning is significant because it possibly can be detrimental to patients (Lush et al. 1988; Ackerman 1993). Ackerman (1993) demonstrated that a 5-cc saline instillation prior to suctioning had an adverse effect over time on oxygen saturation after suctioning. Hagler and Traver (1993) determined that glycoccalyx-protected bacteria are dislodged in lower airways through saline instillation and catheter insertion. Hagler and Traver (1994) conducted a study that analysed ETTs from 10 critical care patients that had been intubated for at least 48 hours. Each tube collected was used in random order for both saline instillation and suction catheter insertion. Any material dislodged by these two procedures was cultured. The results of this study documented that suction catheter insertion dislodged up to 60 000 viable bacterial colonies. However, the use of 5-cc saline instillation dislodged up to 310

000 viable colonies. This evidence suggests that mechanically ventilated patients are at risk of a nosocomial infection by dislodging bacteria into the lower airways. This study recommended that routine instillation of normal saline prior to suctioning should be abandoned. Another study was conducted to document the location of instilled saline, and the results documented that it did not go beyond the mainstem bronchi (Hanley et al. 1978). Furthermore, suctioning only recovered a mean of 10.7% and 18.7% of secretions.

The instillation of saline prior to suctioning has been thought to be beneficial due to eliciting a cough, liquefying secretions for easier removal, and preventing encrustations from forming in the endotracheal tube. Research has demonstrated that a cough may or may not be elicited. Gray and colleagues (1990) observed that the cough elicited by the saline did attempt to provide secretion clearance for the patient. The volume of secretions that could be removed by cough alone was not documented. Regarding liquefying secretions, saline did not travel beyond the mainstem bronchi even with hyperinflation; therefore, the presumption that saline liquefies secretions is questionable.

Studies to date on saline instillation have not documented any substantial benefits. In contrast, it has been noted that harmful effects may be produced by the instillation of saline such as the dislodgment of bacteria into the lower airways. Ackerman and others (1996) provided a synthesis of current information about normal saline instillation and implications for practice. After reviewing all available data, they stated little benefit is documented using normal saline and encouraged all practitioners to monitor the humidity delivered to the airways and promote adequate systemic hydration to facilitate secretion removal. By maintaining humidification and hydration, Ackerman et al. (1996) suggest that the negative consequences of instilling normal saline could be curtailed.

Raymond (1995) also performed a review of the literature regarding the benefits of saline instillation. After a comprehensive review of the literature, he recommended that the routine use of saline instillation should be avoided until further research could support the physiologic benefit of the practice. In this review, no research describing the patient's perception of the use or non-use of saline was documented; therefore, there is a lack of knowledge regarding the patient's perception of saline instillation, and the effect of dyspnoea experienced by the patient.

Patients on a mechanical ventilator experience dyspnoea, and suctioning is needed to remove secretions to allow optimal oxygenation. There is no documented benefit of using saline prior to suctioning. Several studies have documented detrimental effects of the use of saline. Even though no benefit of saline has been documented, some institutions continue to use saline instillation prior to suctioning. Because saline continues to be used in clinical practice, a comparison of the patient's perception of dyspnoea with and without saline instillation prior to suctioning needs to be considered. To date, no study has attempted this comparison. The purpose of this study was to compare the level of dyspnoea experienced by mechanically ventilated patients with and without saline instillation prior to suctioning.

THEORETICAL FRAMEWORK

A review of the literature reveals that there has been little empirical or theoretical information cited regarding the cause or sensation of dyspnoea among ventilator-assisted patients. Carrieri et

al. (1984) proposed a complex model incorporating personal variables, health status information, and situational data related to dyspnoea. Gift (1991) also presented a model of dyspnoea that consisted of five components: sensation, perception, distress, response, and reporting. She defined each component but did not relate the components to mechanically ventilated patients. McCord and Cronin-Stubbs (1992) also proposed a model for operationalizing dyspnoea. Accepting the definition that dyspnoea is an unpleasant subjective sensation, they formulated a model of dyspnoea that included antecedents, mediators, reactions, and consequences associated with dyspnoea. None of these studies incorporated measurable physiological factors with dyspnoea. Thus, a new conceptual framework was identified for this study.

Various physiological factors such as normal saline, mucus, radius of the airway, airway resistance, fatigue, and distress have a direct effect on dyspnoea. Normal saline and mucus that reside in the endotracheal tube decrease the radius of the tube of the airway, which directly increases airway resistance. Dyspnoea is the result of a decrease in the radius of the airway. The airway resistance is directly effected by radius of the airway as expressed by Poiseuille's law (Nunn 1987). The major components of Poiseuille's law include resistance to airflow as predicted by the radius of the airway, length of the airway, and viscosity of gas. The magnitude of resistance depends on the physical factors of density and viscosity of gas, and the geometry of the airways. Artificial airways such as an endotracheal tube increase resistance as the length of the artificial airway is increased. Also, changes in airflow caused by saline, secretions, bronchoconstriction, and obstructions will increase airway resistance (Vasbinder-Dillon 1988).

Increased airway resistance requires the individual to work harder to overcome the resistance to achieve adequate tidal volumes and oxygenation. The longer and harder a patient works to breathe, the greater the level of dyspnoea is experienced.

This study specifically evaluated the level of dyspnoea with and without saline instillation prior to suctioning. Based on the conceptual framework, the act of instilling normal saline decreases the radius of the airway and increases airway resistance. The increase in airway resistance effects the degree of dyspnoea experienced. Many variables may contribute to dyspnoea. The focus of this research was to build on three variables: saline instillation, suctioning to recover secretions and saline, and level of dyspnoea experienced.

METHOD

Design

A crossover, quasiexperimental design was used in this study to examine the level of dyspnoea associated with the ETS with and without saline instillations in mechanically ventilated adults.

Sample

Setting

The subjects were recruited from 11 intensive care units at 2 large mid-south hospitals located in a metropolitan area.

Subjects

A convenience sample of 25 intubated, mechanically ventilated subjects who were alert, awake, oriented, older than 21 years of age, and English-speaking was obtained. Pharmacological

interventions such as analgesics and sedatives were considered but did not exclude subjects from enrolling in the study if the subjects remained oriented while medicated. Alertness and wakefulness was assessed by the subjects already having eyes open or opening eyes after being spoken to, e.g. 'Hello, my name is Pam O'Neal, and I am a nurse.' Orientation was assessed by asking the individual to identify his/her name, location, and day of the week.

Power analysis for this study was based on the mathematical computations from Tice (1990). Tice concluded that a standard deviation for dyspnoea before suctioning was 21 mm. A sample size of 20 is sufficient to detect a difference as small as 13.7 mm on the VVAS with alpha = 0.05 and 1-B as 0.80 assuming that the correlation between measurements within a patient is at least 0.50.

Instrumentation

Dyspnoea was measured using the vertical visual analogue scale (VVAS) (Gift 1989; Gift et al. 1986). The VVAS is a simple pencil and paper test that allows subjects to relate their perceptions of dyspnoea. The VVAS consists of a vertical 100-mm line in the middle of a page with the anchors 'GREATEST BREATHLESSNESS' at the top and 'NO BREATHLESSNESS' at the bottom. A communication system was developed between the researcher and the patient. The patient would point to the place on the vertical line between the two anchors that represented the level of dyspnoea that was being experienced. If the patient was unable to directly point, the researcher moved a pen from 'NO BREATHLESSNESS' up the vertical line toward 'GREATEST BREATHLESSNESS.' When the patient indicated by blinking the level of dyspnoea experienced, the researcher would mark the line at the point noted by the patient. The VVAS was chosen because it has been reported to be easier to use with consistently reported higher readings than the horizontal vertical analogue scale (Scott & Huskisson 1979). The VVAS has been administered to mechanically ventilated ICU patients yielding reliable results (Gift 1989; Tice 1990; Crihfield, 1990; Wiggins, 1993). Construct and concurrent validity of the VVAS has been documented among dyspnoeic patients in both asthmatics [n = 15, t-test score of 12.35 ($P < 0.01$)] and COPD patients [n = 30, t-test score 9.72 ($P < 0.01$)] (Gift 1989).

Mechanical ventilators used in this study included Puritan Bennett 7200, Bear I, and Servo 900C. Respiratory and clinical engineering departments serviced these ventilators. The respiratory department maintained logs regarding routine checks of all ventilator equipment. If any ventilator or ventilator equipment did not pass inspection, the engineering department was notified. Appropriate servicing schedules were followed to ensure adequate functioning.

Closed in-line 14 French Ballard® suction catheters which were no more than half the inner diameter of the tracheal or endotracheal tube (mean was 8.0 French) were also used in this study. A new suction catheter was applied prior to each suctioning event. A total of 40 catheters were used during this study. A closed suction system was chosen to maintain positive end expiratory pressure (PEEP) and pressure support during suctioning to control for potential confounding effects such as pressure changes that may have an effect on dyspnoea.

Procedure

Approval from the participating agencies and the Local Research Ethics Committee was obtained. The researcher surveyed participating ICUs several times per week and

recruited subjects who met the inclusion criteria. Subjects who met study inclusion criteria were approached, orientation and language assessed, and informed of the research project. A consent form was signed if they agreed to participate in the study. Data collection began by obtaining demographic data from the chart.

A 14 French Ballard® closed suction system was applied to all study participants. The appropriate wall suction was verified by titrating the amount of suction to 16 L per minute flow according to a manometer that was used on all subjects. A flow manometer was used to provide consistency in the amount of wall suction used. The use of 16 L flow compares to about 90 mm/Hg to 100-mm/Hg wall suction. Because some wall suction regulators were different and not always functioning adequately, the flow manometer was used to verify that the same suction was applied to all 20 patients during the 40 suctioning episodes. The first suctioning event was randomly assigned either 'with saline' or 'without saline' instillation prior to suctioning. Saline was premeasured in a cylinder and evacuated with a syringe. The saline was instilled through the irrigation port of the closed suction catheter with a needleless syringe. A 5-cc bolus was chosen because it has been consistently used in other research studies as the choice of volume. A saline instillation of 5-cc was randomized between two suctioning events. If the patient was assigned saline instillation, the procedure was as follows. Immediately prior to suctioning, the patient was asked to rank the VVAS. After the VVAS was marked, the primary nurse delivered 100% oxygen via the ventilator. After the patient had been preoxygenated, the primary nurse instilled saline through the irrigation port of the closed suction catheter if the episode was randomized to give saline and waited 15 seconds as determined by the researcher, who used a stopwatch. After the time interval was permitted for presumable saline dispersion, the suction catheter was inserted approximately 6 inches down the endotracheal/tracheal tube or until resistance was felt. The nurse then depressed the control valve continuously as the suction catheter was withdrawn over 10 seconds as the researcher counted the seconds out loud. The nurse made two passes with the suction catheter while waiting 15 seconds between each pass as timed and designated by the investigator. This procedure was institutional policy in the research sites. If the subject was preassigned through randomization to receive saline prior to the first suction pass, then next suctioning episode as determined by the patient or the primary nurse occurred without saline. When the primary nurse decided that the patient needed to be suctioned again, the procedure was the same except if saline was used on the first suction event, in which case no saline was used on the second suctioning event and vice versa.

The investigator was present for two consecutive suctioning events. Immediately upon completion of suctioning, the VVAS was marked again. The VVAS was marked either independently by the patient or by the researcher as the patient indicated by blinking once or nodding their head up and down to indicate 'yes, stop.' The VVAS was also marked at 10, 20, and 30-minute intervals after suctioning as designated by the investigator using a stopwatch.

Data analysis

Descriptive statistics were used to describe the sample. Repeated measures analysis of variance was used to interpret the level of dyspnoea experienced by mechanically ventilated patients with and without saline instillation prior to suctioning.

RESULTS

Sample

During the study, 25 patients met the inclusion criteria of being alert, oriented, mechanically ventilated, older than 21 years of age, and English-speaking.

Of the 25 patients approached, five refused to be in the study due to fatigue, and three patients needed to be suctioned before the 20-minute interval of data collection. A total of 17 patients were the subjects of data analysis.

The typical subject was 55 (f19.4) years of age, and 65% were less than 60 years old. There were 11 males (65%) and 9 (53%) were African-American while the others were white (8,47%). Of the 17 subjects, the respiratory system was the primary system failure (41%) with trauma (41%) being the most frequent precipitating factor for the failure. Demographic portrays characteristics of a heterogeneous sample.

Dyspnoea

The purpose of this study was to compare the level of dyspnoea experienced by mechanically ventilated patients with and without saline instillation prior to suctioning. The outcome of the research study yielded non-significant results of the level of dyspnoea experienced with saline and without saline instillation prior to suctioning.

Dyspnoea ratings from patients were taken immediately after suctioning and at 10-minute intervals following the procedure up to 30 minutes. Data were analyzed with repeated measure analysis of variance (ANOVA) with time of measure (immediate, 10-, 20- and 30-minute intervals) and treatment type (with saline vs without saline). The multivariate results were interpreted to avoid difficulties with the stringent assumptions of the univariate results (Maxwell & Delaney 1989). The analysis indicated no difference between treatment types ($F(1,16) = 0.283$, $P = 0.602$), time of measure ($F(3,14) = 1.56$, $P = 0.242$), and no treatment by interaction ($F(3,14) = 1.2$, $P = 0.344$).

The presence of a wide range in ages allowed examination of the effects of treatment on dyspnoea while controlling for age. Age was dichotomized into young (<60, n =12) and old (>60, n = 5) based on other literature identifying age as a risk for nosocomial pneumonia (Fagon et al. 1994; Tosata et al. 1998). Nosocomial pneumonia literature was used to support the dichotomy of age because research supports the consequence of dislodging bacteria in the endotrcheal tube into the lower airways by saline instillation.

The analysis of differences in dyspnoea was then examined with age as a between subject variable. The multivariate results indicated a nonsignificant effect of treatment type: ($F(1,15) = 2.26$, $P = 1.53$) and time of measure ($F(3,13) = 1.47$, $P = 0.268$). However, the treatment type by age group interaction was significant ($F(1,15) = 5.41$, $P = 0.034$). Older patients experienced less dyspnoea without saline instillation prior to suctioning than did younger subjects. Conversely, older patients reported somewhat higher levels of dyspnoea with the use of saline than younger patients reported. Follow-up analysis using simple contrasts between times of measure showed a trend toward age by treatment by time interaction effect between times one and two ($F(1,15) = 3.17$, $P = 0.095$). Reported dyspnoea in younger patients in both with and without saline was rather constant across time. Older patients in the saline condition reported significantly elevated

dyspnoea in 10 minutes following suctioning, while the older subjects in the without saline condition reported significantly low levels of dyspnoea in the 10 minutes following suctioning (Fig. 1). While these results should be interpreted with caution because of the small sample size, they may reflect differences in pulmonary compliance due to age, which may then result in different perceptions of dyspnoea.

DISCUSSION

This was the first study to compare the level of dyspnoea with and without saline instillation prior to suctioning. The level of dyspnoea based on treatment type (with or without saline) was non-significant. A significant difference was observed between the treatment type (with saline vs without saline) by age group (<60 > years of age). When compared to younger patients, older patients reported greater differences in the level of dyspnoea experienced based on treatment type (with or without saline).

The aetiology of the differences in dyspnoea found between age groups is unknown. Pathophysiological changes and greater self-knowledge of sensitivity to dyspnoea may be consequences of aging. Regardless of whether suctioning occurred with or without saline instillation, little variation in the pattern of dyspnoea among younger subjects was observed.

Several factors may explain the lack of statistical significance between the treatment type and time measurement. Since previous studies have shown that the saline travels only into the trachea and mainstem bronchi, suctioning could possibly remove most of the saline instilled, reducing its impact. In addition, the saline may have stimulated a productive cough, which could result in reduced airway resistance decreasing the sensation of dyspnoea. However, cough produced after saline instillation was not monitored in this study. Additionally, interventions provided between data collection periods may have affected the outcome. The mean time between suctioning events was 2 hours and 36 minutes (range 30 minutes to 4 hours and 5 minutes). Patient activities and interventions during suctioning episodes were not recorded. Intervening treatments such as the administration of bronchodilator therapy between suctioning events may confound these results. Based on this evidence and previous studies, saline should not be used routinely due to associated risks and lack of any proven benefit.

CONCLUSION

The level of dyspnoea experienced was non-significant when compared to treatment type: with or without saline instillation. Further analysis of the data revealed a significant difference between the treatment type (saline vs no saline) and age group (<60 or >60 years old). Older patients (>60), when no saline was instilled, had the lowest level of dyspnoea. This

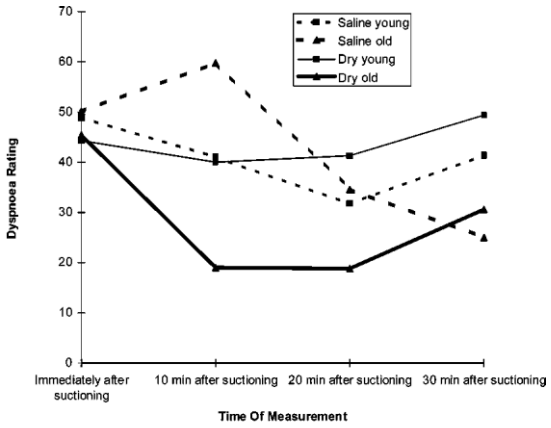

Fig. 1 Mean level of dyspnoea (measured in millimeters) over time (immediately after suctioning, 10 20, 30 minutes after suctioning) with saline (saline) and without saline (dry) instillation prior to suctioning and age dichotomized as young (<60) and old (≥60).

new information is important clinically because any decrease in dyspnoea is beneficial to the patient.

There are no documented benefits from the use of saline during suctioning. Therefore, routine use of saline should be avoided because of associated risks and complications. Further research is warranted in the evaluation of any benefits of saline in using nonconventional ventilation such as a high-frequency oscillation or jet ventilation due to the decrease in humidification as well as the effect of no saline on other variables (SaO2), and various time intervals surrounding the data collection.

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