2002

A survey of neonatal suction techniques performed by registered nurses

Craig H. Register

A SURVEY OF NEONATAL SUCTION TECHNIQUES PERFORMED BY REGISTERED NURSES

Thesis submitted to
The Graduate College of
Marshall University

In partial fulfillment of the
Requirements for the degree of
Master of Science
Nursing

Craig H. Register

Marshall University

July 7, 2002

This thesis was accepted on ______July__________7_________2002_____
Month Day Year

as meeting the research requirements for the master's degree

Advisor ____

Department of Nursing

____
Dean of the Graduate College

Acknowledgements

I am deeply indebted to Ms. Cynthia Tolles and Dr. Kathleen Stone for allowing me to use the Neonatal Endotracheal Suctioning Procedure Questionnaire.

Additionally I would like to thank Ms. Amy Smith for allowing me to conduct this survey within her unit and the registered nursing staff who took time to complete the questionnaires. I am particularly indebted to Ms. Vickie Boster for her efforts in distributing and ensuring completion of the questionnaires.

Lastly, but most importantly, I would like to thank Dr. Karen Stanley. Dr. Stanley graciously agreed to serve as chair of my thesis committee. Without her dedication and timely input, this thesis would not have been possible.

Abstract

Purpose. The purpose of this study was to determine the suction practices of the registered nurse in the neonatal intensive care unit.

Design. A descriptive research design was used to describe the suctioning practices of the registered nurse providing care to the neonatal patient.

Method. Data were collected through the use of demographic and knowledge questionnaires. Frequency and percentages of responses were determined. The independent samples t test was used to determine what, if any, differences in practice existed based upon nursing education, nursing experience, or NICU experience.

Findings. The results of this study demonstrated that the current practices were not always based upon current research findings. No significant differences (p # .05) were found to exist based upon nursing education, nursing experience, or NICU experience.

Conclusion. Further research is needed to determine both the safety and efficacy of these interventions upon the neonatal population.

Table of Contents

Page

Chapter One

A large number of premature infants require prolonged ventilatory support. In order to provide this support an artificial airway must be inserted. This airway can be established in one of two ways, either with an endotracheal tube or through the means of a tracheotomy tube. Regardless of which method is used, the neonate's upper airway is bypassed, thus reducing the neonate's ability to clear secretions spontaneously. Additionally, the presence of the tube may lead to an increase in sputum production. For these reasons neonates with an artificial airway in place will require airway suctioning (Buglass, 1999).

Background and Significance

At present, there are no national standards containing specific guidelines describing when mechanical suctioning should be applied to the neonatal patient with an artificial airway. Many published studies pertaining to both adult and neonatal populations have suggested criteria to use to determine the need to apply mechanical suctioning. These criteria include (a) diminished breath sounds, (b) dyspnea, (c) visible secretions in the artificial airway, (d) gurgling or coarse breath sounds, and (e) decreased oxygen saturation levels (Clarke, 1995; Day, 2000; Place & Fell, 1998).

The provision of mechanical suction is not without complication. The following complications have been identified with the application of mechanical suction (American Academy of Respiratory Care (AARC) Clinical Practice Guideline 1993; Demers & Saklad 1973; Hess 1999; Hodge 1991; Knox, 1993; and Stone & Turner 1989): (a) hypoxemia, (b) atelectasis, (c) soft tissue trauma, pneumothorax, (d) increased intracranial pressure, (e) infection, and (f) normal saline instillation.

The following techniques have been identified which may be useful in reducing the incidence and severity of these complications (a) hyperoxygenation (Day, 2000; Goodnough, 1985), (b) hyperventilation (Feaster, West, Ferketich; 1985), (c) hyperinflation (Shorten, 1989; Goodnough, 1985), (d) technique (Clark, 1995; Day, 2000; Place & Fell, 1998; Griggs, 1998; Hodge, 1991; McEleney, 1998; Shorten, 1989; Demers & Saklad, 1973.

Reasons to Suction a Neonate

Due to the significant complications, suctioning should not be undertaken as a routine procedure on a fixed frequency. For this reason, the decision to suction the artificial airway should be based on the results of the physical assessment of the neonate. It must be remembered that infrequent suctioning as well as inadequate suction when needed also carries substantial complications such as “hypoxia, pneumonia, atelectasis, infection, increased airway pressures…retention of carbon dioxide, ventilation perfusion mismatch, blockage of the endotracheal tube, retention of sputum, and neonate’s discomfort…” (Simmons, 1997, p.4). The following criteria have been identified in the literature as appropriate indicators for performing endotracheal suctioning (Clarke, 1995; Day, 2000; Place & Fell, 1998).

Diminished breath sounds. Diminished breath sounds (breath sounds that are less prominent or more difficult to auscultate) or absent breath sounds are a possible indicator of an obstructed artificial airway. For this reason both Clarke (1995) and Day (2000) identify diminished or absent breath sounds as an indicator to perform endotracheal suctioning.

Dyspnea. Dyspnea, as indicated by tachypnea (an increased respiratory rate) or the use of accessory muscles, has been identified as an indication to perform endotracheal suctioning by both Clarke (1995) and Day (2000). Due to the wide age and developmental variations in respiratory rate, tachypnea is difficult to quantify. Rather, the registered nurse must carefully observe the patient and note a sustained increase in respiratory rate from baseline. Moderate narrowing of the airway diameter can cause a disproportionately large increase in airway resistance (Place & Fell, 1998). An increased airway resistance manifests itself as an increase in airway pressure in the neonate who is being mechanically ventilated, resulting in a high-pressure alarm from the ventilator (Day, 2000). The high-pressure alarm is an indicator that mechanical suctioning of the airway may be necessary and that further assessment of the neonate is required to determine the cause of the alarm.

Visible secretions in the artificial airway. Visible secretions are those secretions that have migrated from the lower airways into the endotracheal or tracheotomy tube. These secretions may represent excess sputum production or transudate from the pulmonary circulation. Clark (1995) and Day (2000) have both identified visible secretions in the airway as an indication for endotracheal suctioning.

Gurgling or coarse breath sounds. Coarse breath sounds, or rhonchi, are an indication of secretions in the larger airway passages (Demers & Saklad, 1973). Rhonchi are a rattling sound noted upon auscultation, that resembles snoring (Thomas, 1985). These coarse breath sounds are an indication that endotracheal suctioning may be required (Clark, 1995; Day, 2000; Demers & Saklad, 1973). Finer airway sounds, or rales, indicate secretions in the small distal airway passages; these secretions most likely are not accessible through endotracheal suctioning (Demer & Saklad, 1973). Audible breath sounds in the non-ventilated neonate with spontaneous respirations are similar to rhonchi and indicate a buildup of secretions in the larger airways that should also be suctioned.

Decreased oxygen saturation levels. As the artificial airway becomes obstructed, the passage of air is significantly reduced due to the reduction of the internal diameter of the artificial airway. If untreated, this leads to a rise in oxygen consumption, which ultimately leads to an oxygen desaturation (Place & Fell, 1998). Several authors cite decreased oxygen saturation as an indication for performing endotracheal suctioning (Clark, 1995; Day, 2000; Glass & Grap, 1995; Place & Fell, 1998; Wrightson, 1999). A continued decrease in the oxygen saturation level may indicate worsening hypoxemia.

Complications of Suctioning a Neonate

Although clearing the artificial airway through the use of mechanical suction is a vital aspect in caring for the neonate with an artificial airway, suctioning the artificial airway is not without risk. The following complications associated with endotracheal suctioning have been identified in the literature: (a) hypoxemia, (b) atelectasis, (c) trauma, (d) pneumothorax, (e) increased intracranial pressure, (f) infection, and (g) the use of normal saline bolus instillation (American Academy of Respiratory Care (AARC) Clinical Practice Guideline 1993; Demers & Saklad 1973; Hess 1999; Hodge 1991; Knox, 1993; and Stone & Turner 1989).

Hypoxemia. Hypoxemia, decreased oxygen tension of the blood, is a frequent complication associated with endotracheal suctioning (Hodge, 1991; Knox, 1993; Shorten, 1989). Transient hypoxia is a result of several factors. First, the process of mechanical suction removes gases from within the airways along with secretions (Demer & Saklad, 1973). A large percentage of ventilated infants suffer from pre-existing pulmonary disease or premature lung development and are ventilator dependent to maintain adequate oxygenation. Any disruptions of the ventilator cycle such as removing the neonate from the ventilator to perform open endotracheal suctioning can also lead to transient hypoxemia (Knox, 1993; Shorten, 1989).

Atelectasis. Atelectasis occurs as a result of excessive negative pressure being applied during the suctioning process (Hodge, 1991; Shorten, 1989; Simmons, 1997; & Wrightson, 1999). Atelectasis can also occur if suction is applied while the catheter is being advanced or immediately after the catheter has been fully advanced to the carina in the instance of deep endotracheal suctioning (Demers & Saklad, 1973). Utilizing a catheter that is too large for the artificial airway of a neonate can also cause atelectasis (Demers & Saklad, 1973; Hodge, 1991).

Trauma. Tissue damage to the respiratory mucosa can result from endotracheal suctioning. This damage may be the result of tissue invagination (tissue being aspirated into the suction catheter) during the application of suction or direct contact with the tissue (McEleney, 1998). This tissue damage is evident upon bronchoscopy. Shorten (1989) reports that neonates have developed right lung emphysema as a result of obstructive granulation tissue, which may have developed as a result of tracheal suctioning.

Pneumothorax. A pneumothorax “is the collection of air or gas in the pleural cavity” (Thomas, 1985, p. 1328). Hodge (1991) and Shorten (1989) both discussed the occurrence of pneumothoraces as a result of perforation of the lung parenchyma with the suction catheter. Knox (1993) also identified hyperinflation as a possible cause of pneumothorax. Signs of pneumothorax in the neonatal patient include decreased breath sounds on the infected side, hypotension, skin mottling, and a mediastinal shift (Deacon & O'Neill, 1999).

Increased intracranial pressure. Increased intracranial pressure (IICP) has been reported as a result of endotracheal suctioning. Knox (1993) cites an increased hypercapnea, hypoxemia, and increased systemic blood pressure as possible causes of IICP. This IICP can lead to intraventricular hemorrhage in the premature infant. Major complications for survivors of intraventricular hemorrhage can be cerebral palsy or hydrocephalus (Shorten, 1989).

Infection. Infection is a risk of endotracheal suctioning that can be greatly reduced through the use of aseptic technique (Creamer and Smyth, 1996). Gloves should be worn during the suctioning procedure. Although sterile gloves are routinely used during the open suctioning procedure, Creamer and Smyth (1996) report that there is no reduction in the risk of infection when using sterile gloves compared with clean gloves.

Another important aspect in reducing the risk of infection is in routinely changing the suction equipment. In one study of intubated adult patients, Soles, et al. report most suction equipment was infected with potential pathogens. Of 18 subjects tested, 18 (94%) tonsil suction devices, 15 (83%) suction tubes, and 11 (61%) inline suction catheters were found to be contaminated.

If using the open suction method, a new, sterile suction catheter should be utilized for each suction event, with the catheter cleaned with sterile water or sterile normal saline between passes. This water should be dispensed into a sterile container for each suction event, and the supply container should be changed every 12 hours (Creamer & Smyth, 1996).

Normal saline bolus. Normal saline instillation (NSI) as a part of the suction process is a common practice utilized by registered nurses (Ackerman, Ecklund, & Abu-Jumah, 1996; Druding, 1997; Raymond, 1995). The registered nurse commonly performs NSI to loosen secretions, lubricate the suction catheter, increase clearance of aspirate, enhancing cough mechanism, mobilizing secretions, and diluting secretions (Druding, 1997).

Instilled normal saline tends to remain in the trachea and mainstem bronchi. Raymond (1995) reports that normal saline that had been tagged with Technetium 99m remained in the upper airway for 30 minutes after instillation, with none reaching terminal bronchus or alveoli. Demers and Saklad (1973) report that mucus and water are immiscible, and that the use of nebulized water or saline has been shown to be effective in thinning secretions. For these reasons the use of normal saline bolus instillation is not an effective method of thinning secretions.

The use of NSI has also been associated with an increased risk of infection. Ackerman et al. (1996) report that 23% of the vials of normal saline used for irrigation were contaminated while being opened. Hagler and Traver (1994) determined that a significantly greater number of bacteria were dislodged from endotracheal tubes by the instillation of sterile normal saline without preservative than by passage of a sterile suction catheter.

Minimizing the Risks of Neonatal Suctioning

It is of vital importance that registered nurses perform endotracheal suctioning in safe and efficient manner to minimize the harmful effects of this procedure on neonates. Although these complications may not be totally relieved, their effects can be minimized through the use of one of the following techniques: hyperoxygenation, hyperventilation, hyperinflation (Stone & Turner, 1989).

Hyperoxygenation. Hyperoxygenation is delivering a fraction of inspired oxygen (FiO_2) greater than that which the neonate normally receives (Day, 2000). Hyperoxygenation can occur either with a manual resuscitation bag (MRB) or by the ventilator. One problem associated with ventilator-induced hyperoxygenation is that of “bleed out”, or the time that it takes for the increased FiO2 to work through the ventilator circuitry and reach the neonate (Stone & Turner, 1989). Much of the research regarding hyperoxygenation relates to the adult ventilator patient. However, this clinical application has frequently been applied to the neonatal population (Stone & Turner, 1989). Goodnough (1985) reported an increased immediate post suctioning PaO_2 in 22 study participants when suctioning was preceded by hyperoxygenation alone, and an increased post suctioning PaO_2 in 27 of 28 study participants when suctioning was preceded by hyperoxygenation and hyperinflation combined.

Hyperventilation. Hyperventilation is achieved through an increase in the ventilation rate. This can be completed through the use of an MRB or the ventilator. Feaster, West, and Ferketich (1985) conducted a study of ventilated pediatric patients and the use of various combinations of hyperoxygenation, hyperventilation, and hyperinflation were employed. The results showed that all of the methods succeeded in preventing significant desaturation

Hyperinflation. Hyperinflation is the practice of inflating the lungs with a larger volume or higher ventilatory pressure than that which is delivered by a normal ventilator breath. This hyperinflation can either be delivered with an MRB or ventilator (Day, 2000). Hodge (1991) reports that ventilating with peak pressures 10% to 20% greater than normal may be adequate. If used, hyperinflation should not be conducted without an in-line device to monitor airway pressure. If hyperinflation is utilized, care should be exercised as this procedure has been identified as a possible cause of pneumothorax (Knox, 1993). As a result, Shorten (1989) reports that most neonatal researchers have concentrated on hyperoxygenation and hyperventilation rather than hyperveninflation. In a study of 28 adult post cardiac surgery patients Goodnough (1985) reported a statistically significant decrease in PaO_2 in patients provided post-suctioning hyperinflation only. Hyperinflation combined with hyperoxygenation however preceded an increased post suctioning PaO_2 in 27 of 28 study participants.

Proper technique. As previously noted, endotracheal suctioning should be performed only on an "as needed basis," and never routinely scheduled (Clark, 1995; Day, 2000; Place & Fell, 1998). When physical assessment reveals the need for endotracheal suctioning, use of proper technique is possibly the most important aspect in limiting the harmful effects of endotracheal suctioning.

Selection of a properly sized suction catheter is necessary in order to minimize atelectasis. Ideally, the size of the catheter should not exceed one half of the internal diameter of the artificial airway (Day, 2000; Griggs, 1998). While this is practical for the term infant, it may be impossible in the small or premature infant (Hodge, 1991).

Avoiding the use of excessive amount of suction pressure is also important. Hodge (1991) recommends setting the suction at no more than –50 to –80 cm water pressure although a source for this recommendation is not given. Maximum suction pressures ranging from –120 millimeters of mercury (mmHg) to –150 mmHg have been cited, but these are referenced to adult patients (Buglass, 1999; Day, 2000). McEleney (1998) reported that secretion recovery was not increased in adult patients with an increase in suction pressure greater than –100 mmHg. No information was found relating to suction pressures and the neonatal patient.

Depth or catheter insertion is another consideration that is of extreme importance. As previously noted both soft tissue injury to the respiratory mucosa (McEleney, 1998) and pneumothorax (Hodge, 1991; Shorten, 1989) are potential complications of endotracheal suctioning. For this reason Hodge (1991) recommends not advancing the suction catheter beyond the tip of the artificial airway. Day (2000) also identifies vagal stimulation as a potential complication of advancing the catheter beyond the tip of the artificial airway.

Suction should only be applied to the catheter as it is being withdrawn. Atelectasis can also occur if suction is applied while the catheter is being advanced or immediately after the catheter has been fully advanced (Demers & Saklad, 1973). The number of passes of the suction catheter should be limited to two unless large quantities of secretions have been aspirated (Hodge, 1991).

Significance of the Problem

The following complications are associated with endotracheal suctioning (American Academy of Respiratory Care (AARC) Clinical Practice Guideline 1993; Demers & Saklad 1973; Hess 1999; Hodge 1991; Knox, 1993; and Stone & Turner 1989): (a) hypoxemia, (b) atelectasis, (c) soft tissue trauma, (d) pneomothorax, and (e) increased intracranial pressure. While the occurrence of these adverse effects may not be entirely eliminated, the registered nurse may be able to limit their occurrence of effects by careful and timely application of mechanical suction.

Problem Statement

There are no national standards for suctioning the neonate with an artificial airway. The purpose of this study was to determine the current procedures used by the neonatal intensive care unit (NICU) nurses caring for the neonate with an artificial airway who required manual suction to maintain a patent airway.

Research Questions

Data were collected through the use of the Neonatal Suctioning Procedure Questionnaire to determine the practice patterns of registered nurses working in the NICU when suctioning neonatal patients. The researcher developed the following research questions to analyze the responses from the knowledge questionnaire.

1. What are the actions performed by the registered nurse before, during, and after the suctioning procedure?
2. If hyperoxygenation is used, when and how is it applied?
3. If hyperventilation is used, when and how is it applied?
4. If hyperinflation is used, when and how is it applied?

5. What are some of the miscellaneous actions associated with the suctioning procedure?

6. What is the frequency, type, and amount of irrigant used during the suction procedure?

Operational Definitions

Neonatal Nurse

For this investigation, the neonatal nurse is any registered nurse working in the neonatal intensive care unit. No registered nurse was excluded on the basis of age, education level, or nursing or neonatal nursing years of experience.

Neonate

Thomas (1985) defines a neonate as “a newborn infant up to six weeks of age” (p. 1105). For the purposes of this study, any infant patient with an artificial airway resident within the NICU was included. No infant was excluded on the basis of gestational age, birth age, or medical diagnosis.

Importance of Study

The results of this study were important for all levels of nursing practice and will be discussed as they pertain to practitioners, educators, and nursing administrators.

Practitioners

The results of this study reported the current practices of the registered nursing staff within one NICU. Accurate understanding of current practice is necessary to determine if these practices are being performed in a manner consistent with current research. In light of the harmful side effects associated with applying manual suction to the neonatal patient with an artificial airway, it is vitally important to assure that this practice is being performed in a safe, efficient, and consistent manner. Results of this study can be used to ensure that current practice is performed in a safe and effective method.

Educators

Nursing educators must be aware of research-based changes associated with current nursing practice. All nursing education, both college and hospital based must be based upon current research. Results of this study are important to nursing educators at all levels. College based nursing educators can use the results of this study to obtain current research based information pertaining to mechanical suctioning of the neonatal patient. Nursing educators at the hospital level can use the results of this study to determine current nursing practice, and to determine whether this practice is consistent with current nursing research.

Nursing educators must first understand the current level of knowledge of the registered nursing staff in order to determine what level and amount of instruction is necessary. Results of this study can be utilized by the nursing educator to develop an educational program for all registered nurses required to provide mechanical suction to the neonatal patient with an artificial airway.

Nursing Administrators

The nursing administrator is responsible for ensuring that current nursing practice within their assigned area is safe, efficient, and based upon current nursing research. In order to determine what changes are required for the unit's standards and practice policy and procedures, the nursing administrator must first have a clear and concise understanding regarding current practices within this unit. Information obtained from this survey can be used by the nursing administrator to determine the current standard or practice, and whether the registered nursing staff is providing mechanical suction in a manner consistent with current policies and procedures.

Summary

There are no national standards pertaining to the suctioning of the neonatal patient with an artificial airway. The following have been suggested as reasons to provide mechanical suction to the patient with an artificial airway: a) diminished breath sounds, (b) dyspnea, (c) visible secretions in the artificial airway, (d) gurgling or coarse breath sounds, and (e) decreased oxygen saturation levels. The following problems have been associated with suctioning the neonatal patient with an artificial airway: (a) hypoxemia, (b) atelectasis, (c) soft tissue trauma, pneumothorax, (d) increased intracranial pressure, (e) infection, and (f) normal saline instillation. Although associated with these complications, suctioning is still a vital and necessary function in maintaining a patent artificial airway. Techniques such as hyperoxygenation, hyperventilation, and hyperventilation all may be utilized to lessen the seriousness of these complications. Other useful interventions in minimizing the harmful effects of mechanical suction include: using a catheter less than half of the internal diameter of the artificial airway, limiting the length of time that negative pressure is applied, limiting the amount of negative pressure, and avoiding the use of irrigants such as normal saline.

Chapter Two

A review of the literature indicates much has been written pertaining to mechanically suctioning the adult patient with an artificial airway. Interventions such as hyperoxygenation, hyperventilation, and hyperinflation have been evaluated to determine their efficacy in alleviating or reducing the complications associated with mechanical suctioning. A computer search was conducted via CINAHL to obtain current literature pertaining to mechanical suctioning of the neonatal patient with an artificial airway.

Literature Review

Feaster et al., (1985) reported the results of a study examining the effects of hyperinflation, hyperventilation, and hyperoxygenation on children less than two years of age. To be included in the study, the child must have a tracheostomy tube, be receiving ventilatory support, require suctioning at least every six hours, and have an adequate pulse for successful application of pulse oximetry. A total of seven patients were enrolled in this study.

The investigators reported utilizing the following experimental protocols: hyperinflation alone; hyperinflation and hyperoxygenation; hyperinflation and hyperventilation; and hyperinflation, hyperoxygenation, and hyperventilation. Each child was randomly assigned to an order of hyperinflation alone, or in combination with hyperoxygenation and or hyperventilation.

The investigators reported the following sequence of. A pulse oximeter was applied five minutes prior to performing chest physiotherapy. An oxygen saturation reading was recorded five to 10 seconds prior to performing the chest physiotherapy.

An oxygen saturation reading was recorded 15 seconds prior to initiating the experimental protocol. The suction pass was repeated a sufficient number of times to ensure adequate removal of secretions, as evidenced by the absence of audible rhonchi. After completion of the last suction pass, oxygen saturation readings were recorded at 30 seconds, and one, five, 10, and 20 minutes.

Feaster et al., (1985) reported that all patients returned to at least the baseline oxygen saturation level after the 20-minute period regardless of the study protocol applied. Although the hyperinflation with hyperoxygenation and hyperinflation with hyperoxygenation and hyperventilation groups both had statistically significant decreases in oxygen saturation after chest physiotherapy these decreases were not clinically significant. A statistically significant increase in oxygen saturation was noted in the hyperinflation, hyperoxygenation, and hyperventilation group at 30 seconds post suction. The hyperinflation, hyperoxygenation, and hyperventilation group was the only group that demonstrated a statistically significant overall increase.

Cordero, Sananes, and Ayers (2000) comparied the closed endotracheal suction system with an open endotracheal suction system in small premature infants. The purpose of the study was to determine if there was a difference in airway bacterial colonization, nosocomial pneumonia, blood stream infection, incidence and severity of bronchopulmonary dysplasia, neonatal mortality, frequency of suction and reintubation, and nurse preference.

A total of 175 consecutive infants with low birth weight (≤ 1250 g) who had been intubated in the delivery room were enrolled in the study. Each neonate assigned to the study received two passes of the suction catheter every eight hours or more frequently if needed. Closed suction catheters were changed every 24 hours, and open suction catheters were replaced after each use. All mechanically ventilated neonates were considered at risk for infection and were treated with prophylactic intravenous Ampicillin and Gentamicin. Antibiotic treatment continued for three days in the presence of negative blood cultures, and for five to seven days with a positive blood culture.

Cordero et al., (2000) reported similar results of bacterial colonization patterns between both groups. Nosocomial pneumonia and blood stream infection rates were not statistically significant for either group. The number of suction events per day and reintubations were similar as well. There was also a significant difference in bronchopulmonary dysplasia scores between groups. Cordero et al., (2000) also reported that 40 of the 44 nurses familiar with both systems considered the closed system to be easier to use, better tolerated by the neonate being suctioned, and less time-consuming.

Hagler and Traver (1994) investigated the effects of normal saline bolus instillation and suction catheter insertion upon dislodged bacteria. Ten adult patients who had been intubated for greater than 48 hours were recruited for this study. After extubation, the endotracheal tubes were collected and subjected to two study interventions. The order in which the interventions were applied was randomly assigned.

The first intervention consisted of passing a sterile 14 French (Fr) suction catheter through the entire length of the endotracheal tube. After the distal end of the suction catheter exited the endotracheal tube it was removed by cutting with a pair of sterile scissors and collected in a sterile cup.

The second intervention consisted of pouring five milliliters of sterile normal saline without preservative through each endotracheal tube. The saline was instilled into the endotracheal tube through a universal adapter and collected in a sterile specimen cup.

Results of a paired *t* - test demonstrated a significant difference ($p = .004$) in the amount of bacteria dislodged with each intervention. Hagler and Traver (1994) determined that a greater number of bacteria were dislodged with the instillation of the normal saline than by passing the suction catheter. The mean colony count of bacteria dislodged by passage of the suction catheter was 10, 460 (∀19,229) compared with a mean colony count of bacteria dislodged with normal saline bolus instillation of 79,972 (∀106,400). Order of intervention was randomly assigned and did not demonstrate a significant effect on colony counts of dislodged bacteria.

Tolles and Stone (1990) conducted a national survey of neonatal suctioning techniques. The authors identified the following techniques as interventions to reduce the harmful side effects associated with endotracheal suctioning performed on the neonate: (a) hyperventilation, (b) hyperinflation, and (c) hyperoxygenation. A modified endotracheal tube adaptor allowing the endotracheal tube to be suctioned without removing the neonate from the ventilator was also identified as being helpful in reducing complications.

Tolles and Stone (1990) mailed the survey to 354 centers that had been identified in Ross Laboratories *Guide to Centers Providing Perinatal and Neonatal Special (1982, 1984)* Care as providing ventilator assistance to the neonate. The cover letter included with the questionnaire asked that an experienced neonatal nurse complete and return the questionnaire. A total of 203 nurses completed and returned the questionnaires. The results of the survey indicated that there was a large variation of techniques used to suction the neonate.

Tolles and Stone (1990) reported that only 66% (*n* = 133) of the respondents routinely hyperoxygenate the neonate prior to performing endotracheal suctioning. Hyperoxygenation after suctioning occurred 49% (*n* = 67) of the time with those neonates who were returned to the ventilator and 74% (*n* = 74) of the time for those neonates that were ventilated with a manual resuscitation bag. Thirty four percent (*n* = 70) of the respondents did not routinely provide hyperoxygenation. The authors found hyperoxygenation was provided on a case by case basis dependent upon the neonates past response to suctioning.

Tolles and Stone (1990) indicate that 98% (*n* = 199) of the respondents provided hyperoxygenation for the neonate undergoing endotracheal suctioning. Tolles and Stone indicate that five percent (*n* = 10) of the respondents provided a standard increase in oxygenation for all neonates undergoing endotracheal suctioning with the remaining 88% (*n* = 178) of respondents who hyperoxygenate providing an increase based upon the infants needs and previous response to suctioning.

Tolles and Stone (1990) reported that only 9% (*n* = 19) of respondents indicated using the hyperinflation technique when providing endotracheal suctioning to the neonate, and only ten respondents (5%) indicated the use of the inline suction device.

Swartz, Noonan, and Edwards-Beckett (1996) reported results of a survey of pediatric endotracheal suctioning techniques. Questionnaires were mailed to all of the pediatric intensive care units in the 92 hospitals listed in the 1991 National Association of Children's Hospitals and Related Institutions directory, Eighty nurses (90%) completed and returned the questionnaire. The patient population consisted of infants and children between the ages of 8 weeks and 12 years. Consistent with previous work, the authors reported a wide range in techniques used in suctioning the pediatric patient.

The authors (1996) report that the majority of respondents provided hyperoxygenation, hyperventilation, or hyperinflation prior to performing endotracheal suctioning. Eighty eight percent (n = 70) of the respondents indicated they hyperoxygenated prior to suctioning, 97% (n = 76) of the respondents during suctioning, and 94% (n = 74) of the respondents after suctioning. 79% (n = 60) of the respondents reported increasing the oxygen concentration to 100%, with 20% (n = 13) basing the increased percentage upon the patient's previous response.

Swartz et al. (1996) reported that hyperventilation was used less frequently than hyperoxygenation. The decision to apply hyperventilation was based on the child's past response to suctioning (52%, n = 42), child's appearance (60%, n = 48), or on a decreased oxygen saturation (56%, n = 45). The majority of respondents (92%, n = 43) reported the hyperinflation volume was determined by the child's previous response to the endotracheal suctioning procedure. Hyperinflation was also applied to a smaller percentage of patients undergoing endotracheal suctioning. Twenty eight percent (n = 22) of respondents utilized hyperinflation before endotracheal suctioning, 49% (n = 30) during the endotracheal suctioning process, and 46% (n = 36) hyperinflated after completing endotracheal suctioning.

Swartz et al. (1996) reported that suction frequency of children varied indicating suctioning was performed on an as needed basis rather than on a scheduled basis. The majority of nurses (71%, *n* = 57) indicated they performed deep endotracheal suctioning by inserting the suction catheter until resistance was encountered. Fifty-three percent (*n* = 42) of nurses reported using intermittent suctioning, with suction being applied for two to 15 seconds during the suctioning procedure. Swartz et al. (1996) repored that 97% (*n* = 74) of respondents reported using a manual resuscitation bag to post-ventilate the patient after performing endotracheal suctioning.

Copnell and Fergusson (1995) reported the results of their study to determine the criteria that nurses use to determine the need to perform endotracheal suctioning. Twenty-four nurses participated in the study. The study took place in an intensive care unit that admitted patients from newborn to adolescent. Critical care experience of the nurses ranged from six months to 14 years. Copnell and Fergusson reported that there were no differences in nursing practices based upon experience or education level.

The investigators found that all respondents were able to identify valid reasons for performing endotracheal. Seventeen criteria were reported by the investigators that the nurses performed during the respiratory assessment. Although the nurses knowledge of the 17 respiratory assessment criteria was deficient, many of the nurses identified several of the criteria when deciding to suction patients.

Goodnough (1985) reported the effects of hyperoxygenation and hyperinflation during the suctioning procedure using arterial blood gas values. This study included 28 adult patients located at two separate medical centers. The sample included patients who were four to six hours post cardiac surgery. Inclusion criteria for this study were (a) an FiO_2 of less than or equal to 0.8, (b) peak inspiratory pressure less than or equal to 50 cmH_2O, (c) absence of PEEP, (d) PaO_2 greater than or equal to 80 mmHg, (e) functional indwelling arterial catheter, (f) stable systolic blood pressure, and (g) absence of cardiac dysrhythmias.

Hyperoxygenation was performed using the ventilator and the FiO_2 was increased to 1.0 for one minute. Hyperinflation was performed using a tidal volume one-and-one-half times the normal tidal volume and at a rate to maintain the previous minute volume. Suctioning of patients was performed with a 14 Fr suction catheter. The suction catheter was advanced without the application of negative pressure until resistance was met and then the catheter was withdrawn approximately one centimeter. Negative pressure was continuously applied and then the suction catheter withdrawn.

Goodnough (1985) developed the following four suctioning procedures:

1. Hyperoxygenation before suctioning, hyperinflation after suctioning.
2. Hyperoxygenation before suctioning, hyperoxygenation after suctioning.
3. Hyperinflation before suctioning, hyperinflation after suctioning.
4. Hyperoxygenation/hyperinflation before suctioning, hyperoxygenation/hyperinflation after suctioning.

Each study participant was subjected to each of the four suctioning procedures in random sequence. Arterial blood gases (ABGs) were drawn prior to the first suction pass and then immediately upon completion of the suction passage prior to return of the patient to the ventilator. Additional ABGs were drawn at five and ten minutes after suctioning was completed. The ten-minute ABGs were used as the baseline for the next suctioning procedure.

The investigators found significant differences between the four procedures (p = .0001). The PaO_2 values were also noted to be significantly different between the pre-suction and immediate post suction ABG results (p = .0001) and immediate post suction to five-minute post suction ABG results (p = .0014). The PaO_2 was not significantly different from the five minute post suction to ten-minute post suction ABG results.

Results revealed that hyperinflation (alone) before suctioning was the only procedure that led to a significant decrease in PaO_2 in 79% (n = 22) of the study population (p < .001). Hyperoxygenation (alone) preceded an increased post suctioning PaO_2 in 75% (n = 21) of the study group (p < .01), and hyperoxygenation and hyperinflation combined prior to suctioning preceded an increased post suctioning PaO_2 (p < .0001) for 27 (96%) of 28 study participants. An insignificant transient increase in $PaCO_2$ was also reported, however, this increased level had returned to baseline prior to the five minute ABG result.

Chulay (1988) reported similar findings in a study of hyperinflation and hyperoxygenation during the suctioning procedure. The sample consisted of 32 males, aged 35 to 70 years, scheduled for elective cardiac surgery. Inclusion criteria included (a) hemodynamic stability, (b) presence of an endotracheal tube, (c) indwelling arterial catheter, (d) and pulmonary artery catheter, (e) mechanical ventilatory support with constant ventilator settings, (f) not previously diagnosed with chronic obstructive pulmonary disease, and, (g) not suctioned within the last hour.

The procedure consisted of the following sequence of events: (a) administration of five hyperinflation and hyperoxygenation breaths with a Puritan Manual Resuscitator manual resuscitation bag (PMR – 2) over 30 seconds, (b) administration of ten seconds of continuous negative pressure endotracheal suctioning, (c) repeated administration of five hyperinflation and hyperoxygenation breaths with a PMR – 2 manual resuscitation bag over 30 seconds, and (d) administration of ten seconds of continuous negative pressure endotracheal suctioning, and (e) repeated administration of five hyperinflation and hyperoxygenation breaths with a PMR – 2 manual resuscitation bag over 30 seconds.

The hyperinflation and hyperoxygenation breaths were administered at one-and-one-half the preset tidal volume. Hyperoxygenation was administered at a flow rate of 15 liters per minute, that resulted in a delivered FiO_2 of 0.65 – 0.85. Tidal volume and FiO_2 were monitored through the use of an inline manometer and oxygen analyzer.

Blood for ABG analysis was obtained at one minute prior to the start of the intervention and then every minute for five minutes (plus four minutes post suctioning). Results of the ABG analysis revealed similar PaO2 evaluation at the minus one-minute and zero minute intervals (immediately at the start of the suctioning intervention). The PaO_2 was increased an average of 40 mmHg at one minute post suction and 153 mmHg at two minutes post suction. Thirty-one of the thirty-two (97%) study participants maintained this increased PaO_2 over the entire suctioning procedure and evaluation. One participant had a decreased PaO2 at three and four minutes post suction, however this individual had a 140-pack year history of cigarette smoking. The results revealed an increased PaO_2 was significant at the one, two, and three-minute intervals ($p < .01$) and at the four minute interval ($p < .05$).

Theoretical Framework

The registered nurse caring for the intubated neonate must be able to perform an accurate assessment to determine what interventions are necessary to maintain a patent airway for effective ventilations. The ability to perform this nursing assessment and then apply the appropriate intervention becomes a more “natural” act with experience. Patricia Benner’s Novice to Expert Theory (1984) discusses the changes that registered nurses go through as he or she progresses through the five stages of novice to expert.

Practitioners in the novice stage have no knowledge or experience related to the situation that they are involved in. This lack of knowledge places the novice practitioner in situations in which they must be provided with rules to govern their actions. These rules must be clear, concise, and easily understood. Benner (1984) states that applying a set of rules provides a set of tasks for the novice, but these rules cannot prioritize these tasks for the novice practitioner. The use of these applied rules prevents the synthesis of all aspects of the situation and makes attainment of successful performance more difficult. The novice practitioner is also unable to discern between relevant and irrelevant facts (Benner, 1984; Mitre, Alexander, & Keller, 1998).

The advanced beginner has obtained some experience in the practice setting and has demonstrated marginally acceptable performance. The advanced beginner has acquired enough experience to identify, either on their own or after it has been pointed out by others, the meaningful aspects of the situation. The advanced beginner still depends on rules and guidelines, and has difficulty in understanding the current situation in the context of the overall perspective (Benner, 1984; Mitre et al., 1998).

The competent nurse is capable of independent planning, and is able to determine which aspects of the current situation are relevant. Although the competent practitioner is able to cope with and manage the many variables associated with nursing practice, they do so much slower, and they lack the flexibility associated with the proficient or expert provider (Benner, 1984; Mitre et al., 1998).

Nurses at the proficient level are capable of viewing the situation completely. The proficient practitioner has learned from their experiences, and possesses the ability to determine what is important, and is able to grasp the situation based on the knowledge obtained by all previous experiences. The proficient provider is capable or establishing individual goals for the patient (Benner, 1984; Mitre et al., 1998).

The expert provider “no longer relies on analytical principles such as rules, guidelines, or maxims, to connect their understanding of the situation to an appropriate action” (Benner, 1984, p. 31). The expert provider is able to instinctively grasp the situation. The expert nurse’s primary concern is meeting the neonate’s actual needs. The expert nurse is capable of making a decision and implementing the appropriate action without consciously being aware of their decision (Benner, 1984; Mitre et al., 1998).

Benner (1984) writes that “clinical knowledge is gained over time and the clinicians themselves are often unaware of their gains” (p. 4). As a result of this increased clinical knowledge the neonatal nurse is able to develop an appropriate interpretation of the present clinical situation. As the registered nurse develops a greater knowledge base and advances from the novice stage to levels of greater skill and experience, they are able to recognize subtle changes in the neonates condition that might indicate the need for suctioning the artificial airway. These subtle changes are often subjective, and precede more definitive and documentable objective changes in vital signs. These changes are only important when incorporated into the complete situation, that includes the neonate's present condition, and past health history.

Benner (1984) further states that "as a nurse gains "experience," clinical knowledge that is a hybrid between naive practical knowledge and unrefined theoretical knowledge develops" (p. 8). Many of these experiences can have a significant impact on the nurse's development and growth if they resulted in a significant change of perception of practice patterns. Many of these experiences may stand as a paradigm case and guide the proficient or expert nurse in their actions and behaviors.

An increase in patient illnesses and advance practice skills interventions has created a need for registered nurses to apply diagnostic and monitoring skills. Many treatments and interventions offered today have a narrow range of therapeutic safety, and the astute nurse is often the patient's first line of defense. Benner (1984) has identified the following domains within the diagnostic and monitoring function of the patient: (a) detection and documentation of significant changes in condition, (b) providing an early warning signal (anticipating breakdown and deterioration prior to explicit confirming diagnostic signs), (c) anticipating problems (future think), (d) understanding the particular demands and experiences of an illness (anticipating patient care needs), and (e) assessing the patient's potential for wellness and for responding to various treatment strategies (p. 97). The proficient or expert nurse is often able to identify early warning signals and intervene before measurable changes in the patient's condition develop. The proficient or expert nurse possesses a better understanding of the particular demands of the patient's illness and anticipates necessary interventions.

The registered nurse caring for the neonatal patient with an artificial airway is often the first to identify signs of deterioration and must be able to manage the rapidly changing condition until the physician's arrival. Benner (1984) identified the following components that are required for effective management of the rapidly changing patient condition: (a) skilled performance in extreme life threatening emergencies (rapid grasp of a problem), (b) contingency management (rapid matching of demands and resources in emergency situations), and (c) identifying and managing a patient crisis until physician assistance is available (p. 111). The novice or advanced beginner, due to their reliance on a concrete set of rules, is frequently unable to effectively manage this rapid change or deterioration in the patient condition. The proficient or expert nurse with their intuitive grasp of the overall patient care situation is more capable of providing appropriate patient care until the arrival of the physician.

While providing mechanical suction to the neonatal patient with an artificial airway is frequently required to maintain airway patency, this intervention should be provided on an as needed basis rather than using a set time table or frequency. In order to determine the need to provide mechanical suctioning, the registered nurse providing this care must be able to integrate all aspects of the current patient situation to make this decision. Benner's (1984) from novice to expert was chosen as the theoretical model for this study for this reason.

Summary

Much has been written pertaining to suctioning the patient with an artificial airway. Techniques such as hyperoxygenation, hyperventilation, and hyperinflation have been described. The lack of efficacy of normal saline bolus instillation has been documented in the adult population, yet this technique continues to be applied to both the adult and neonatal population. Many of these techniques are being applied to the neonatal population without adequate study (Stone & Turner, 1989). Benner's Novice to Expert theory will serve as the theoretical framework to be used while analyzing the results of this study.

Chapter Three

The registered nursing staff caring for the neonatal patient with an artificial airway was surveyed to analyze the techniques currently in use. These data were collected through the use of two questionnaires that were modified from the questionnaire utilized by Tolles and Stone (1990). The data were analyzed to determine the current suction practices performed by the registered nurse caring for the neonatal patient with an artificial airway. A convenience sample of registered nurses in a 30 bed NICU was used.

Methodology

A descriptive research design was used to describe the suctioning practices of the registered nurse providing care to the neonatal patient. Data were collected through the use of two questionnaires: (a) a six-item Demographic Questionnaire (Appendix A), and (b) the Neonatal Suctioning Procedure Questionnaire (NSPQ) (Appendix B).

Design

Data were collected from registered nurses working in a 30 bed NICU. The NICU is located within a regional referral center. The facility provides services to patients located within a three state area. The selected facility is a teaching facility affiliated with the Schools of Medicine and Nursing of a local university. In addition to the NICU, the facility also provides for pediatric and adult intensive care, maintains a burn unit, and is a certified level II trauma center. The medical center also provides specialized rotary wing air and ground transport services.

Setting and Sample

A convenience sample of twenty-one registered nurses was completed over a two week time frame. All registered nurses working in the NICU were eligible to participate in this survey. Inclusion criteria to participate in this study were: (a) licensure as a registered nurse and (b) assignment to the NICU as a staff registered nurse. SInce all inclusion criteria were met, there were no exclusion criteria used within this study.

Instrument

Two instruments were used to collect data during this study. They were a six-item Demographic Questionnaire and a 30-item Neonatal Suctioning Procedure Questionnaire. The investigator developed the Demographic Questionnaire (Appendix A). The 30 item Neonatal Suctioning Procedure Questionnaire was developed from the National Survey of Neonatal Endotracheal Suctioning Practice Questionnaire (Tolles and Stone, 1990). The National Survey of Neonatal Endotracheal Suctioning Practice Questionnaire is copyrighted material, therefore written permission was obtained from the authors prior to using their questionnaire (Appendix D). The NSPQ consists of 30 forced response questions designed to assess the registered nurses practice when suctioning the neonatal patient with an artificial airway. A cover letter provided instructions to the registered nurse to select the response or responses that most closely match their own suctioning technique (Appendix C).

Procedures

After obtaining permission from both the Institutional Review Board and the NICU, packets where delivered to the nurse manager for distribution to the NICU nurses. Each packet consisted of an envelope with a copy of the cover letter, Demographic Questionnaire, and NSPQ. The cover letter requested that the questionnaires be completed and returned within one week. A pen was also enclosed within each envelope to facilitate the completion and return of the questionnaires. The nurse manager or her designated representative distributed the packets to the NICU nurses. The nurses were instructed to complete the questionnaire and return in a sealed envelope to the collection box provided by the investigator. The collection box was located in the nurse manager's office. The investigator collected two completed questionnaires one week after delivering them to the nurse manager. After one week a reminder letter was posted within the unit requesting that the remaining questionnaires be completed and returned within the second week (Appendix E). One week after delivery of the reminder letter, an additional 19 completed questionnaires were collected (N = 21) from the container.

The completed questionnaires were coded sequentially from one to twenty-one. The information contained in the questionnaires was coded in a Microsoft Excel 97 spreadsheet for subsequent conversion to a Statistical Package for the Social Sciences (SPSS 11.0 for Windows Student Version) for Windows file. After the information was coded the questionnaires were destroyed. The investigator maintained possession of the opened questionnaires until destruction, and was the only person to view the completed questionnaires.

Summary

The Demographic Questionnaire and the NSPQ were delivered to the nurse manager of the NICU for distribution. Questionnaires were distributed to the nursing staff and returned to the collection box after completion. After the first week of the survey period completed questionnaires were retrieved and a reminder letter delivered. One week after delivery of the reminder letter an additional 19 completed questionnaires were retrieved. Two additional questionnaires were returned without response and were discarded.

Chapter Four

Data were collected through the use of two questionnaires. Responses to the questionnaires were analyzed through the use of a statistical computer program. Responses were reported through the use of frequencies and distributions. Data was evaluated using six themes identified as research questions.

Data Analysis

Responses to each question on the Demographic Questionnaire and NSPQ were entered into a computer database and analyzed using the SPSS computer program (Statistical Package for the Social Sciences, version 11.0 for Windows). The data were analyzed to answer the six research questions proposed by the study, using frequency distributions and aggregate percentages. The total number of affirmative responses and the percentages for each question was determined. Independent samples *t* - tests were conducted to determine if differences in suction practice existed based upon nursing education (diploma/associate's/bachelor's/master's), years of nursing experience (five or less years/greater than five years), and years NICU experience (five or less years/greater than five years). Additionally, good internal consistency of the Neonatal Suctioning Procedure Questionnaire was demonstrated as evidenced by a Cronbach's Coefficient Alpha score of ∀ = .76.

Demographic Data

Demographic data were obtained through the use of a six-item Demographic Questionnaire. Upon reviewing the responses, question number four was discarded because the NICU surveyed had a bed capacity of 30 beds, and none of the response options provided were appropriate.

Eighty six percent (*n* = 18) of the nursing staff had eight or more years nursing experience. Eighty one percent (*n* = 17) of the nursing staff had five or more years of NICU experience. Twenty four percent of the nursing staff (n = 5) were diploma prepared nurses, forty eight percent (n = 10) held associates degrees, twenty four percent of the nursing staff (*n* = 5) were prepared at the baccalaureate level, and one member of the nursing staff was a masters prepared nurse (Table 1). Approximately one third of the neonates on this unit received mechanical ventilation during data collection.

Results

The results of this survey provide current information pertaining to the suction practices of the registered nurse caring for neonatal patients with an artificial airway. The data were analyzed using the themes identified as the six research questions.

Nursing Actions Performed Before, During, and After The Suctioning Procedure

The respondents were asked to identify nursing actions performed before, during, and upon completion of the suctioning of neonates. Actions performed during the suction procedure were further subdivided to reflect suctioning performed with both an in-line suction adapter and suctioning performed by removing the neonate from the ventilator. Independent samples *t* - tests did not reveal significant differences (*p* # .05) between nursing education, years of nursing experience, or NICU experience of RNs.

Nursing actions performed prior to suctioning. Twenty (95%) of nurses provided a response to this question. The most common pre-suctioning intervention was postural drainage and/or percussions and vibrations of neonates, with 95% (*n* = 20) of respondents indicating they performed this intervention prior to neonatal suctioning.

Eighteen respondents (86%) indicated they hyperoxygenated the neonate prior to suctioning. Seventeen (81%) of the respondents indicated they repositioned the neonate prior to suctioning. Seventeen (81%) of the respondents indicated an irrigant was instilled prior to suctioning with one respondent (5%) indicating they performed hyperventilation after instilling the irrigant. Three respondents (14%) indicated an aerosol treatment was administered prior to suctioning, and only one (5%) respondent indicated blood was obtained for labs prior to the suctioning process (Table 2). Independent samples *t* - tests did not reveal significant differences (*p* # .05) between nursing education, years of nursing experience, or NICU experience of RNs.

Nursing actions performed during the suction procedure. Nineteen respondents (90%) indicated they performed the suctioning procedure with the use of an in-line adapter. Nineteen respondents (90%) indicated making at least two separate suction passes, with six (29%) indicating the use of a third suction pass. Thirteen respondents (62%) indicated use of hyperoxygenation after each suction pass, and three respondents (14%) indicated use of hyperventilation after each suction pass. No respondents indicated hyperinflation was used between suction passes. Four (19%) respondents indicated they rotated the infants head between suction passes.

Twelve respondents (57%) indicated they also performed the suctioning procedure by removing the neonate from the ventilator. Ten respondents (48%) indicated making a second suction pass, and three respondents (14%) indicated routinely making a third suction passes. Hyperventilation and hyperoxygenation were provided both through the use of a manual resuscitation bag and by returning the neonate to the ventilator. One respondent (5%) indicated they applied hyperinflation between suction passes (Table 3). Independent samples *t* - tests did not reveal significant differences (*p* # .05) between nursing education, years of nursing experience, or NICU experience of RNs.

Nursing actions performed after the suctioning procedure. Returning the neonate to the ventilator at the pre-suctioning settings was the most common post-suction procedure, with 16 respondents (73%) indicating this response. Two respondents (10%) indicated they hyperventilated the neonate with a manual resuscitator bag before returning the neonate to the ventilator and five respondents (24%) indicated the neonate was hyperoxygenated with the manual resuscitator bag. One respondent (5%) indicated the neonate was returned to the ventilator and hyperventilated while eight respondents indicated the neonate was hyperoxygenated after being returned to the ventilator (Table 4). Independent samples *t* - tests did not reveal significant differences (*p* # .05) between nursing education, years of nursing experience, or NICU experience of RNs.

Hyperoxygenation of Neonates

Twenty respondents (95%) indicated hyperoxygenation was sometimes provided to the neonate before, during, or after the suctioning procedure. Several factors were listed as affecting the use of hyperoxygenation during the suctioning procedure. The most commonly listed reason to hyperoxygenate was the neonates past response to suctioning. Nineteen respondents (90%) provided this response as the reason to hyperoxygenate the neonate. Eighteen respondents (86%) indicated the neonates current physical appearance was an indication for hyperoxygenation. Sixteen respondents (76%) indicated hyperoxygenation was used if the neonate demonstrated a decrease in SaO_2 or $TcPO_2$ during the suctioning process. Fifteen respondents (71%) indicated the neonate's current physiological status was used as a basis to determine the need for hyperoxygenation. Only five respondents (24%) indicated the decision to hyperoxygenate was based upon the latest PaO_2 value.

Eighteen respondents (86%) indicated the registered nurse made the decision to hyperoxygenate. One respondent (5%) indicated that the attending physician or neonatal nurse practitioner determined if the neonate was to be hyperventilated, and two respondents (10%) indicated either the registered nurse or physician/neonatal nurse practitioner determined the need to hyperoxygenate the neonate. Eighteen respondents (86%) indicated the neonate's needs determined the percentage for the fraction of inspired oxygen (FiO_2) to be increased. One respondent (5%) indicated the FiO_2 was always increased to 1.0, one respondent (5%) indicated the FiO2 was increased by 30%, and one respondent (5%) indicated the increase was based upon the neonates set ventilatory rate.

Hyperoxygenation was applied before, during, and after the neonatal suctioning process. Eighteen respondents (86%) indicated the use of hyperoxygenation prior to the suctioning procedure. Fifteen respondents (71%) indicated hyperoxygenation was applied between suction passes. Fourteen respondents (67%) indicated hyperoxygenation was applied after the suctioning procedure. Thirteen respondents (62%) indicated Hyperoxygenation was performed with either a manual resuscitation bag or the ventilator, with seven respondents (33%) indicating hyperoxygenation was applied with the ventilator only (Table 5). Independent samples *t* - tests did not reveal significant differences (*p* # .05) between nursing education, years of nursing experience, or NICU experience of RNs.

Hyperventilation of Neonates

Twenty respondents (95%) indicated that hyperventilation was sometimes provided to the neonate before, during, or after the suctioning procedure. As with the use of hyperoxygenation, several factors were listed as affecting the use of hyperoxygenation during the suctioning procedure. The most commonly listed reason to hyperventilate was the neonates past response to suctioning. Seventeen respondents (81%) provided this response as a reason to hyperventilate the neonate. Fifteen respondents (71%) indicated the neonate’s current physical appearance was an indication to hyperventilate the neonate. Fifteen respondents (71%) indicated the neonate’s current physiological status was used as a basis to determine the need for hyperventilation. Fourteen respondents (67%) indicated that hyperventilation was used if the neonate demonstrated a decreased SaO_2 or $TcPO_2$ during the suctioning process. Four respondents (19%) indicated the decision to hyperventilate was based upon the latest PaO_2 value. One respondent (5%) indicated providing hyperventilation to the neonate at risk for persistent pulmonary hypertension of the newborn (PPHN).

Thirteen respondents (62%) indicated the registered nurse made the decision to hyperventilate. Two respondents (10%) indicated the attending physician or neonatal nurse practitioner determined if the neonate was to be hyperventilated, and four respondents (19%) indicated either the registered nurse or physician/neonatal nurse practitioner made the determination to hyperventilate the neonate. Seventeen respondents (81%) indicated the neonate’s needs determined the increase in the ventilatory rate. Two respondents (10%) indicated always increasing the ventilatory rate by 10 breaths per minute.

Hyperventilation was applied before, during, and after the suctioning process. Eighteen respondents (86%) indicated use of hyperventilation prior to the suctioning procedure. Fourteen respondents (67%) indicated hyperventilation was applied between suction passes. Fourteen respondents (67%) indicated hyperventilation was applied after the suctioning procedure. Fifteen respondents (71%) indicated that hyperventilation was performed with either a manual resuscitation bag or the ventilator, with five respondents (24%) indicating hyperventilation was applied with the ventilator only (Table 6). Independent samples *t* - tests did not reveal significant differences (*p* # .05) between nursing education, years of nursing experience, or NICU experience of RNs.

Hyperinflation of the Neonate

Nineteen respondents (90%) indicated that hyperinflation was sometimes provided to the neonate before, during, or after the suctioning procedure. Thirteen respondents (62%) indicated hyperinflation was applied with either the ventilator or manual resuscitation bag, five respondents (24%) indicated hyperinflating by increasing the pressure setting on the ventilator, and one respondent (5%) indicated providing hyperinflation with a manual resuscitation bag with in-line pressure manometer only.

Nine respondents (43%) indicated the registered nurse made the decision to hyperinfilate. Three respondents (14%) indicated the attending physician or neonatal nurse practitioner determined if the neonate was to be hyperinfilated, and six respondents (29%) indicated either the registered nurse or physician/neonatal nurse practitioner made the determination to hyperinfilate the neonate.

Hyperinflation was applied before, during, and after the suctioning process. Six respondents (29%) indicated use of hyperinflation prior to the suctioning procedure. Thirteen respondents (62%) indicated hyperinflation was applied between suction passes. Ten respondents (48%) indicated hyperinflation was applied after the suctioning procedure. Sixteen respondents (76%) indicated an increase in ventilatory pressure was determined based upon the neonate's needs, and two respondents (10%) indicated the ventilatory pressure was always increased by 10 millimeters of mercury (mmHg) (Table 7). Independent samples *t* - tests did not reveal significant differences (*p* # .05) between nursing education, years of nursing experience, or NICU experience of RNs.

Miscellaneous Nursing Actions Related to the Suctioning Procedure

The frequency of neonatal suctioning procedure varied from two to four hours. The most common response to how frequently the neonate was suctioned was four hours. Eighteen respondents (86%) indicated providing suction every four hours. Other responses to how frequently the neonate was suctioned were every three hours (n = 7, 33%) and every two hours (n = 2, 10%).

Several factors affected the frequency of the suction procedure. Twenty respondents (95%) indicated the amount of secretions affected the frequency of the suctioning process; whereas, 18 respondents (86%) indicated the consistency of the secretions would affect the frequency of the suctioning procedure. Other factors that were identified as having an affect on the suction frequency were the neonate's tolerance of the procedure (*n* = 14, 67%) and the current TcPO2 or SaO2 value (*n* = 4, 19%). Only two respondents (10%) indicated breath sounds as a factor affecting the frequency of the suctioning procedure.

Although only two respondents (10%) provided breath sounds as a factor affecting the frequency of the suctioning process, twenty respondents (95%) indicated evaluating the neonate's breath sounds on a regular basis. Eighteen respondents (90%) indicated evaluating the neonate's breath sounds every two hours. Four respondents (20%) indicated evaluating breath sounds every hour, and four respondents (20%) indicated evaluating breath sounds with every care. Two respondents each (10%) indicated breath sounds were evaluated every three hours and every four hours, respectively.

Twenty respondents (95%) indicated the suctioning procedure was performed with only one registered nurse. Two respondents (10%) indicated PEEP bags were routinely used. Thirteen respondents (62%) indicated performing the suctioning procedure with between -80 millimeters of mercury (mmHg) and -120 mmHg. Four respondents (19%) indicated performing the suction procedure with between -50 to -80 mmHg, with one of these four respondents also indicating using less than -50 mmHg. Seventeen respondents (81%) indicated applying continuous negative pressure during the suctioning procedure. One respondent (5%) indicated using intermittent negative pressure, and one respondent (5%) indicated using both continuous and intermittent negative pressure, depending upon whether an in-line adapter was used or the neonate was removed from the ventilator and a suction catheter passed.

The approximate length of time that negative pressure was applied also varied. Nine respondents (43%) indicated applying negative pressure for less than three seconds. Six respondents (26%) indicated applying negative pressure for three to five seconds, and two respondents (10%) indicated applying negative pressure for five to ten seconds (Table 8). Independent samples *t* - tests did not reveal significant differences (*p* # .05) between nursing education, years of nursing experience, or NICU experience of RNs.

Irrigant Instillation

Nineteen respondents (90%) indicated use of an irrigant during the suction procedure. Thirteen respondents (62%) indicated using either normal saline or sterile water as an irrigant. Four respondents (19%) who indicated using sterile water commented that it was used in the instance of a pulmonary bleed. Six respondents (29%) indicated using only sterile saline. Thirteen respondents (62%) indicated using 0.2 mL of irrigant. Five respondents (24%) indicated using 0.3 mL of irrigant, and one respondent each indicated using 0.1 mL, 0.4 mL, 0.5 mL, and greater than 0.5 mL or irrigant. Seventeen respondents (81%) indicated using an in-line adapter to instill the irrigant, and one respondent (5%) indicated using both an in-line adapter or removing the neonate from the ventilator (Table 9). Independent samples *t* - tests did not reveal any significant differences (*p* # .05) between nursing education, years of nursing experience, or NICU experience of RNs.

Limitations

A major limitation of this study was the use of a convenience sample of registered nurses. Study participants were recruited from a 30 bed NICU located at a teaching hospital within the Eastern United States. For this reason, the results are indicative of the practice patterns for that facility only. The results of this study may not reflect the results obtained in either a smaller urban hospital setting or a NICU located in a more rural setting, or a multi-hospital setting.

The nursing staff received the survey packet from either the nurse manager or her designated representative. This might have implied an interest by the nurse manager, and this interest might have led to a response bias by the nursing staff. Additionally, a small number of respondents indicated one or two questions were not clearly written. If the study investigator had been present to provide additional clarification, a greater number of surveys might have been completed and returned by the staff.

Implications for Practice

The registered nurse caring for the neonate with an artificial airway is responsible for providing well-timed, safe, and effective suctioning in order to maintain a patent airway. In order to perform safe and effective suctioning, the registered nurse must be utilizing a technique that is based upon current research. Additionally, the mechanical suctioning intervention should only be applied on an as needed basis, rather than on a regularly scheduled basis scheduled (Clark, 1995; Day, 2000; Place & Fell, 1998). Benner (1984) stated that as the practitioner advances from the novice to the expert stage, they rely less on a set of rules and are able to synthesize all data that pertain to the situation. As the registered nurse is better able to integrate these data, they are more likely to apply the suctioning intervention on an as-needed basis.

Based upon responses provided, it appears the majority of NICU nurses are providing mechanical suctioning on a routine, scheduled basis.

All infants should be hyperoxygenated and hypervenitlated prior to suctioning. Further research is required to determine the optimum increase in both FiO_2 and ventilatory rate for NICU infants during suctioning.

Hyperinflation, if used, must be used with extreme caution and limited to no more than a 20% increase in ventilatory pressure from baseline (Hodge, 1991). Nineteen respondents indicated the use of hyperinflation. The total increase in the ventilatory pressure was indicated, however this increase was listed as an increase in mmHg and not a percentage. The use of an irrigant such as normal saline or sterile water should not be included within the suctioning procedure.

Recommendations for Future Research

This study was conducted using the registered nursing staff assigned to a 30 bed NICU located within a moderate size community academic-teaching hospital. These results were only indicative of local nursing practice. In order to more effectively determine the registered nurses' practice patterns related to their suctioning practice of the neonate with an artificial airway, this study should be replicated on a larger scale. Study participants should be recruited from as many hospitals as possible. Additionally, these hospitals should be not only be of various sizes, but should be selected to cover a wider range of hospital types such as suburban, rural, and teaching facilities so that comparisons can be made. The results obtained from an expanded survey would provide a much better understanding of the registered nurses' knowledge level and practice patterns related to suctioning practices of the neonate with an artificial airway.

The results of this study revealed the techniques of hyperoxygenation, hyperventilation, and hyperinflation were widely used by NICU nurses. Further research is needed to address the following research questions.

1. What is the optimal increase in FiO_2 when providing hyperoxygenation before, during, or after the suctioning procedure?
2. What is the optimal increase in ventilatory rate when providing hyperventilation before, during, or after the suctioning procedure?
3. What is the optimal increase in ventilatory pressure when providing hyperventilation before, during, or after the suctioning procedure?
4. When are hyperoxygenation, hyperventilation, and/or hyperinflation most optimally performed before, during, or after the suctioning procedure?
5. What is the effect of hyperoxygenation, hyperventilation, and/or hyperinflation on either the $TcPO_2$ or SaO_2 before, during, and after the suctioning procedure?
6. Does the instillation of an irrigant aid in the removal of secretions during the suctioning process?
7. Does the instillation of an irrigant during suctioning affect either the $TcPO_2$ or SaO_2 before, during, and/or after the suctioning procedure?

Conclusions

Results of this study indicated that a wide range of interventions were performed prior to the suctioning procedure. Nineteen respondents (90%) indicated providing suction through the use of an in-line adapter, and twenty one respondents (100%) indicated they also removed the neonate from the ventilator to perform the suctioning procedure. The majority of respondents reported making at least two suction passes (n = 19, 90% if suctioned on ventilator, n = 10, 48% if removed from ventilator).

Eighteen respondents (86%) indicated hyperoxygenating prior to suctioning. No respondents indicated performing either hyperventilation or hyperinflation prior to suctioning. Hyperoxygenation and hyperventilation were both identified as being sometimes applied before, during, or after the suction procedure by 20 nurses (95%). One study involving pediatric patients (Feaster, et al., 1985) and two studies involving adult, post cardiac surgery patients (Copnell & Fergussen, 1995; and Goodnough, 1985) have reported the benefits associated with both hyperoxygenation and hyperventilation before, during, and after the suctioning procedure.

Nineteen respondents (90%) indicated hyperinflation was sometimes applied before, during, or after the suctioning procedure. The use of this intervention can be a cause for concern as hyperinflation has been identified as a possible cause of pneumothorax in the neonatal patient (Knox, 1993).

Nineteen respondents (90%) indicated use of an irrigant during the suctioning procedure, with only one respondent (5%) indicating the use of hyperventilation after irrigant instillation. This trend is also cause for concern because previous studies have demonstrated the use of normal saline instillation is not effective in thinning or removal of secretions (Raymond, 1995; Demers & Saklad, 1973). Further research is needed to determine safe and effective guidelines for suctioning the neonatal patient. The findings of this study support this need and provide research questions for future studies.

References

AARC clinical practice guideline. Endotracheal suctioning of mechanically ventilated adults and children with artificial airways. American Association for Respiratory Care. (1993). *Respiratory Care, 38,* (5), 500-504

Ackerman, M. H., Ecklund, M. M., & Abu-Jumah, M. (1996). A review of normal saline instillation: Implications for practice. *Dimensions of Critical Care Nursing, 15,* (1), 31-38

Benner, P. (1984). *From novice to expert. Excellence and power in clinical nursing practice.* Menlo Park, CA: Addison-Wesley.

Buglass, E. (1999). Tracheostomy care: Tracheal suctioning and humidification. *British Journal of Nursing, 8,* (8), 500-504

Chulay, M. (1988). Arterial blood gas changes with a hyperinflation and hyperoxygenation suctioning intervention in critically ill patients. *Heart and Lung, 17*, 654-660

Clarke, L. (1995). A critical event in tracheostomy care. *British Journal of Nursing, 4,* (12), 676, 678-681

Copnell, B., & Fergusson, D. (1995). Endotracheal suctioning: Time-worn ritual or timely intervention? *American Journal of Critical Care, 4,* (2), 100-105

Cordero, L., Sananes, M., & Ayers, L. W. (2000). Comparison of a closed (Trach Care MAC) with an open endotracheal suction system in small premature infants. *Journal of Perinatology, 20,* (3), 151-156

Creamer, E., & Smyth, E. G. (1996). Suction apparatus and the suctioning procedure: Reducing the infection risks. *Journal of Hospital Infection, 34,* (1), 1-9

Day, T. (2000). Tracheal suctioning: When, why, and how. *Nursing Times, 86,* (20), 13-15

Deacon, J., & O'Neill, P. (Eds.) (1999). *Core curriculum for neonatal intensive care nursing.* Philadelphia: W. B. Saunders.

Demers, R. R., & Saklad, M. (1973). Minimizing the harmful effects of mechanical aspiration. *Heart and Lung, 2,* (4), 542-545

Druding, M. C. (1997). Re-examining the practice of normal saline instillation prior to suctioning. *Medsurg Nursing, 6,* (4), 209-212

Feaster, S. C., West, S., & Ferketich, S. (1985). Hyperinflation, hyperventilation, and hyperoxygnation before tracheal suctioning in children requiring long term respiratory care. *Heart and Lung, 14,* 379-384

Glass, C. A., & Grapp, M. J. (1995). Ten tips for safer suctioning. *American Journal of Nursing, 95,* (5), 51-53

Griggs, A. (1998). Tracheostomy: Suctioning and humidification. *Nursing Standard, 13,* (2), 49-56

Goodnaugh, S. (1985). The effects of oxygen and hyperinflation on arterial oxygen tension after endotracheal suctioning. *Heart and Lung, 14*, 11-17

Hagler, D. A., & Traver, G. A. (1994). Endotracheal saline and suction catheters: Sources for lower airway contamination. *American Journal of Critical Care, 3,* (6), 444-447

Hess, D. R. (1999). Managing the artificial airway…Journal Conference on Artificial Airways, part II. *Respiratory Care, 44,* 759-776

Hodge, D. (1991). Endotracheal suctioning and the infant: A nursing care protocol to decrease complications. *Neonatal Network, 9,* (5), 7-15

Knox, A. M. (1993). Performing endotracheal suction on children: A literature review and implications for nursing practice. *Intensive and Critical Care Nursing, 9,* (1), 48-54

McEleney, M. (1998). Endotracheal suction. *Professional Nurse, 13,* (6), 373-376

Mitre, J. C., Alexander, J. E., & Keller, S. L. (1998). Patricia Benner. From novice to expert: Excellence and power in clinical nursing practice. In A. M. Tomey & M. R. Alligood (Eds.), *Nursing theorists and their work* (4^{th} ed), (pp. 157-172). St Baltimore, MD: Mosby.

Place, B., & Fell, H. (1998). Clearing tracheobronchial secretions using suction. *Nursing Times, 94,* (47) 54-56

Raymond, S. J. (1995). Normal saline instillation before suction: Helpful or harmful? A review of the literature. *American Journal of Critical Care, 4,* (4), 267-271

Shorten, D. R. (1989). Effects of tracheal suctioning on neonates: A review of the literature. *Intensive Care Nursing, 5,* (4), 167-170

Simmons, C. L. (1997). How frequently should endotracheal suctioning be undertaken? *American Journal of Critical Care, 6,* (1), 4-6

Soles, M. L., Poalillo, F. E., Byers, J. F., & Ludy, J. L. (2002). Bacterial growth in secretions and on suctioning equipment of orally intubated patients: A pilot study. *American Journal of Critical Care, 11*, (2), 141-149

Stone, K. S., & Turner, B. (1989). Endotracheal suctioning. *Annual Review of Nursing Research, 7,* 27-49

Swartz, K., Noonan, D. M., & Edwards-Beckett, J. (1996). A national survey of endotracheal suctioning techniques in the pediatric population. *Heart and Lung, 25,* (1), 52-60.

Thomas, C. L. (1985). *Taber's Cyclopedic Medical Dictionary* (5th ed.). Philadelphia, PA: F. A. Davis

Tolles, C. L., & Stone, K. S. (1990). National survey of neonatal endotracheal suctioning practice. *Neonatal Network, 9,* (2), 7-14

Wrightson, D. D. (1999). Suctioning smarter: Answers to eight common questions about endotracheal suctioning in neonates. *Neonatal Network, 18,* (1), 51-55

Table 1
Demographic Data (*N* = 21)

Variable:	Frequency (*f*)	Percentage (%)
Neonatal ICU Experience		
Less than two years	2	10
Two to five years	2	10
Five to eight years	4	19.0
Eight to ten years	1	5
Ten or more years	12	57
Years Experience as an RN		
Less than two years	1	5
Two to five years	2	10
Five to eight years	0	0
Eight to ten years	5	24
Ten or more years	13	62
Nursing Education		
Diploma	5	24
Associates	10	48
Baccalaureate	5	24
Masters	1	5
Other	0	0
Total NICU Beds		
29	14	67
30	7	33
Average Daily Ventilated Neonates		
Less than 10	21	100

Table 2
Nursing Actions Performed Before the Suctioning Procedure (*N* = 21)

Variable:	Frequency (*f*)	Percentage (%)
Prior to suctioning I perform the following		
Postural drainage and/or percussions and vibrations	20	95
Reposition the neonate	17	81
Draw lab work. If so do you use:		
Arterial line	1	5
Heel stick		
Both	8	38
Perform aerosol treatment	3	14
Hyperoxygenate the neonate	18	86
Hyperventilate the neonate	0	0
Hyperinflate the neonate	0	0
Install irrigant into the artificial airway	17	81
Hyperventilate after instillation irrigant	1	5

Table 3
Nursing Actions Performed During the Suctioning Procedure (*N* = 21)

Variable:	Frequency (*f*)	Percentage (%)
If I suction with an in-line adapter I perform the following		
Make first suction pass	18	86
Hyperventilate after suction pass	3	14
Hyperoxygenate after suction pass	13	62
Hyperinflate after suction pass	0	0
Rotate the neonate's head	4	19
Make second suction pass	19	90
Make third suction pass	6	29
If I disconnect the patient from ventilator to suction I perform the following		
Disconnect the neonate from the ventilator	11	52
Make first suction pass	12	57
Return neonate to ventilator and		
Hyperventilate	4	19
Hyperoxygenate	11	52
Hyperinflate	1	5
Bag infant with bagging device and		
Hyperventilate	5	24
Hyperoxygenate	6	29
Hyperinflate	0	0
Rotate the neonates head	2	10
Make second suction pass	10	48
Make third suction pass	3	14

Table 4
Actions Performed After the Suctioning Procedure (*N* = 21)

Variable:	Frequency (*f*)	Percentage (%)
After the last suction pass I do the following		
Bag before returning to the vent and:		
Hyperventilate	2	10
Hyperoxygenate	5	24
Hyperinflate	0	0
Return to ventilator at pre-suction settings	16	76
Return neonate to ventilator and:		
Hyperventilate	1	5
Hyperoxygenate	8	38
Hyperinflate	0	0
Oropharyngeal suction	16	76
Vital signs	7	33
Draw lab work. If so do you use:		
Arterial line	0	0
Heel stick	0	0
Both	1	5
Reposition infant	14	67
Gavage feed	13	62

Table 5
Hyperoxygenation (*N* = 21)

Variable:	Frequency (*f*)	Percentage (%)
If supplemental oxygen is only sometimes used, what determines when the neonate will be hyperoxygenated:	20	95
Latest PaO_2 value	5	24
Neonates past response to suctioning	19	90
Current appearance of the neonate	18	86
General physiological status of neonate	15	71
Decreased SaO_2 or $TcPO_2$	16	76
Other	0	0
Who makes the decision to hyperoxygenate the neonate?		
Registered nurse	20	95
Physician/Neonatal Nurse Practictioner	3	14
If supplemental oxygen is administered, by what percentage is the oxygen increased		
Always by 3%	0	0
Always by 5%	0	0
Always by 10%	0	0
Always by 20%	0	0
Always increased to 100%	2	10
Other	1	5
Varies depending upon neonates needs	18	86
If supplemental oxygen is sometimes used, when is it administered (Choose all that apply)?		
Prior to suctioning	18	86
Between suctioning passes	15	71
After suctioning	14	67
If supplemental oxygen is sometimes used, how is it administered (Choose all that apply)?		
By ventilator	7	33
By manual resuscitation bag	0	0
Both	13	62

Table 6
Hyperventilation (*N* = 21)

Variable:	Frequency (*f*)	Percentage (%)
If hyperventilation is only sometimes used, what determines when the neonate will be hyperventilated:		
Latest PaO_2 value	4	19
Neonates past response to suctioning	17	81
Current appearance of the neonate	15	71
General physiological status of neonate	15	71
Decreased SaO_2 or $TcPO_2$	14	67
Other	1	5
Who makes the decision to hyperoxygenate the neonate?		
Registered nurse	18	86
Physician/Neonatal Nurse Practictioner	6	29
If hyperventilation is administered, by what amount is the ventilatory rate increased		
Always by 3 breaths per minute	0	0
Always by 5 breaths per minute	0	0
Always by 10 breaths per minute	2	10
Other	17	81
Varies depending upon neonates needs		
If hyperventilation is sometimes used, when is it administered?		
Prior to suctioning	14	67
Between suctioning passes	17	81
After suctioning	14	67
If supplemental oxygen is sometimes used, how is it administered (Choose all that apply)?		
By ventilator	5	24
By manual resuscitation bag	0	0
Both	15	71

Table 7
Hyperinflation (*N* = 21)

Variable:	Frequency (*f*)	Percentage (%)
If increased pressure is sometimes uses, how is it administered?		
Increasing pressure setting on ventilator	5	24
By manual resuscitation bag	1	5
Both	13	62
Who makes the decision to hyperinflate		
Registered nurse	15	71
Physician/Neonatal Nurse Practitioner	9	43
If hyperinflation is administered, by what amount of additional breaths per minute is the ventilatory pressure increased (Choose one)?		
Always by 3 mmHg	0	0
Always by 5 mmHg	0	0
Always by 10 mmHg	2	10
Other	1	5
Varies depending upon neonates needs	16	76
If hyperinflation is sometimes used, when is it administered?		
Prior to suctioning	6	29
Between suctioning passes	13	62
After suctioning	10	48

Table 8
Miscellaneous Information Related to the Suctioning Procedure (*N* = 21)

Variable:	Frequency (*f*)	Percentage (%)
How often are neonates routinely suctioned?		
Every 2 hours	2	10
Every 3 hours	7	33
Every 4 hours	18	86
What variables affect the suction frequency		
Amount of secretions	20	95
Consistency of secretions	18	86
Neonate's tolerance of procedure	14	67
$TcPO_2$ Value	4	19
Other	3	14
On average, how often are an intubated neonate's breath sounds?		
Every hour	4	19
Every 2 hours	18	86
Every 3 hours	2	10
Every 4 hours	2	10
With every care	4	19
How many persons are used to suction?		
One person	20	95
Does your unit routinely use PEEP bags?		
Yes	2	10
No	18	86
How long is negative pressure applied?		
Less than 3 seconds	9	43
Three to five seconds	6	29
Five to ten seconds	2	10
As you suction, do you apply:		
Continuous negative pressure	18	86
Intermittent negative pressure	2	10
How much negative pressure is applied		
Less then –50 mmHg	1	5
Between –50 to –80 mmHg	4	19
Between –80 to –120 mmHg	13	62

Table 9
Irrigant Instillation (*N* = 21)

Variable:	Frequency (*f*)	Percentage (%)
Do you instill an irrigant during the suctioning procedure?		
No	2	10
Yes	19	90
What type of irrigant do you instill prior to performing the suctioning procedure		
0.9% normal saline	19	90
Sterile water	13	62
How much irrigant is instilled?		
0.1 ml	1	5
0.2 ml	13	62
0.3 ml	5	24
0.4 ml	1	5
0.5 ml	1	5
Greater than 0.5 ml	1	5
Is the irrigant instilled by removing the neonate from the ventilator or through the use of an inline adapter?		
Removing from the ventilator	1	5
In-line suction adapter	18	86