Cardiovascular Changes During Open Suctioning Technique for Patients under Intermittent Positive Pressure Ventilation

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Abstract

A descriptive study was conducted on purposive sample of 50 patients (32 males and 18 females) were between 21 - 70 years of age from October 2011 to April 2012 in the respiratory care unit at Al - Kadhimia Teaching Hospitals and Al- Shaheed Ghazi Teaching Hospital in Baghdad city to identify the cardiovascular changes during open suctioning technique for patients under intermittent positive pressure ventilation. Check-list type was developed and the data were collected by interview method, review of patients' records and observation the patients monitors. The criteria for diagnosis of cases depended on the medical decision by the physician.

The results showed that during endotracheal suctioning (ETS) the mean values of heart rate (HR) and blood pressure (BP)were increased from the baseline while the oxygen saturation (SPO_2) as indicated by pulse oximeter was decreased. The changes in the variables of the study in regarded to the males were 26%, 12%, and -18 changes from baseline respectively while in females the changes from baseline were 21% ,2% , and -18%.The males were more affected than females in regard to HR and BP while in SPO_2, the results stayed the same in both sex. After 2-3 minutes of ending the suctioning procedure all the values gradually returned to baseline over the next 7 minutes.

During ETS the mean value of HR increased from a baseline in relation to duration (1- 10, 11-15 and >15 seconds) of ETS .17%, 20% and 33% changes from baseline respectively. Also, in BP the changes from baseline were 3%, 11% and 9% while the mean value of the SPO_2 as indicated by pulse oximeter was decreased from a baseline. -10%,-17%, and -20% changes from baseline respectively. The total mean value was increased in HR (24%) and BP (8%) while decreased in SPO_2 (18%). ETS resulted in an increase in HR and BP while the SPO_2 decreased when there an increase in the duration of suctioning. The results also, showed that 68% of the patients were on appropriate size of the ETT in relation to outer diameter (OD) of the suction catheter while, 32% weren't. 35% (12 out of 34) of the patients who were on appropriate size lasted more than 15 second of suctioning duration while there was 81% (13 out of 16) in the same duration were on inappropriate size. The present study recommended that duration of 10-15 seconds is advocated as the longer the duration of each suctioning event the greater the risk of increasing HR and BP, and decreasing of SPO_2. Selection of appropriately sized suction catheter for a given tube inner lumen diameter is also important to avoid complications during the suctioning procedure. Further studies are recommended to perform on comparison of closed endotracheal suction versus open endotracheal suction on mechanically ventilated patients.

الخلاصة

أجريت دراسة وصفية على عينة مقصودة من ٥٠ مريضا (٣٢ من الذكور و ١٨ من الإناث) ما بين ٢١-٧٠ سنة من العمر للفترة من أكتوبر ٢٠١١ إلى أبريل ٢٠١٢ في وحدة العناية التنفسية في مستشفى الكاظمية التعليمي و مستشفى الشهيد غازي التعليمي في مدينة بغداد لتحديد التغيرات قيد الدراسة التي تحدث في القلب والأوعية الدموية خلال نظام الشفط المفتوح للأنبوب ألرغامي لمرضى التهوية الميكانيكية. تم تصميم استمارة استبيانيه تشمل البيانات المتعلقة بالدراسة عن طريق أسلوب المقابلة ومراجعة سجلات المرضى ورصد التغيرات التي تحصل من خلال شاشات أجهزة مراقبة المرضى.

أظهرت النتائج الدراسة أنه خلال عملية شفط (سحب) الإفرازات من الشعب القصبية عن طريق الأنبوب الرغامي زاد متوسط قيم ضربات القلب وضغط الدم في حين انخفض متوسط تشبع الأكسجين عن خط الأساس كما تبين من خلال جهاز Pulse oximeter

و بعد ٢-٣ دقائق من نهاية عملية الشفط فان جميع التغيرات في القيم للمتغيرات أعلاه قد عادة تدريجيا إلى خط الأساس خلال الدقائق السبعة التي تلت عملية الشفط وكانت نسب التغيرات عن خط الأساس للمتغيرات التي شملتها الدراسة في الذكور % ٢٦ و % ١٢ و % 18 – على التوالي في حين كانت في الإناث %٢١ و %٢ و % 18- وكانوا الذكور أكثر تأثرا من الإناث فيما يتعلق بمعدل ضربات القلب وضغط الدم في حين كان تشبع الأوكسجين نفسه في كلا الجنسين. زاد متوسط القيم ضربات القلب وضغط الدم عن خط الأساس بالنسبة للفترة التي استغرقتها عملية سحب الإفرازات والتي كانت من ١- ١٠ و ١١- ١٥ وأكثر من ١٥ ثانية وكانت نسب التغيرات بما يخص ضربات القلب بحدود ١٧% و 20% و % ٣٣ من التغييرات الأساسية على التوالي في حين بلغت التغييرات من خط الأساس بالنسبة لضغط الدم % 3 و % 11 و % ٩ على التوالي. بينما انخفض متوسط قيم تشبع الأوكسجين عن خط الأساس بنسبة % ١٠ و % 17 و % ٢٠ على التوالي. وزاد متوسط القيم الإجمالية لمعدل ضربات القلب (24%)وضغط الدم (8%) عن خط الأساس في حين انخفض متوسط القيم الإجمالية لنسبة تشبع الأوكسجين (18%). شفط الإفرازات من الشعب القصبية يؤدي إلى زيادة في معدل ضربات القلب وضغط الدم وانخفاض نسبة تشبع الأوكسجين كلما كان هناك زيادة في مدة الشفط. وتنصح الدراسة الحالية بان لا تزيد عملية شفط الإفرازات عن ١٠-١٥ ثانية لما لها من آثار ضارة على المرضى حيث إن نظام الشفط المفتوح للأنبوب الرغامي لمرضى التهوية الميكانيكية البالغين له آثاره السلبية على معدل ضربات القلب وضغط الدم وتشبع الأكسجين واختيار الحجم المناسب لأنبوب شفط الافرازات لتجنب الاختلاطات خلال عملية الشفط. ويوصى الباحث بتنفيذ دراسة مقارنة ما بين نظام الشفط المفتوح و نظام الشفط والمغلق للأنبوب الرغامي لمرضى التهوية الميكانيكية.

Introduction

Mechanical ventilators are being used for some patient in intensive care units (ICUs) due to various physiological and clinical causes. Keeping endotracheal tube (ETT) clean and open is necessary in order to improve the patient oxygenation [1]. Endotracheal suctioning (ETS) is common invasive nursing procedure performed in the routine management of the critically ill patients with artificial airways.Hemodynamic parameters changes during and after the procedure. If appropriate strategies do not be applied during the ETS, Hemodynamic changes can be significant and life threateing in critically ill patients [2] .The most frequent procedure for suctioning consists of disconnection from mechanical ventilation, followed by insertion of a suction catheter into the trachea while negative pressure is generated. Disconnection itself results in an airway pressure drop and loss of lung volume, but a further volume decrease is observed during suctioning due to the generation of negative pressure in the airway [3] .The procedure includes patient preparation, the suctioning event, and follow-up care [4,5] . Appropriate management of the patient with an artificial airway can have an impact on reducing complications, length of stay and mortality and morbidity. It has a number of potential risks that may lead to complications including hypoxia, cardiac dysrhythmias ,mucosal damage and causes stress to patients, which may alter their haemodynamic status. Correct technique and preparation by the clinician can assist in reducing the risks of adverse events and reduce the level of discomfort for the patient. Although considered a routine procedure, suctioning should be carried out on the basis of clinical need and may vary among different diagnostic groups [6] .The first reports on the serious side-effects of ETS came from thoracic surgeons, probably because they were the first to use positive pressure ventilation, suction and oxygen saturation monitoring on a routine basis during anesthesia. In 1948 in the Journal of Thoracic Surgery, Kergin *et al* [7] presented a number of patients undergoing thoracotomy and stated that the sudden profound fall in arterial oxygen saturation associated with bronchial

suction is probably due not only to sucking out oxygen, but also to a temporary increase in the atelectasis by negative intra-bronchial pressure. Our anesthetists now watch the oximeter and apply positive pressure as indicated. In the beginning of the described cardiac and student deaths during tracheal suctioning was thought to be caused by respiratory tract reflexes. As better was of monitoring oxygen saturation (SPO_2), blood pressure (BP) variation and lung volumes were developed the circulatory and respiratory side-effects of suctioning could be observed. It became obvious that the suctioning induced lung collapse was the primary reason for these cardio-pulmonary effects [7]. Although the need for intensive care has often been defined by the need for ventilation, and there are literally thousands of publications on techniques, principles, complications, and challenges of ventilation, there is a surprising lack of evidence for best practice regarding a fundamental technique in ventilation: suctioning of the airway. Since tracheostomy or endotracheal intubation (ETI) was first undertaken, potential obstruction of the (ETT) by mucus has been a consistent and life-threatening problem [8]. The primary purpose of ETS is to remove secretions and prevent airway obstruction, thereby aiming to prevent atelectasis whilst optimising oxygenation and ventilation and decreasing the work of breathing. A number of studies suggest that lung compliance drops following suctioning. Animal studies have shown a drop in static lung compliance following suctioning [9].The present study aimed to identify the cardiovascular changes during open suctioning (OS) technique for patients under intermittent positive pressure ventilation (IPPV).

Materials and Methods

A descriptive study was conducted on purposive sample of 50 patients (32 males and 18 females) were between 21 - 70 years of age from October 2011 to April 2012 in the respiratory care unit at Al - Kadhimia Teaching Hospitals and Al- Shaheed Ghazi Teaching Hospital in Baghdad city to identify the cardiovascular changes during open suctioning (OS) technique for patients under intermittent positive pressure ventilation (IPPV). Check-list type was developed and the data were collected by interview method, review of patients' records and observation the patients' monitors .The criteria for diagnosis of cases depended on the medical decision by the physician. The simple way to calculate the patients mean arterial pressure is to use the following formula: MAP = [(2 x diastolic) + systolic] divided by 3 [10].

Results

The results as showed in table (1) that 64 % of the patients were males and 36% were females and they were between 21 - 70 years of age. 48% of the patents were between 21-30 years of age.

Table 1 Disruption of the sample by age and gender.

Gender / Age groups	Males		Females		Total	
	No.	%	No.	%	No.	%
21-30	14	**28**	10	**20**	24	**48**
31-40	7	14	1	2	8	16
41-50	5	10	2	4	7	14
51-60	3	6	2	4	5	10
61-70	3	6	3	6	6	12
Total	32	**64**	18	**36**	50	**100**

The results as showed in table (2) that during endotracheal suctioning (ETS) the mean values of heart rate (HR) and blood pressure (BP) were increased from the baseline while the oxygen saturation (SPO_2) as indicated by pulse oximeter was decreased. In males, 26%, 12% and -18% changes from baseline respectively. In females, the changes from baseline were 21%, 2% and -18%. The males were more affected than females in regard to HR and BP while in SPO_2, the results stayed the same in both sex. After 2-3 minutes of ending the suctioning procedure all the values gradually returned to baseline over the next 7 minutes.

Table 2 Cardiovascular changes during ETS periods in relation to gender.

Gender	Cardiovascular changes								
	HR			BP			SPO_2%		
	before	**during**	after	before	**during**	after	before	**during**	after
Males	107 *	135 **(26%) ***	104	98	110 **(12%)**	97	97	80 **(-18%)**	98
Females	113	137 **(21%)**	112	100	102 **(2%)**	97	96	79 **(-18%)**	96
Total mean value	110	136 **(24%)**	108	99	107 **(8%)**	97	97	80 **(-18%)**	98

***** Mean value.

***** Percentage of the changes from baseline.

The results as showed in table (3) that during endotracheal suctioning the mean value of HR increased from a baseline in relation to duration (1- 10, 11-15 and >15 seconds) of endotracheal suctioning . 17%, 20% and 33% changes from baseline respectively. Also, in BP the changes from baseline were 3%, 11%, and 9%.While the mean value of the oxygen saturation (SPO_2) as indicated by pulse oximeter was decreased. -10%,-17% and -20% changes from baseline respectively. The total mean value was increased in HR (24%) and BP (8%) while decreased in SPO_2 (-18). After 2-3 minutes of ending the suctioning procedure all the values gradually returned to baseline over the next 7 minutes.

Table 3 Cardiovascular changes (HR, BP, SPO_2) in relation to duration of endotracheal suctioning.

Duration			Cardiovascular changes								
			HR			BP			SPO_2		
Second	No.	%	before	during	after	before	during	after	before	during	after
1-10	10	20	110 *	129 (17%) *	108	104	107 (3%)	105	98	88 (-10%)	98
11-15	15	30	112	134 (20%)	109	95	105 (11%)	93	98	81 (-17%)	97
>15	25	50	109	145	108	98	107	94	96	77	96
Total	50	100		(33%)			(9%)			(-20%)	
Total mean value			110	136 (24%)	108	99	107 (8%)	97	97	80 (-18%)	98

***** Mean value.
***** Percentage of the changes from baseline.

The results as showed in table (4) that 68% of the patients were on appropriate size of the ETT in relation to outer diameter (OD) of the suction catheter while, 32% weren't. 35% of the patients who were on appropriate size lasted more than 15 seconds of suctioning duration while there was 81% in the same duration were on inappropriate size.

Table 4 Duration of endotracheal suctioning in relation to size of the ETT / outer diameter of the suction catheter.

Duration	Appropriate		Inappropriate		Total	
Second	No.	%	No.	%	No.	%
1-10	10	30	2	13	12	24
11-15	12	35	1	06	13	26
>15	12	**35**	13	**81**	25	50
Total	34 **(68%)**	100	16 **(32%)**	100	50	100

Discussion

Reducing risks associated with mechanical ventilation in critically ill patients is a vast, complex, and interdisciplinary process. Although our understanding of the uses, complications, and outcomes associated with mechanical ventilation changes almost every day, the importance of this understanding for bedside clinicians is paramount [11]. Endotracheal suctioning (ETS) is a routine RCU procedure, although it has significant side effects [12].

The results as showed in table (2) that during ETS the males were more affected than females in regard to HR and BP while in SPO_2 the results stayed the same in both sex. The total mean value of heart rate increased from a baseline of 107 beats/ minute to 135 beats/ minute with a range of 100 to 170 beats/ minute. A 26% change from baseline. This results declared that the open- system ETS in

mechanically ventilated patients had an effects on increase HR because of deprivation the patients from oxygen and increase respiratory effort while after 2-3 minutes of ending the suctioning procedure all the values dropping toward the baseline over the next 7 minutes as a result of remove of chest secretion [13]. In BP the females were less affected than males. Also there was no significant change from baseline in regard to females BP deterioration. This may be indicates that the female hormone has an effect against the increase of BP during ETS.

The total mean value of BP increased from a baseline of 99 to 107 mm Hg during suctioning. An 8% mm Hg change from baseline. It is well known that direct stimulation of the airway causes various cardiovascular and respiratory reflexes, such as increase BP, increase HR, and cough. These responses may also be marked during ETS [14]. Increase BP occurs, most likely due to the intense pain of tracheal suction causing sympathetic stimulation and voluntary muscle contraction. This is seen at all ages despite moderate sedation and systemic analgesics. Patient assessment post suction should include an evaluation of the effects on the patients' pre suction signs and symptoms as well as the development of hypertension [15]. This result in agree with similar study which showed that elevated mean arterial blood pressure had been observed during open tracheal suctioning (OS) in intubated patient [16] and could result from hypoxemia, airway manipulation and tracheal stimulation [17].

During ETS, the total value of SPO_2 as indicated by pulse oximeter decreased from a baseline of 97% to 80 % with a range of 42 to 90. A – 18 % change from baseline. The effects of OS on oxygenation were similar to data reported in other studies. They also found a greater SPO_2 reduction during OS than during closed tracheal suctioning (CS) [17, 18].One study had shown that heart rate and mean arterial pressure increased significantly but returned to baseline 5 minutes after suctioning [11].Secretions were cleared from these patients' airways in order to maintain airway patency, to prevent atelectasis secondary to blockage of smaller airways, and to ensure that adequate gas exchange (particularly oxygenation) occurs [19]. Suctioning has also been associated with many deleterious effects including decreased arterial oxygen tension, which may be more pronounced in cardiac surgical patients and in patients with hypoxemic respiratory failure requiring high levels of positive end-expiratory pressure, in patients with cardiac arrhythmias and in cardiac arrest in patients with acute spinal cord injury [20].

The results as showed in table (3) that ETS resulted in an increase in HR and BP while the SPO_2 decreased when there an increase in the duration of suctioning .The patient should be monitored for adverse reactions and be placed on a pulse oximeter to assess oxygenation during and following the procedure [4]. It may be difficult to determine exactly which complications can be attributed to the duration of suctioning [21]. The procedure has many complications and many patients find the experience painful and anxiety inducing major complications includes hypoxia which may be related to an interruption in inspired oxygen flow and partial airway obstruction as the catheter passes into the ETT. The maximum duration of suctioning is inadequately documented. The procedure may 'suck' oxygen/ gas out of the bronchial tree and contribute to alveolar collapse. One study had shown that simple measures may reduce this such as suction should not

be applied for more than ten seconds (certainly in less than 10 seconds) [22, 23]. In a comparative study of complications associated with suctioning, a maximum of 10 seconds was recommended for the suctioning itself and 15 seconds for the entire procedure [3, 24, 25]. Studies in adult patients had shown that the duration of less than 15 seconds reduced the drop in partial pressure of oxygen (PaO2) and functional residual capacity (FRC) [17, 26, 27]. Also based on clinical experience, in adult patients, it was recommended that the suctioning procedure should last no longer than 15 seconds [4, 27]. There was variation in the recommended amount of time taken to perform ETS. As in most research [25], the present study recommended that duration of 10-15 seconds is advocated as the longer the duration of each suctioning event the greater the risk of increasing HR and BP, and decreasing of SPO_2.

The results as showed in table (4) that 68% of the patients were on appropriate size of the ETT in relation to outer diameter (OD) of the suction catheter while, 32% weren't. 35% (12 out of 34) of the patients who were on appropriate size lasted more than 15 seconds of suctioning duration while there was 81% (13 out of 16) in the same duration were on inappropriate size. Selection of appropriately sized suction catheter for a given tube inner lumen diameter is also important to avoid complications during the suctioning procedure .The OD of the suction catheter should be clearly labeled and never exceeds half the inner diameter of the tracheal tube or its connector [15,28]. Further studies are recommended to perform on comparison of closed endotracheal suction versus open endotracheal suction on mechanically ventilated patients.

References

1-M. Zolfaghari , A. Nikbakht N , A. Karimi R , H. Haghani. Effect of open and closed system endotracheal suctioning on vital signs of ICU patients. *Hayat Journal of Faculty of Nursing & Midwifery*. 2008; 14 (1): 78-78.

2-Agha F H, Hamid P, Nooredin M. Effect of endotracheal suctioning education for nurses on patient & apos: Hemodynamic parameters. *Hayat Journal of Faculty of Nursing & Midwifery*. 2012;18 (2):38-46.

3-Maria-del-M, Enrique P, Lluis B and Rafael F. Changes in lung volume with three systems of endotracheal suctioning with and without pre-oxygenation in patients with mild-to-moderate lung failure. *Intensive Care Med* .2004; 30:2210–2215.

4-AARC clinical practice guidelines.Endotracheal suctioning of mechanically ventilated patients, with artificial airways . *Respir Care*. 2010;55(6):758 – 764.

5-Woodrow P. *Perspectives in intensive care nursing*. Routledge, London and New York, 2000.

6-Kaye R, Kelvin S,Pauline J : Suctioning an Adult with a Tracheal Tube, 2010.

7-Sophie L.Open and closed endotracheal Suctioning. *Experimental and human studies* ,Department of Anesthesiology and Intensive Care, Institute of Clinical Sciences ,Sahlgrenska Academy, Goteborg University, Goteborg 2007.

8-Andrew C A. Endotracheal suctioning is basic intensive care or is it? *Pediatric Research* 2009.66: 364-367.

9-Morrow B, F. M and Argent A. Effect of endotracheal suction on lung dynamics in mechanically ventilated paediatric patients. *Australian Journal of Physiotherapy*. 2006; 52: 121-126.

10-Johannes P. V. L, Jan H. Z., Bert G. L., *et al.* Endotracheal suctioning

versus minimally invasive airway suctioning in intubated patients: a prospective randomised controlled trial. *Intensive Care Medicine.* 2003; 29(3): 426-43.
11-Mary Jo Grap. Not-so-Trivial Pursuit: Mechanical Ventilation Risk Reduction. *Am J Crit Care* July. 2009 ; 18 (4) 299-309.
12- Brenda M. M., Merle J. F., and Andrew C. A. Endotracheal suctioning: from principles to practice, *Intensive Care Med.* 2004; 30:1167–1174.
13-Christopher W. S, Brian J. C., Colin R. C., *et al* . Physiologic impact of closed-system endotracheal suctioning in spontaneously breathing patients receiving mechanical ventilation. *Respiratory Care.* March 2009; 54 (3).
14-Okuda M, Furuhashi K, Konishi K et al. Effects of intravenous or endotracheal lidocaine on circulatory changes during recovery from general anesthesia. J *Anesth.*1990; 4: 331-336.
15- T J Voss Tracheal Suction: A Review. *Australasian Anesthesia, 1994.*
16-JR Kaiser, CH Gauss, and DK Williams. The Effects of closed tracheal suctioning plus volume guarantee on cerebral hemodynamics. *J perinatol.* 2011 ;31(10):671-676.
17-Maurizio c. Federico V. Enrico V .Gianluca G .Mirco N. and Antonio P. Closed system endotracheal suctioning maintains lung volume during volume-controlled mechanical ventilation. *Intensive Care Med* . 2001; 27: 648-654.
18-Maria P.C., Guilherme S,Klaudiusz S. *et al.* The impact endotracheal suctioning on gas exchange and hemodynamics during lung- protective ventilation in acute respiratory distress syndrome. *Respiratory Care* .May 2006; 51(5).
19-Royal F. H. NHS Trust. Guidelines for tracheal suction.1999 [online].
20- Sanja J, Jennifer A C, Phillip F, Clinical review: Airway hygiene in the intensive care unit, *Critical Care.* 2008; 12 (2) : 209.
21-Carsten M. P, Mette R-N,Jeanette H,Ingrid E. Endotracheal suctioning of the adult intubated patient-What is the evidence? *Intensive and Critical Care Nursing* .February 2009;25(1): 21-30.
22-Dan H, RN. Tracheal suction. *Nursing practice, clinical research* .22 February 2005;101(8) :36.
23- International Networking for Healthcare Education Conference. Midwifery Training Program. Emirates Nursing Association4-6 September 2012.
24- Celik and Kanan, . S.A. Celik, N. Kanan. A current conflict: use of isotonic sodium cloride solution on endotracheal suctioning in critically ill patients. *Dimens Crit Care Nurs*.2006; 25 (1): 11–14.
25-Wood, C.J. Wood. Endotracheal suctioning: a literature review. *Intensive Crit Care Nurs*. 1998b; 14 (3): 124–136.
26-Tenaillon, A. Tenaillon Tracheobronchial suctions during mechanical ventilation. *Intensive Care Emerg Med*.1990; 10 : 196–200.
27-Daniele T, Nicoletta D, Vincenzo Z. The management of endotracheal tubes and nasal cannulae: The role of nurses. *Early Human Development* .*October 2009*; 85 (10):585-587.
28-Bersten AD, Soni N, and Oh TE, eds. *Oh's intensive care manual*, 5th edition. Butterworth Heinemann, London, 2003.