Assessment of the Methods Used for the Confirmation of Correct Endotracheal Tube Placement in Critical Care Units in Selected Hospitals in Khartoum, Sudan (2017)

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Assessment of the Methods Used for the Confirmation of Correct Endotracheal Tube Placement in Critical Care Units in Selected Hospitals in Khartoum, Sudan (2017)

Ashjan Abdulrahman Mohamed Arbab

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Assessment of the Methods Used for the Confirmation of Correct Endotracheal Tube Placement in Critical Care Units in Selected Hospitals in Khartoum, Sudan (2017)

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Date of Examination: ...../...../..........
Dedication

To the memory of my father, who was supporting me, and doing anything and everything to put me on a path towards success.

To my mother who taught me to believe in myself and always be there for me.
Acknowledgements

I would like to express my deepest gratitude to my supervisors Dr. Sanaa Oro and Dr. Mohammed S. Zarooq for their support and mentorship throughout this research.

I would like to thank all doctors for being nice and very cooperative with me.

My thanks also extended to my uncles for being my guardian during my educational career.
Assessment of the Methods Used for the Confirmation of Correct Endotracheal Tube Placement in Critical Care Units in Selected Hospitals in Khartoum, Sudan (2017)

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Abstract

Endotracheal intubation is a common procedure in intensive care units (ICUs), and may be performed for numerous reasons and under varying circumstances. The aim of this study to evaluate the methods for confirmation correct endotracheal tube placement in Critical Care Units in Selected Hospitals in Khartoum, the prospective cross sectional study was conducted in Khartoum state hospital intensive care units, fifty patients included in the study in selected central hospitals in Sudan such as (Khartoum north teaching hospital(bahry teaching hospital),Ibrahim Malik teaching hospital, Omdurman military hospital and Ribat university hospital).the result revealed that 92% of the patients endotracheal tube (ETT)placement confirmed by the clinical methods, 2% confirmed by capnography. The study concluded that the most used confirmation methods for endotracheal tube placement in Sudanese hospitals are clinical assessment and monitoring pulse oxymetry. The clinical method of ETT position confirmation is acceptable in Sudanese hospitals but it cannot be enough as a sole and ideal confirmation method for detection of ETT placement. Moreover, it is not acceptable for medico legal aspect. Thus, using of other confirmation methods is highly recommended.
تقييم الطرق المستخدمة للتأكد من وضع أنبوب القصبة الهوائية في وحدات الرعاية الحرجة بعد من مستشفيات الخرطوم، السودان (2017)

اشجان عبدالرحمن محمد أرباب

ملخص الدراسة

التنبيب الرغامي هو إجراء متبع في وحدات العناية المركزة، ويمكن أداءه لأسباب عدة وتحت الظروف المختلفة. هدفت هذه الدراسة لتقييم الطرق المستخدمة للتأكد من وضع التنبيب الرغامي في وحدات العناية المكثفة في عدد من مستشفيات الخرطوم. استخدمت دراسة قبلية قطاعية تضمنت وحدات العناية المكثفة بمستشفيات مركزية مختارة في الخرطوم، شملت الدراسة خمسين مريض بالمستشفيات المختارة التالية (مستشفى بحري التعليمي، مستشفى ابراهيم مالك التعليمي، مستشفى ام درمان العسكري، مستشفى جامعة الرباط). وقد اظهرت النتائج ان 92% وضع أنبوب الرغامي للمريض اكدته الطرق السريرية، 2% اكدت عن طريق جهاز قياس نسبة ثاني أكسيد الكربون. وقد خلصت هذه الدراسة إلى أن معظم الطرق المستخدمة في التأكد من وضع الأنابيب الرغامي في مستشفيات السودان هي الطرق السريرية وقياس نسبة الأكسجين في الدم. الطرق السريرية المستخدمة في التأكد من وضع الأنابيب الرغامي بمستشفيات السودان مقبولة ولكن ليست كافية لوحدها كطريقة مثالية لمعرفة موقع الأنابيب الرغامي. واضافة لذلك ليست مقبولة من ناحية الطب الشرعي لهذا نوصي باستخدام الطرق الأخرى.
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<td>ETCO₂</td>
<td>End tidal carbon dioxide</td>
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<td>ED</td>
<td>Emergency department</td>
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<td>CXR</td>
<td>Chest X ray</td>
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<td>EDD</td>
<td>Esophageal detector devise</td>
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<td>Carbon dioxide</td>
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<td>RMS</td>
<td>Right main stream</td>
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<td>NAP₄</td>
<td>4th National adult project</td>
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Chapter One

Introduction
1. Introduction

1.1 Background:

Endotracheal intubation is an essential technique in airway management. However, it can be associated to potentially serious complications, such as unrecognized esophageal intubation or one-lung intubation. Consequently, it is important to verify the correct placement and depth of insertion of the endotracheal tube (ETT) after each intubation. (Timmermann et al., 2007; Werner et al., 2007; Pfeiffer et al., 2011)

Esophageal intubation may occur with a difficult laryngoscopy, inexperience, an emergency situation, accidental extubation with movement of the patient’s head, or distraction of the person intubating. An unrecognized esophageal intubation may result in gastric distension, regurgitation, and hypoxic damage to the brain. Early detection of esophageal intubation will prevent or reduce the morbidity and mortality of this life threatening situation. There are both clinical and technical tests that can be used to assess tracheal tube position. (Clyburn and Rosen, 1994)

Methods of confirmation include direct visualization of passage, chest and abdominal auscultation, esophageal detector devices, pulse oxymetry, and end tidal capnography (both colorimetric and quantitative). With the exception of continuous end tidal CO₂ monitoring, each alternative method is fraught with potential problems resulting in poor sensitivities and specificities. Although continuous end tidal CO₂ has become the preferred method, (Sayre et al.,
There are still significant risks of false positives with hypo pharyngeal placement and false negatives during cardiac arrest. (MacLeod et al., 1991; Li J. 2001; Takeda et al., 2003). Moreover, continuous end tidal CO₂ monitoring is not widely available in many emergency departments (EDs). (Deiorio 2005). As a result, there is increasing research about the use of ultrasound to visually confirm ETT placement. (Sağlam et al., 2013; Ma G et al., 2007; Chou et al., 2011).

Confirmation of endotracheal tube placement should be completed in all patients at the time of initial intubation. During intubation, although direct visualization of the endotracheal tube passing through the vocal cords into the trachea should constitute firm evidence of correct tube placement, additional techniques must be used to confirm proper endotracheal tube position. (EMSSA, 2009)

Physical examination methods are not reliable by themselves to confirm endotracheal tube placement, although they form an important part of the overall assessment. Pulse oximetry and chest radiography not reliable by themselves to confirm endotracheal tube placement, although they form an important part of the overall assessment. End-tidal carbon dioxide detection is the most accurate means to evaluate endotracheal tube position in patients who have adequate tissue perfusion. For patients in cardiac arrest, or peri-arrest, end-tidal carbon dioxide determination may be less accurate. In these situations, other methods should be used. (EMSSA, 2009)

Endotracheal tubes may become displaced due to patient or equipment movement. Continuous assessment continuous end-tidal carbon dioxide monitoring is ideal. Reconfirmation
of endotracheal tube position should be undertaken immediately in all patients when their clinical status changes, or when there is concern regarding proper location of the endotracheal tube. (EMSSA, 2009)

In preparation for transfer of intubated patients, the attached form should be completed to ensure adequate checking and documentation of the patient’s status. (EMSSA, 2009)

Unfortunately, capnography is not always or freely available, especially in small centers. (Adi et al., 2013)

1-2 Problem statement:

Endotracheal intubation is a life-saving procedure that is routinely performed by anesthesiologists, emergency medicine physicians, and critical care physicians. Numerous techniques exist for discriminating between endotracheal and esophageal placement. (Grmec 2002; Knapp et al., 1999). However, while it is now straightforward to discriminate tracheal intubation from esophageal intubation, identifying correct location of the endotracheal tube (ETT) within the trachea remains challenging. Endobronchial intubation is the most common malposition encountered (Szekely et al 1993), and it carries potential serious complications such as hypoxemia, atelectasis, hyperinflation, and barotrauma and can lead to pulmonary infection if not diagnosed early (Owen and Cheney 1987). The American Society of Anesthesiologists Closed Claims Project showed that bronchial intubation accounts for 2% of adverse respiratory claims in adults and 4% in children (Caplan et al., 1990; Morray et al., 1993). Within the hospital, the frequency of inappropriate ETT location (less than 2 cm from carina) has been reported to be as high as 20% (Geisser et al., 2009), and bronchial intubation has been shown to be at a rate of 5 to 8% of all intubations (Geisser et al., 2009; Bissinger et al., 1989).
In our country there is lack of using method like ultrasound and capnography in ETT placement confirmation.

1.3 Justifications

To avoid any serious complication of incorrect placement of ETT, in other words, if this tube is not placed in the right place in the trachea, subsequently the death may occur.

And to avoid the collapse of one lung if the tube is intubated in one bronchus which can cause baro& velotrauma in the intubated lung especially in the mechanical ventilation patients, thus the time of staying in ICU would be increased.

1.4 Objectives of the study

1.4.1 General objective

- To study the methods used for identification of correct endotracheal tube (ETT) placement after intubation in adult patients at hospitals located in Khartoum, Sudan.

1.4.2 Specific objectives

- to identify the predominant method that used for confirmation of correct endotracheal tube placement and pulse oxymetric monitoring in Sudan hospitals.
- to compare between different techniques used for identification of correct endotracheal tube (ETT) placement in intubated adult patients at hospitals located in Khartoum, Sudan.
- to standardize the current used methods for minimizing/preventing the complications of incorrect ETT placement
- to find out a method that might be useful for checking the correct ETT placement in mechanically ventilated adult patients.
Chapter Two
Literature Review
2. Literature Review

2.1 Confirmation of endotracheal tube placement methods

There are two strategies used to confirm ETT placement: methods that detect the physiological results of moving air through the ETT and methods that attempt to detect the location of the ETT using imaging and/or that exploit the inherent characteristics of the trachea or esophagus or of their relationship to the ETT within them. (Schaner et al., 2013)

Methods are used to verify ETT placement, including visual confirmation of the ETT passing through the vocal cords during laryngoscopy, expansion of the chest wall during ventilation, visualization of the tracheal rings and carina using a flexible bronchoscope, auscultation, capnometry, capnography, and chest x-ray. These techniques vary in their degree of accuracy (Grmec, 2002; Salem 2001).

2.2 Clinical assessment

Classically, a combination of clinical observations has been used to confirm correct ETT placement. These include:

- Direct visualization of the ETT passing through the vocal cords during intubation
- Auscultation of clear and equal breath sounds over both lung fields
- Absence of breath sounds when auscultating over the epigastrium
- Observation of symmetrical chest rise during ventilation
- Observation of condensation ("fogging") within the ETT during ventilation (Stephen Alerhand, Alex 2016)

Verification of endotracheal tube placement is imperative for the oxygenation, ventilation, and airway protection of your patient. A tube in the esophagus, or in the hypopharyngeal space, may be incorrectly thought to be in position and may place your patient at undue risk of hypoxemia or aspiration. Therefore, confirmation of proper endotracheal tube placement should be completed in all patients at the time of initial intubation. (Knapp et al., 1999; O'Connor and
Swor, 1999; Birmingham et al., 1986; Cummings and Hazinski, 2000; Williamson et al., 1993; Jenkins et al., 1994; Katz and Falk, 2001)

A variety of techniques may enhance your ability to confirm airway placement; comfort with these techniques is essential to your practice. (Knapp et al., 1999; O'Connor and Swor, 1999; Birmingham et al., 1986; Cummings and Hazinski, 2000; Williamson et al., 1993; Jenkins et al., 1994; Katz and Falk, 2001).

2.3 Direct visualization of the ETT passing through the vocal cords during intubation:

Visualization of the endotracheal tube passing through the vocal cords remains the optimal method for initial endotracheal tube placement. Unfortunately, direct visualization is not always possible, especially in the anatomically difficult airway or an airway that is obscured by blood, secretions, or vomitus (Knapp et al., 1999; O'Connor and Swor, 1999; Birmingham et al., 1986; Cummings and Hazinski, 2000; Williamson et al., 1993; Jenkins et al., 1994; Katz and Falk, 2001).

2.4 Bilateral auscultation of chest and palpation of symmetrical chest movements:

Bilateral auscultation of the chest can be done to identify and prevent possible endobronchial intubation. Although auscultation of the lungs can be used to verify the position of the ETT, it may be deceptive in patients with decreased lung compliance or in patients who experience severe bronchospasm. (Sitzwohl et al., 2010).

In false negative results by auscultation, examiners did not clearly hear breath sounds and did not see good chest wall excursions because of obesity, or breath sounds were mistakenly identified as stomach gurgling in some clinical conditions such as pulmonary oedema, excessive secretions or aspiration (Grmec 2002; Takeda et al., 2003).

Auscultation is a common method to ensure correct placement of the ETT; however, it is inaccurate when used alone and by inexperienced examiners. Furthermore, auscultation does not reveal how well the lungs are functioning and whether or not blood is being oxygenated effectively for gaseous exchange (Grmec 2002). Auscultation and palpation of symmetrical
chest movements are most reliable when used with other methods, such as capnography (Varshney et al., 2011; Grmec 2002).

2.5 Esophageal Detector Devices (EDD):

It has been reported that EDDs, consisting of either a self-inflating bulb or a 60 mL syringe, have become one of the simplest methods to confirm ETT placement. In a prospective study by Hussain et al. (Hussain et al., 2006) it was shown that EDDs had a sensitivity, specificity and positive predictive value of discriminating esophageal from endotracheal intubation of nearly 100% in healthy adults who were intubated. The effectiveness of this method can be affected by the rigidity and structural differences of the trachea, as well as secretions, vomit, blood or any other fluids in the airway. During cardiac arrest, negative results caused by the use of this method are not uncommon and clinical methods should then be applied as an adjunct method of verification. EDDs appear to be highly reliable in controlled settings such as the operating theatre, but should be used with greater caution in other settings (Dittrich 2002; Takeda et al., 2003; Hussain et al., 2006). See Figure (2.1) in A 7.

Esophageal detector devices (EDD) are designed to aspirate air via the endotracheal tube and depend on the structural differences between the trachea and esophagus to indicate ETT position. The ability to aspirate air easily when connected to an ETT indicates tracheal intubation as the trachea and main bronchi have a rigid structure and do not collapse when a negative pressure is applied. Failure to aspirate air indicates esophageal intubation as the esophagus collapses around the end of the ETT (Haridas, 1997).

2.5.1 The advantages of the EDD:

- EDDs can be easily assembled using inexpensive and readily available equipment. They are easy to use (even by non-anesthetists), portable, non-electronic, and provide a highly reliable assessment of ETT position. They are ideal for use in countries where capnography is not routinely available. They may also be useful for intubations performed outside the operating room (e.g., in the recovery room, emergency room, intensive care unit, and out in the field).

- EDDs provide a rapid assessment of ETT position. In Wee's original study (Wee MYK, 1988), the average time to perform the test was 6.9 seconds (range 5 - 16 seconds). Nunn (Nunn, 1988) obtained a result with the Ellick's bulb in 3 - 5 seconds. When the bulb from a disposable bulb syringe was used, full re-inflation of the bulb took up to 30 seconds in only 6% of tracheal
intubations (Zaleski et al., 1993). The result of the EDD test is obtained more rapidly than that from capno-graphy, and relies solely on observation.

-EDDs are useful in patients in cardiac arrest as the test result does not depend on carbon dioxide being present in exhaled gas (Haridas, 1997).

-EDDs are useful when a Combitube (an emergency device that can be inserted into the airway blindly and used to ventilate patients) has been used. They can indicate whether the Combitube is positioned in the trachea or esophagus, and whether or not the airway is patent. (Haridas, 1997)

2.5.2 The disadvantages of the EDD include:

- Some false results may occur. However, the incidence of this is low.
- Regurgitation of gastric air, distension of the esophagus with air, or an EDD that is not airtight may give a false impression of tracheal intubation when the tube is in fact in the esophagus (Haridas, 1997).
- Thick secretions may occlude a tracheal tube (Wee MYK, 1988) and give a false impression of esophageal intubation. Occlusion of the bevel of a reinforced ETT by the wall of the trachea has been described to cause failure of bulb refill.
- Bronchial intubation, bronchospasm, tracheal compression, obesity, chronic obstructive pulmonary disease, may also cause resistance to aspiration or delayed refill of the bulb-type EDD.
- Wee (Wee MYK, 1988) had no problem in identifying tracheal intubation in two patients with moderate broncho-spasm (peak airway pressures of 3.0 - 4.2kPa). However, delayed refill of the bulb-type EDD has been observed in an asthmatic patient. The slow re-inflation of the bulb seen in the presence of bronchospasm represents the slow exhalation that is characteristic of acute asthma.

2.5.3 Causes of False Results with the Esophageal Detector Devices:

-False positive result
Regurgitation of gas from the stomach.
Esophageal distension with gas.
Esophageal detector device not airtight.

-False negative result
Thick secretions occluding the ETT.
Occlusion of the end of an ETT (with no Murphy eye) by the tracheal wall.
Bronchial intubation.
Bronchospasm.
Tracheal compression.
Obese patient.
Chronic obstructive pulmonary disease. (Haridas, 1997)

2.6 Capnography:

End-tidal capnography refers to the graphical measurement of carbon dioxide partial pressure (mm Hg) during expiration. First established in the 1930s, clinical use of end-tidal carbon dioxide measurement became accessible in the 1950s with the production and distribution of capnograph monitors. (Westhorpe and Ball, 2010; Jaffe, 2008)

And capnography also refers to the evaluation of the CO2 in the respiratory gases of mechanically ventilated patients. (Block and McDonald, 1992)

Paco2 denotes the partial pressure of carbon dioxide in arterial blood. End tidal carbon dioxide (ETco2) is the percentage concentration, or partial pressure, of carbon dioxide at the end of exhalation. (Ortega et al., 2012)

A capnographic device incorporates one of 2 types of sampling techniques: mainstream or sidestream. (Block and McDonald, 1992) see Figure (2.2) in A 8.

Mainstream technique inserts a sampling window into the ventilator circuit for measurement of CO2, whereas a sidestream analyzer samples gas from the ventilator circuit, and the analysis occurs away from the ventilator circuit. Analyzers utilize infrared, mass or a photoacoustic spectra technology. (Block and McDonald, 1992; O’Flaherty, 1994).

Flow measuring devices are utilized in volumetric capnographs. Colorimetric CO2 detectors are a form of mainstream sampling, but are simplistic. The colorimetric CO2 detector has a pH-sensitive chemical indicator that undergoes color change with each inspiration and expiration, thus reflecting the change in CO2 concentration. These devices start at baseline color when minimal CO2 is present and undergo gradual color change with increasing CO2 concentration. (Walls and murphy, 2012)

Colorimetric capnography is a qualitative method of determining the presence of carbon dioxide using a pH-sensitive filter. (Ortega et al., 2012)
In another word Colorimetric ETCO2 detectors are small disposable devices that connect between the bag and the ETT. When the device detects ETCO2, its colorimetric indicator changes from purple to yellow; the absence of this color change indicates the tube is incorrectly placed in the esophagus. See Figure (2.3) in A 9.

Generally, end-tidal carbon dioxide is displayed as a waveform with partial pressure of carbon dioxide on the Y-axis and time on the X-axis. (Christopher and zab, 2015)

A normal capnogram shows a regular, nearly square waveform that oscillates at the same frequency as the patient’s respiratory rate. During inspiration, the capnogram should be at zero as the patient breathes in fresh gas. When the patient starts to exhale, the first gas exhaled will be from the anatomical dead space and will contain little or no carbon dioxide. However, the concentration of carbon dioxide in the exhaled gas will rise rapidly and plateau as the alveoli begin to empty. As exhalation proceeds, the concentration of carbon dioxide remains high and increases slightly. The peak concentration reached at the end of exhalation is the ETco2. As the patient begins to

inhale again, the capnogram falls rapidly to zero, indicating the absence of carbon dioxide in the inspired gas. (Ortega et al., 2012) See Figure (2.4) in A 10.

In patients undergoing endotracheal intubation, capnography helps to show that the trachea, and not the esophagus, has been successfully intubated. However, if the stomach is insufflated with air that contains carbon dioxide, or if the patient has recently swallowed a carbonated beverage, the capnogram might transiently show the presence of carbon dioxide, even if the endotracheal tube has been erroneously placed in the esophagus. A series of successive, steady, normal capnographic waveforms must be seen to rule out esophageal intubation. A capnogram tracing indicates gas exchange but does not inform the clinician as to whether the endotracheal tube is positioned properly (e.g., in a bronchus or in the oropharynx). Capnography is useful for the measurement of the ventilatory characteristics of intubated patients. It may reduce the need to measure arterial blood gas. (Ortega et al., 2012)
Numerous national organizations, including the American Heart Association, now endorse capnography and capnographic methods for confirming endotracheal tube placement. (American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care, 2005). Despite these recommendations, capnography is not always widely available nor consistently applied. (Deiorio, 2005). Although no study, to date, has shown a single device to be 100% sensitive and specific for determining proper endotracheal tube placement, capnography should be considered as a mandatory adjunct to confirm correct endotracheal tube. In one ICU intubation study, esophageal intubation occurred in 25 of the 297 (8%) intubation procedures. (101) Only 10 of 25 (40%) procedures that resulted in esophageal intubation met the criteria for difficult intubation. During 22 of the 25 intubations, the esophagus was intubated only once before tracheal intubation was accomplished. In the remaining three, the esophagus was intubated a total of 13 times before successful completion of tracheal intubation. Thus, there were 35 esophageal intubations among the 25 procedures. Of the 35 esophageal intubations, 32 were recognized by clinical criteria, which included auscultation of breath sounds and gastric distention. Three esophageal intubations were not recognized until there was a decrease in the oxyhemoglobin saturation as measured by pulse oximetry. (Schwartz et al., 1999). Two of the esophageal intubations were associated with new infiltrates in chest radiographs. Patients in ICU have a decreased margin of safety in terms of oxygen reserves and an unrecognized esophageal intubation can result in severe hypoxemia progressing to cardiac arrest and ultimately death. Therefore, during emergent intubation, the correct placement of the endotracheal tube should be confirmed immediately. A decrease in oxyhemoglobin saturation, as measured by pulse oximetry, might detect an otherwise unrecognized esophageal intubation. However, this recognition may be delayed because of the use of oxygenation before intubation and by alveolar ventilation (with room air) via diaphragmatic movement produced by esophageal intubation and gastric ventilation. (Birmingham et al., 1995)

Studies have shown that end-tidal CO2 detectors are useful for confirmation of correct endotracheal tube placement. (Takeda et al., 2003) The sensitivity in these studies has been described as ranging from 20-100%, but the specificity (percentage of incorrect esophageal placement detected when no CO2 is detected) has ranged from 97-100%. (Gremec and Klemen, 2001). Therefore, the positive predictive value (probability of correct endotracheal tube
placement if CO2 is detected) is nearly 100% while the negative predictive value (probability of esophageal tube placement if no CO2 is detected) has a broader range of 20-100% (American Heart Association, 2005).

Despite the above controversies, it seems simply illogical in the present times not to use capnography to confirm correct endotracheal tube placement when capnography is considered as a standard of care in the operating rooms. This is echoed by Schwartz et al. in the above study; they cared for a patient after the completion of the study in whom an esophageal intubation was not detected clinically before death. Therefore, they state in the discussion that although the detection of exhaled carbon dioxide after tracheal intubation in critically ill patients has not been rigorously studied, they believe it should be used to provide additional confirmatory evidence whenever possible. (Schwartz et al., 1999)

2.7 Using Ultrasound to Confirm Proper ETT Placement:

It is used to image the upper airway, trachea and pleural cavity. The ultrasound is now more readily available and its advantages are that it is safe, simple, non-invasive, and repeatable. When combined with a thorough knowledge of regional anatomy and practical skills in ultrasound technology, it can provide vast amount of information which can be used to improve the quality of care we deliver to patients. (Prasad et al., 2009)

Frontal and lateral walls of almost all upper airway segments are visible by the ultrasound either partially or completely. (Sustic, 2007)

The material of an endotracheal tube which is mainly plastic is hyperechoic, which makes it distinguishable from the surrounding tissues and facilitates the visualization. (Muller, 1993; Gerscovich et al., 2001)

Ultrasound can quickly and efficiently visualize the motion of the diaphragm and pleura, which are indirect quantitative and qualitative indicators of lung expansion indirectly. (Gottesman and McCool, 1997). If ETT is placed in a correct position, bilateral motion of the diaphragm toward the abdomen can be visible. Besides, by intercostal view, simultaneous motion of the pleura with ventilation can be viewed as a lung sliding sign. (Lichtenstein and Menu, 1995)
Several bedside sonographic tests for confirmation of endotracheal intubation have been proposed and are gaining wide acceptance. Assessment of the upper anterior chest for sliding of the visceral pleura against the parietal pleura is easily accomplished. (Gavin et al., 2014)

2.7.1 Sliding lung sign technique:

Images were taken on both sides of the chest within the third to fifth rib interspaces, along the anterior and mid axillary line, during positive-pressure ventilation with an ambu bag. Each examiner performed the US examination and recorded results individually. A positive sliding lung sign signified lung expansion with ventilation. On the basis of the presence or absence of the sliding lung sign on both sides of the chest, a determination of endotracheal tube position was made. Sliding lung sign presence on both sides of the chest was assumed to signify tracheal intubation. Sliding lung sign presence on the right but absence on the left was assumed to indicate right main stem intubation. Finally, absence of sliding lung sign on either side was assumed to indicate esophageal intubation. The sonologists were allowed to use the power Doppler settings as well as to manipulate the other settings of the US as desired. Power Doppler was used to pick up pleural movement. (Cunningham et al., 2002)

The ETT may also be directly visualized inside the trachea (transtracheal visualization). This process is usually accomplished by obtaining a transverse window over the cricothyroid membrane or suprasternal notch. With esophageal intubation, the tube may be identified deep and lateral to the trachea. This procedure has also been described as a reliable method for confirming ETT placement. (Gavin et al., 2014) see Figure (2.5) and Figure (2.6) in A 11.

2.7.2 For transtracheal visualization:

-Gently place the high-frequency linear probe just superior to the suprasternal notch in the transverse plane. (Stephen and Alex, 2016)

-The trachea will appear as a hyperechoic curvilinear structure with shadowing. A comet tail, or reverberation rings, appear deep to that structure. (Stephen and Alex, 2016). See Figure (2.7) in A 12.

-The esophagus will appear distally and to the right. It has a hyperechoic wall and hypoechoic center. (Stephen and Alex, 2016)
- Tracheal intubation: Visualize the second hyperechoic curvilinear structure within the trachea. You can also gently shake the ETT and visualize tracheal movement on the screen. Using Doppler, a color ray will also appear within the trachea. (Stephen and Alex, 2016)

- Esophageal intubation: The “double tract sign” (in which there seemingly appears to be two tracheas) indicates esophageal intubation. (Stephen and Alex, 2016). See Figure (2.8) in A13.

### 2.7.3 Diaphragm motion technique:

Indirect confirmation of ETT placement may also be accomplished by observing bilateral sonographic movement of the diaphragm with ventilations. Several methods are described, including probe placement in the subxiphoid area or in the posterior axillary lines bilaterally. (Gavin et al., 2014).

The probe was placed in the right upper quadrant of the abdomen, exactly below the edge of the ribs with a 45 degree angle toward the chest near the midclavicular line. The probe was toward the right side of the patient. This view provides a suitable vision of the liver and echogenic diaphragm. During positive pressure via ventilation with bag (inspiratory phase), diaphragm motion toward the abdomen was registered as an intratracheal intubation. In contrast, the observation of diaphragm motion toward chest or non-significant motion was in favor of esophageal intubation. (Hosseini et al., 2013). See Figure (2.9) and Figure (2.10) in A 14.

### 2.8 Using chest radiology in ETT placement confirmation:

Endotracheal tube placement is frequently assessed using chest radiography. In adults, the tip of the ET tube should be approximately 5 cm from the carina (approximately halfway between the interclavicular line and the carina). (Knipe et al., 2005). See Figure (2.11) in A 15.

The tracheal tube (TT) tip-carina relationship was retrospectively determined using a millimeter scale laid on the radiograph. (Schwartz et al., 1994)

- Changes in position:

The position of the ET tube tip is dependant on the position of the head. Most people think that neck flexion will result in elevation of the ET tube tip. However, neck flexion results in
depression of the ET tube tip. Conversely, extension of the neck results in elevation of the ET tube tip. Tip position may change by up to 2 cm up or down from neutral position. (Knipe et al., 2005)

Tube placement could be predicted as being high, low or normal, and if low, whether above the carina or in a mainstem bronchus. An endotracheal tube tip less than 2 cm above the carina was considered too low, and a tip higher than the clavicular heads was too high. (Lotano et al., 2000) see Figure (2.12) in A 16.

Actually chest radiography can be used to assess ETT position but does not confirm ETT placement with in the trachea. Since the esophagus lies directly behind the trachea, an ETT placed incorrectly in the esophagus may appear to be within the trachea on an anterior-posterior chest radiography. (savitsky et al., 2012)

2.9 Pulse Oximetry:
Pulse oximetry is a noninvasive method of measuring the oxygenation level in the blood. (Bruce 2015)

Modern pulse oximeters measure the amount of red and infrared light in an area of pulsatile blood flow. Because red light is primarily absorbed by deoxygenated blood and infrared light is primarily absorbed by oxygenated blood, the ratio of absorption can be measured. Because the amount of light absorbed varies with each pulse wave, the difference of measurement between two points in the pulse wave occurs in the arterial blood flow, with more than several hundred measurements per second. This is compared against baseline values, giving both the pulse oximetry oxygen saturation (SpO2) and the pulse rate. (Bruce 2015)

Continuous noninvasive pulse oximetry should be standard for every patient being intubated. A drop in the measured O2 saturation following intubation is worrisome for an esophageal intubation; if the patient was adequately preoxygenated, this drop may be delayed for several minutes, giving health care providers a false sense of security. In certain patients (i.e., hypotensive), O2saturation measurements may be unreliable or difficult to detect. Although
pulse oximetry is important, it should not be the primary indicator of successful ETT placement. (16)

-Erroneous readings:
  Several situations can cause an erroneous SpO2 reading, especially with the use of transmission probes. Darker skin pigments, certain nail polishes, dyshemoglobinemias (eg, carboxyhemoglobin, methemoglobin), intravenous dyes (eg, methylene blue), hypoperfusion, and hypoxia (especially with SpO2 readings < 80%) can cause errors. Motion and exposure to ambient or excessive light has also been shown to cause erroneous SpO2 readings. (Feiner et al., 2007; Bickler et al., 2005; Hinkelbein et al., 2007; Yamamoto et al., 2008; Sutcu et al, 2011; Hinkelbein et al., 2007; Barker, 2002; Gehring et al., 2002; Wilson et al., 2010; Van de Louw et al., 2001; Barker et al., 2006; Barker et al 1989; Jubran, 2004)

2.10 Previous studies:
A prospective, single-centre, observational study, conducted at the HRPB, Ipoh. Concluded that ultrasonography can replace waveform capnography in confirming ETT placement in centres without capnography. This can reduce incidence of unrecognized esophageal intubation and prevent morbidity and mortality. (Osman Adi et al., 2013)

There is another study conducted a blinded, randomized trial of the 4S technique utilizing an adult human cadaver model. Concluded that a simplified 4S technique was accurate and rapid for US experts. Among novices, the 4S technique was accurate in thin, but appears less accurate in obese cadavers. Further studies will determine optimal teaching time and accuracy in emergency department patients. (Gottlieb et al., 2014)

Various methods have been identified to verify ETT placement in adult mechanically ventilated patients: ultrasonography, the use of centimetre scale printed on the ETT, manual cuff palpation, bilateral auscultation of chest and palpation of symmetrical chest movements, EDDs, visualization of the ETT, use of CXR, pulse oximetry and capnography. Both ultrasonography and capnography were found to be highly sensitive and specific for verifying ETT placement, and are recommended for clinical practice. (P JordanI et al., 2015)
Ultrasound appears to be as effective as capnography, although slower, for identifying endotracheal intubation. Ultrasound may be useful in clinical situations, such as cardiopulmonary resuscitation where capnography is less reliable. Ultrasound is as effective as, and quicker than X-ray for assessment of endotracheal tube insertion depth, and it may contribute to decrease the routine use of X-ray after tracheal intubation. (P. Alonso et al., 2014)

A cross sectional study concluded that although ED intubations have high success rate, the complications of inappropriate intubations are highly remarkable that postintubation CXR remains a necessary step to minimize the misplacement of the tube. (Hooman et al., 2013)

A prospective study was carried out in the emergency department from February to October 2012. Found acceptable sensitivity, specificity, positive predictive value, and negative predictive value for prediction of tracheal ETT placement with the use of dynamic and static ultrasonography. (Abbasi et al., 2015)

A prospective study, apneic or paralyzed patients who had an indication of intubation were selected. And this study suggests that diaphragm motion in right subcostal ultrasound view is an effective adjunct to diagnose ETT place in patients undergoing intubation in emergency department. (Hosseini et al., 2013)

A single-subject prospective study compared an esophageal detector device (EDD) with a capnograph (EtCo2) for verifying tracheal tube placement concluded that Capnography is the gold standard for recognition of tube position. EDD was less successful (sensitivity=98.2% vs 100%) for elective situations, but it provides rapid recognition and high sensitivity for verifying the tracheal tube position, particularly in cases of emergency and cardiac arrest. Because of high sensitivity and positive predictive value, EDD can be used for tube position recognition if necessary, but EtCo2 monitor is more accurate and reliable. (Taghavi et al., 2014)

Current evidence supports that ultrasonography has high diagnostic value for identifying esophageal intubation. With optimal sensitivity and specificity, ultrasonography can be a valuable adjunct in this aspect of airway assessment, especially in situations where capnography may be unreliable. (Eric, 2015)

According to the CXR findings, the distance between tip of the ETT and carina was more than 2 cm in 336 patients (88.2%), whereas it was less than 2 cm in 45 patients (11.8%). In the latter
group, the tip of the tube was located at carina in 8 patients (2.1% of all patients); in 6 patients, it was in the right bronchus (1.6%), and there was 1 left bronchial intubation (0.03%). There was no esophageal intubation diagnosed by CXR. (Hooman et al., 2013)

Ultrasonography has a potential role in airway assessment and in the management of difficult airway. It is easy and rapid to perform and is an inexpensive way of assessing airway difficulties. The increasing availability of small, portable US devices has led to an increased use of US even in the critical care setting. Correct interpretation of US images requires a sound knowledge of sonographic anatomy, otherwise the acoustic artefacts can be mistaken for abnormal structures. The superficial structures can be interpreted quite easily but the interpretation of deeper structures can still be quite challenging. In future, ultrasound has a great potential and can become routine in airway management. (Payal et al., 2010)

All 3 methods for determining ETT placement had similar test characteristics. Transtracheal and thoracic sonography were faster than diaphragmatic sonography for determining ETT placement in pigs. (Gavin et al., 2014)

Current evidence shows US has high diagnostic value for identifying esophageal intubation, especially when capnography may be unavailable. (Chou et al., 2015)

Real-time tracheal US is accurate for identifying ETT position during CPR without need for interruption of chest compressions. Tracheal US in resuscitation may serve as powerful adjunct in trained hands. (Chou et al., 2013)

Transtracheal US is useful for confirming ETI with acceptable sensitivity/specificity. Can be used in emergency situations as preliminary test before final confirmation by capnography. (Das et al., 2015)

The American College of Emergency Physicians recommends the confirmation of correct ETT placement in all patients at the time of initial intubation. They assert that an ultrasound may be useful as an adjunct to identify and monitor the proper location of ETT. However, enough evidence is unavailable to support the widespread implementation of it. (American college of emergency physicians, 2009)
Pfeiffer, et al. in their study manifested that ETT placement with ultrasound is faster than the standard method of auscultation and capnography and is as fast as auscultation alone. (Pfeiffer et al., 2011)

Two studies compared timeliness of ultrasound with that of capnography and found that the median verification time with ultrasound was significantly shorter than with capnography. (Pfeiffer et al., 2012)

A laboratory study using fresh, recently dead cadavers show that US imaging of the sliding lung sign in a cadaver model is an accurate method for confirmation of ETT placement. Further, the technique may have some utility in differentiating RMS bronchus from main tracheal intubations. (Weaver et al., 2006)

A Twenty-seven separate experiments were conducted on 10 conditioned, mongrel dogs concluded that in this model, condensation on the inner surface of the endotracheal tube was common after placement within the esophagus. If these results are confirmed in human studies, the presence of a vapor trial should not be used as a clinical indicator of correct endotracheal tube placement. (Kelly et al., 1998)
Chapter three
materials and
methods
3. MATERIALS AND METHODS

3.1 Study area

This study was carried out in the ICU units of Ibrahim Malic teaching hospital, Khartoum North teaching hospital, Omdurman Military Hospital and Ribat University Hospital. However, these hospitals are four of the major important teaching hospitals in Sudan. Patients who be referred to Khartoum from different states of Sudan would be admitted to one of these four hospitals, especially those who need more intensive care. Ibrahim Malic teaching hospital and Ribat university hospital lie in Khartoum city, whereas Khartoum North teaching hospital and Omdurman military hospital lie in Khartoum Bahri and Omdurman cities, respectively.

3.2 Study design

A prospective cross-sectional study was conducted in four major teaching hospitals located in Khartoum state, Sudan. All data were collected from the study population using standard evaluation form (appendix 1).

3.3 Sample size

Fifty intubated adult patients had been included in this study and the designed questionnaire was filled by the doctors in ICU unit (appendix 1).

3.4 Study population

Any adult patient who intubated and admitted with any disease to ICU unit in one of the above mention hospitals was recruited according to the below criteria (inclusion & exclusion).

3.5 Inclusion criteria

- Sudanese
- Both sexes
- Adult patient
- Intubated patients

3.6 Exclusion criteria

- Non Sudanese
- Pediatric patients

3.7 Data analysis
Data were analyzed using the Statistical Package for Social Sciences (SPSS). Data were expressed as Frequencies of all study variants.

3.8 Ethical consideration

The study approved by Departmental Research and Ethics Review Committee, Faculty of Medicine, University of Gezira and ministry of health of Khartoum State. All participant relatives assured that all personal information concerning their health status well be kept confidential. The participants relevant informed about the objective and need of this study and inform consent from the department of intensive care units in hospitals was in the study.

3.9 data collection tool

The data collected by Questionnaire
Chapter Four Results and Discussion
4. RESULTS

4.1 Distribution of the study subjects according to age:

Fifty intubated adult patients were included in this study, age range from 15 to 80. As presented in table 4.1 and Fig. 4.1, 10% of the study subjects were <30 years old, 30% (30-49 years), 40% (50-69 years) and 20% ≥70 years. See table 4.1 in A 1.

Fig. 4.1: Distribution of the study subjects according to age
4.2 Distribution of the study subjects according to hospitals:

This study was conducted in different four hospitals in Khartoum state. Twenty five patients (50%) from Khartoum North Teaching Hospital, 5 (10%) from Ibrahim Malik Teaching Hospital and 10 (20%) from each of Omdurman Military and Ribat University Hospitals. Please see Table 4.2 in A 2.
4.3 Distribution of the subjects according to causes of intubation and mechanical ventilation:

Fig 4.3 show the distribution of the patients according to causes of intubation and mechanical ventilation. As can be seen from the table and figure, about 30% the causes were decreased level of consciousness, 10% hypoxia, 28% post cardiac arrest, 6% decreased level of consciousness + hypoxia, 8% decreased level of consciousness + hypoxia + tachypnea, 22% hypoxia + tachypnea and 2% decreased level of consciousness + hypoxia + tachypnea + post cardiac arrest. See Table 4.3 in A 3.

4.4 Classification of the subjects according to methods of ETT placement confirmation:

The patients was classified according to methods of ETT placement confirmation as presented in Fig. 4.4, about 92% of them was confirmed by clinical method, 2% by capnography, there was no use of other method like ultrasound, chest x ray and esophageal detector device. See Table 4.4 in A 4.
4.5 Classification of the subjects according to monitoring:

All patients understudy were 100% monitored by pulse oxymetry for oxygen saturation (SPO₂), whereas only one patient was monitored by ETCO₂. (Fig.4.5) please see Table4.5 in A 5.

4.6 Classification of the subjects according to complications:

Different complications were observed in the study subjects including death (Fig. 4.6). Twenty eight of the patients got various complications while 22 of them were free of complications. Please see Table 4.6 in A 6.
Fig. 4.6: Classification of the subjects according to complications
4. DISCUSSION

Based on the reviewed studies, various methods have been identified to verify ETT placement in adult patients, including bilateral auscultation of chest and palpation of symmetrical chest movements, visualization of the ETT pass throughout the vocal cords, ultrasonography, esophageal detector devices, chest X-ray, pulse oxymetry and capnography (Jordan et al., 2015).

The study showed that 50% of intubated adult patients were selected from Khartoum North teaching hospital, 10% from Ibrahim Malik Teaching Hospital and 20% for each of Omdurman Military Hospital and Ribat University Hospital. However, this distribution showed that Khartoum North Teaching Hospital was the highest hospital that received most of the cases (Fig. 3.2) and this may account to its location in the center of the three cities (Khartoum, Omdurman and Khartoum Bahri).

This study revealed that 30% of patients who got endotracheal intubation were due to decreased level of consciousness (fig. 3). Altering of the consciousness level is serious and risk for losing patency of airway protection and aspiration of gastric contents ultimately may lead to aspiration pneumonia. Margolis, (2003) reported that any patient who has decreasing of consciousness level, will not be able to control the soft tissues which leads to partially or completely obstruct the airway, furthermore, this patient cannot clear small amount of secretions or vomit substantially, his risk for aspiration will increase. This result agreed with the findings of McPherson and Stephens (2012) who suggested that patients with a reduced conscious level are unable to clear their own secretions and cannot protect their own airway. A Glasgow Coma Scale of 8/15 or below is often considered the threshold at which intubation is necessary. Patients with reduced conscious level are at risk of aspiration and alveolar hypoventilation, with development of hypercarbia and respiratory acidosis. While Dun can and Thakore (2009) reported that a Glasgow coma scale score of 8 or less indicates a need for endotracheal intubation, however, the loss of airway reflexes and risk of aspiration cannot be reliably predicted using the GCS alone.
Also the present results, shows that 10% of patients were intubated presented with hypoxia (fig.3). That could be related to hypoxia leading to risk of anoxic encephalopathy and brain death. Desaturation to below 70% puts patients at risk for dysrhythmia, hemodynamic decompensating, hypoxic brain injury, and death (Mort, 2004; Davis et al., 2008). This results in agreement with result of Scott D et al., (2011) who found that patients requiring emergency airway management are at high risk of hypoxemic hypoxia because of primary lung pathology, high metabolic demands, anemia, insufficient respiratory drive, and inability to protect their airway against aspiration and tracheal intubation is often required before the complete information needed to assess the risk of peri-procedural hypoxia is acquired.

This research shows that 28% of patients post cardiac arrest were intubated in ICU in present study (fig.3). The earlier endotracheal intubation during cardiopulmonary resuscitation might be beneficial for clinical outcomes following intra-hospital. (Chih et al., 2016) reported that intubation within 8.8 min appears favorable for both neurological and survival outcomes. Nevertheless, this goal should be attempted by clinicians who experienced in intubation to avoid potential complications and harm.

The present study shows that 92% of patients were confirmed for endotracheal intubation position by clinical method.(fig.4). That could be due to faster and easier use of clinical method in verification of endotracheal tube position except in some cases of difficult intubation like when you can’t visualize the vocal cord or you could not auscultate, In the emergency setting, visualization of endotracheal tube placement may be limited. Hence, with the significant morbidity and mortality associated with incorrect placement in critically ill patients, reliable endotracheal tube insertion confirmation procedures are essential. Auscultation of the chest, left upper quadrant, end tidal CO2 monitors, esophageal detector devices, as well as other methods, are currently used as confirmation procedures. However, each of these has disadvantages in the emergency setting and can lead to false-positive results. (Grmek 2002; Cunningham et al., 2002; Tanigawa et al., 2000; Tanigawa et al., 2001)

The current results show that about 2% of confirmation method of endotracheal intubation was detected by capnography (fig. 4). The capnography is a good and simple method of detection of ETT position but it is not available all the time in our hospitals. (Dittrich, 2002) an advantage of using capnography is that the method may be more easily applied without the need.
for specific expertise, compared with ultrasound. Also Dittrich, (2002) reported that capnography is the most reliable method for verification of the ETT position and had the highest sensitivity and specificity.

However the current results obtained that the ultrasound, chest x ray and esophageal detector device were not detected in the present study. (fig.4). that could be related to these methods not available and useful in our hospitals. This study is not agreement with the result of Drescher et al., (2000); Galicinao et al.,(2007); Sustic(2007); Kim(2013); Shibasaki et al., (2010); Hsieh et al.,(2004); Oulego et al., (2012) which confirm that Ultrasonography has been used in airway management to investigate anatomy, estimate the size of the ETT, verify ETT placement, and detect one-lung intubation. Also Chou et al.,(2015) concluded that ultrasonography has high diagnostic value for identifying esophageal intubation. With optimal sensitivity and specificity, ultrasonography can be a valuable adjunct in this aspect of airway assessment, especially in situations where capnography may be unreliable.

This study confirm that all patient understudy monitored by pulse oxymetry for oxygen saturation (SPO2), whereas only (2%) monitored by ETCO2. (Fig.5).That could be related to availiapality and simple use of pulse oxymetry for monitoring of the oxygen saturation .Zhang and Wang, (2007) reported that a pulse oxyemeter is a medical device that indirectly monitor the oxygen saturation of a patient’s blood and changes in blood volume in the akin, producing a photoplethysmograph. However, Nagler and Krauss, (2008) found that capnography provides continuous, dynamic assessment of the ventilator status of patients.

This research shows that 12% of patient had developed a hypoxia immediately after intubation (fig 3.6). prompt recognition of oesophageal intubation is vital to prevent hypoxia in the apnoeic patient. It may be recognized by gurgling sounds over the epigastrium on auscultation, abdominal distension and absence of breath sounds on the thorax. However all such clinical tests are flawed, and precious lives and brains have been lost by relying on clinical signs of oesophageal intubation. The only certain method of confirming correct placement of the ETT is to visualise its passage though the vocal cords; unfortunately this is not possible during a difficult intubation, a common situation in which oesophageal intubation occurs. End tidal CO2
monitoring is essential to confirm tracheal placement of the ETT. Passage of a fibreoptic bronchoscope through the ETT and visualization of the tracheal rings and carina also confirms tracheal placement, but is not universally available. Hypoxemia occurring soon after ETI may be due to unrecognized oesophageal intubation. Every attempt should be made to confirm correct placement. There may sometimes be difficulty in deciding whether the tube has been correctly placed; if there is any doubt, the tube should be withdrawn and reintroduced. The old maxim “when in doubt, take it out” still holds true. (Divatia J. and Bhowmick K. 2005)

Pre-oxygenation should be used routinely as it dramatically prolongs apnoea time before critical desaturation. (Tanoubi I et al 2009)

Unrecognized oesophageal intubation is rare, but the litigation literature and NAP4 reconfirm its importance. In the ASACCP, oesophageal intubation accounts for 14% of respiratory claims. (Caplan et al 1990, Cheney et al 1991, Domino et al 1999, Peterson et al 2005) In 77%, there was no evidence of difficult intubation: 92 of 94 cases died (81%) or suffered permanent brain damage (17%). Oesophageal intubation claims are predominantly successful (82%) and expensive. In the 1990s, the proportion of respiratory claims for oesophageal intubation decreased to 6%, but the absolute number decreased only modestly and still more than 90% led to death or brain damage. Claims are notable for errors of diagnosis with most cases precede by false-positive clinical signs of successful tracheal intubation (auscultation in >60%) and diagnosis most commonly by subsequent cardiovascular collapse. Cyanosis was reported in 34% of cases and cardiovascular collapse in 84%. Misdiagnosis was contributed by ‘preconceived notions of likelihood’, ‘reflex clinical behaviours’, ‘conflicting environmental data’, and ‘the potential for a rapid and poorly reversible clinical cascade’. In the Canadian dataset, oesophageal intubation accounted for 9 of 33 claims: 7 were during not difficult intubations; 6 died or suffered brain damage.37 In the UK dataset, four claims describe oesophageal intubation (6% of airway claims), including three deaths and one of brain injury.1 None recorded ‘airway difficulty’. Capnography was rarely used in any of the reports and where available judgements as to quality of care were highly critical.

In the AIMS study, 35 oesophageal intubations (1 death) accounted for 1.75% all reports and 41% of all TT-related reports.47 In NAP4, there were 11 oesophageal intubations (4% of
reports) causing 6 deaths and 1 brain injury (64% event mortality rate, 16% of all deaths). (Cook et al 2011). All were judged avoidable. Although more than half occurred outside theatres and were associated with failure to use capnography, four occurred during routine anaesthesia and failure to correctly interpret capnography, particularly during CPR, contributed. A flat capnography trace should be assumed to be because of oesophageal intubation until that has been actively excluded. (Cook et al 2011). It is easy to assume oesophageal intubation is only of historical importance. The literature shows it is not.

This research shows that 8% of patient undergoing bronchospasm this could be due to presence of an ETT in the trachea produces reflex bronchoconstriction. (Hawthorne et al 1996). Bronchospasm may be especially severe in the lightly anaesthetized patient with reactive airways. Bronchospasm may be blunted by the prior administration of anticholinergics, steroids, inhaled β2-agonists, lignocaine (topical, nerve block, intravenous), and narcotics. After intubation, deepening anaesthesia with intravenous or inhaled agents and the administration of inhaled or intravenous β-agonists are helpful. It is important to ensure that the audible wheezing is not due to mechanical obstruction of the tube or other causes, such as tension pneumothorax, or heart failure.

Also this research shows that 20% of patient died, the NAP4 reported that at least 25% of major airway events were from ICU or the ED. The outcome of these events was more likely to lead to permanent harm or death than events in anaesthesia (anaesthesia 14%, ED 33%, ICU 61%) and to be avoidable. Overall the incidence of death or brain damage from an airway event was 38-fold higher in the ED and 58-fold higher in the ICU compared with anaesthesia, and ~1 in 3000 ventilated patients. (Whitaker 2011). Even accepting the different case-mixes, these findings are startling. Analysis of the cases identified gaps in care that included poor identification of at-risk patients, poor or incomplete planning, inadequate provision of skilled staff and equipment to manage these events successfully, delayed recognition of events, and failed rescue because of
lack of or failure in interpretation of capnography. The frequency with which reports were judged to describe poor care was higher in ICU and ED than in anaesthesia.
Chapter Five
Conclusion and Recommendations
5.1 CONCLUSION

This study concluded that confirmation method of endotracheal tube placement is by clinical assessment and monitoring by pulse oxymetry in our hospital in Sudan. The clinical method of ETT position confirmation is acceptable in our hospitals but it cannot be enough as a sole and ideal confirmation method for detection of ETT placement. Also it is not acceptable for medicolegal aspect.

5.2 RECOMMENDATIONS

This study recommended that, the other method of ETT placement confirmation is important to make sure for the patient health and safety, so we recommend the health authorities to save others confirmation methods such as capnography and X ray and providing a good training for the anesthesia providers about how to use it correctly. Also further studies are recommended.
References


J. Hope Kilgannon, MD; Alan E. Jones, MD; Nathan I. Shapiro, MD, MPH; Mark G. Angelos, MD; Barry Milcarek, PhD; Krystal Hunter, MBA; Joseph E. Parrillo, MD; Stephen Trzeciak, MD, MPH.(2010). Association Between Arterial Hyperoxia Following Resuscitation From Cardiac Arrest and In-Hospital Mortality FREE. the Emergency Medicine Shock Research Network (EMShockNet) Invest. 303(21):2165-2171.


Appendix list
Appendix 1

Table 4.1: Shows distribution of the study subjects according to age:

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;30</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>30-49</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>50-69</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>≥70</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td>100</td>
</tr>
</tbody>
</table>

Appendix 2

Table 4.2: Shows distribution of the study subjects according to hospitals:

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Khartoum North Teaching Hospital</td>
<td>25</td>
<td>50</td>
</tr>
<tr>
<td>Ibrahim Malik Teaching Hospital</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Omdurman Military hospital</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Ribat University Hospital</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td>100</td>
</tr>
</tbody>
</table>

Appendix 3

Table 4.3 Shows distribution of the patients according to causes of intubation:
### Causes

<table>
<thead>
<tr>
<th>Causes</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decreased level of consciousness</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>Hypoxia</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Tachypnea</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Post cardiac arrest</td>
<td>14</td>
<td>28</td>
</tr>
<tr>
<td>Decreased level of consciousness + hypoxia</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Decreased level of consciousness + hypoxia + tachypnea</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Hypoxia + tachypnea</td>
<td>11</td>
<td>22</td>
</tr>
<tr>
<td>Decreased level of consciousness + hypoxia + tachypnea + post cardiac arrest</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>50</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

### Appendix 4

**Table 4.4:** Shows classification of the patients according to methods of ETT placement confirmation

<table>
<thead>
<tr>
<th>Methods</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical method</td>
<td>49</td>
<td>92</td>
</tr>
<tr>
<td>Capnography</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Ultrasound</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Chest x ray</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Esophageal detector device</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>50</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

### Appendix 5
Table 4.5: Shows classification of the patients according to monitoring:

<table>
<thead>
<tr>
<th>Monitoring</th>
<th>Yes</th>
<th>No</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>%</td>
<td>Frequency</td>
</tr>
<tr>
<td>SPO₂</td>
<td>50</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>ETCO₂</td>
<td>1</td>
<td>2</td>
<td>49</td>
</tr>
</tbody>
</table>

Appendix 6

Table 4.6: Shows classification of the patients according to complications

<table>
<thead>
<tr>
<th>Complications</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypoxia</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Barovulo trauma</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Bronchospasm</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Death</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Hypoxia + death</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>Barovulo trauma + death</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>No complications</td>
<td>22</td>
<td>44</td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td>100</td>
</tr>
</tbody>
</table>

Appendix 7
Figure (2.1) esophageal detector devices.

Appendix 8

Figure (2.2) Sidestream Carbon Dioxide Sampling Line Connected to a Breathing Circuit.

Appendix 9

Figure (2.3). Colorimetric Carbon Dioxide Detector

Appendix 10
Appendix 11

Figure (2.5) The power Doppler box displays color representing movement of the two layers.

Appendix 12

Figure (2.6) the bright interfaces of the parietal and visceral pleura are seen (arrows).
Appendix 13

Figure (2.7) trachea and esophagus appear in ultrasound

Figure (2.8) double tract sign

Appendix 14
Figure (2.9) Position of the probe on the patient's abdomen

Figure (2.10) (a) Diaphragm view in the right subcostal area before ventilation. (b) Right side diaphragm position during the positive-pressure ventilation

Appendix 15

Figure (2.11) 1 Tip-carina-distances: (1) ETT tip > 2 cm above the carina and below the level of the larynx, (2) borderline area of ≤2 cm above the carina, and (3) endobronchial intubation.

Appendix 16
Appendix 17

Questionnaire

1-Personal data

No...

Mobile number (……………………………)

Age………..years.

2-causes of admission to ICU

Shock (……..)       Respiratory failure (……..)       Infection (……..)

Renal injury or failure (……..)       Neurological condition (……..)

Bleeding and clotting (……..)       Postoperative patient (……..)

Figure (2.12) Endotracheal Tube (ETT) Too Low. The tip of the endotracheal tube (blue arrow) is in the right mainstem bronchus so that only the right lung is aerated and the left lung is completely atelectatic (black arrow). The tip of the ETT should normally be about 5 cm above the carina (white arrow).
Cardiovascular condition (……..) Other (……………………)

3-causes of intubation and mechanical ventilation
Decresed level of consciousness (………..)
yhypoxemia (……….)
Tachypnea (………..)
postcardiac arrest (………..)

4- Method of ETT placement confirmation

Direct visualization of an endotracheal tube passing through vocal cords into the trachea (…………) symmetrical equal bilateral chest wall movement (…………) Auscultation (…………) chest radiography (…………)

Ultrasound (……….) capnography (……….)

5-Duration of staying in mechanical ventilation (………..) days

6-Complication of intubation
Bronchospasm (………..) Esophageal intubation (………..)
bronchia intubation either right or left (………..)

Laryngeal edema (………..) hoarseness (………..)

7- Complication of mechanical ventilation
Barotrauma or volotrauma (………..)