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Research paper

Cuff pressure monitoring by manual palpation in intubated patients: How accurate is it? A manikin simulation study

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ABSTRACT

Background: Endotracheal intubation (ETI) for mechanical ventilation has a central role in the Intensive Care Unit (ICU). ETI is one of the main risk factors for the development of ventilator-associated pneumonia (VAP) as its presence reduces the natural defences of the upper airway and allows the micro-suction of secretions in the airways. In order to minimise such complications, it is fundamental to maintain a suitable pressure inside the tube cuff.
Aim and scope: The main objective of the present study is to evaluate the effectiveness and reliability of palpation method, performed with the operators fingers, for detecting the tube cuff pressure.
Results: The study was performed using a manikin to test the pressure of the ETT cuff, on a sample constituted by nurses employed in three Italian ICU from two different Umbrian hospitals.

From a total of 68 participants, detection by palpation method revealed to be not correct in 68% of cases; in particular, only 10% of respondents can correctly detect a pressure in the recommended range (20–30 cmH_2O) using palpation.

Moreover it was possible to highlight that the participation in emergency courses has a positive effect on the correct measurement of cuff pressure using the palpation method (V = 0.501).
Conclusions: The study, in agreement with the literature, confirms the thesis that the palpation method is inadequate to determine an estimate of the pressure existing inside the cuff.

1. Introduction

Endotracheal intubation (ETI) for mechanical ventilation is central to the Intensive Care Unit (ICU), but it can be related to a number of complications. The clinical complexity of critical care produces in patients an ICU-associated infection 5–10 times higher than that in other hospital wards. This phenomenon is mainly due to two factors: the frequent use of invasive diagnostic and therapeutic maneuvers and the increasing spread of antibiotic resistance.[1,2]

Literature defines Healthcare-Associated Infections (HAIs) as infections acquired in the hospital or other care facilities, and that were not present or were incubating at the time of admission.[3] HAIs are the most frequent and severe complications associated with health care activities, and therefore have significant impacts on the outcome, and represent an important criterion in assessing the quality of care. Scientific literature unanimously confirms that the mortality rate is higher for infected patients compared to uninfected ones, and that infections result in longer hospitalisation and an increase in care-related costs.[1]

The most frequent ICU-related HAIs are those related to central venous catheters (CVC), sepsis and Ventilator-Associated Pneumonia (VAP).[4] Lung infections (HAP, hospital-acquired pneumonia) account for about 64% of all infections in the ICU, 83% of which are

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due to mechanical ventilation, according to data from the National Nosocomial Infection Surveillance (NNIS).[1,2,5,6–8]

The endotracheal tube (ETT) is one of the main risk factors for the development of VAP as its presence reduces the natural defences of the upper airway and promotes the micro-suction of secretions into the lower airways. A biofilm is formed that causes an increase in bacterial load and colonisation of the airway, digestive tracts and circuit connected to the ETT. From a pathophysiological point of view, the onset of VAP is due to two main processes: the colonisation of the gastrointestinal and respiratory tract and the micro-suction of secretions into the airways.[9,10]

In the management of the artificial airway, it is fundamental to maintain suitable pressure inside the tube cuff in order to minimise such complications as much as possible. The cuff is a balloon that, when inflated, supports the tracheal wall and occludes its lumen, providing an anchor and avoiding self-extubation. Moreover, if correctly inflated, it allows ventilation, reduces the risk of inhalation of secretions into the supraglottic space and ensures maintenance of the prescribed tidal volume (Vt) during ventilation.

There are various methods to insufflate air into the tube cuff. The gold standard for cuff pressure (Cpressure) measurement involves the use of analog[11] or digital[12] manometers, and it is recommended for both pediatric and adult patients.[11,13,14]

The injection of air into the cuff with a syringe is still the most widely used method because it is simple, fast and cheap,[15] but the relationship between the volume injected and the pressure detected in the tracheal wall (C-T pressure) is not linear and can cause the phenomena of overinsufflation, due to the distension of the cuff in 30–98% of the cases. This phenomenon depends on the type of tube used, the population studied and the clinical context.[13–17]

In normotensive patients, the tracheal wall capillary blood flow is compromised with a pressure of 30 cmH_2O and blocked with a pressure of over 50 cmH_2O. The symptoms most frequently associated with ETI are sore throat, dysphagia and hoarseness. However, these appear to be more strictly related to the type of tubing used rather than to the cuff pressure.[18]

On the other hand, if the cuff has insufficient inflation, it increases the risk of the translocation into the trachea of microaspirations of gastric contents and secretions of a contaminated oral cavity, thus causing potentially life-threatening pneumonia and bronchitis, as well as increasing the risk of accidental extubation and self-extubation, due to the lower seal of the ETT. A previous study has shown that if the pressure inside the cuff is kept below 20 cmH_2O, the risk of the occurrence of VAP is increased by four times compared to higher cuff pressure values.[19]

Partial occlusion of the ETT is associated with an increase of the respiratory work and a marked increase of the weaning time from the mechanical ventilator.[20,21] There also seems to be a correlation between the obstruction of the ETT and the cuff pressure changes during the inspiratory peak pressure.[22] Despite these considerations, the assessment of the correct cuff inflation pressure is often carried out through the widespread palpation method which is faster, but less accurate than the manometer.[23–26]

2. Aim and scope

The main objective of the study was to evaluate the effectiveness and reliability of the palpation method performed by the operators' fingers, for detecting ETT cuff pressure.

From a total of 68 participants, detection by the palpation method revealed errors in 68% of the cases. In particular, only 10% of participants correctly detected a cuff pressure in the recommended range of pressure (20–30 cmH_2O) using palpation.

Moreover, participation in emergency courses had a positive effect on the correct measurement of cuff pressure using the palpation method (V = 0.501).

3. Background

The critical care patient's clinical complexity produces an ICU-associated infection rate 5–10 times higher than in other hospital wards. This phenomenon is mainly due to two factors: the frequent use of invasive diagnostic and therapeutic maneuvers and the increasing spread of antibiotic resistance.[1,2] From a pathophysiological point of view, the onset of VAP is due to two main processes: the colonisation of the gastrointestinal and respiratory tracts and the micro-suction of secretions into the airways.[9,10]

4. Materials and methods

The study was conducted in the period June–July 2015 on a convenience sample of 68 nurses employed in three Italian ICUs. It was performed using a manikin to test the pressure of the ETT cuff.

The study was carried out with: (a) an intubating manikin (LaerdalSimMan®, Laeder Medical AS, AUS); (b) an endotracheal tube, in PVC Kim Vent Micro cuff for adults (Kimberly-Clark ™, Roswell, GA, USA), size 7.5 mm internal diameter (ID), oro-nasal tip Magill, Murphy eye, radiopaque; (c) a Macintosh laryngoscope, blade n. 3; and (d) a manual manometer (Mallinckrodt®, Mallinckrodt, USA).

The ETT was inserted each time to the same length of 22 cm from the mouth. The tube cuff was inflated with air by the researcher using a 20 ml syringe and the manual manometer, to the desired pressure value.

The sample consisted of nurses employed in three Italian ICUs from two different Umbrian hospitals: the Intensive Care Unit (ICU 1) and the Post-Operative Cardiac Surgical Intensive Care Unit (ICU 2) of the University Hospital of Perugia, "Santa Maria della Misericordia,Perugia, and the Intensive Care Unit of the Gubbio-Gualdo Tadino Hospital, Gubbio, USL Umbria 1, Umbria (ICU 3).

During data recording each participant was asked to fill out a personal information file containing information on his/her training, professional experience and academic background. After the researchers intubated the manikin, the cuffs were inflated with pressures that were randomly higher, lower or equal to the recommended range (20–30 cmH_2O).[6] Lower pressure values ranged from 10 to 19 cmH_2O, while higher ones were from 31 to 50 cmH_2O. Then each nurse was asked to determine the value of the tube cuff pressure with the palpation method. Each nurse had one attempt to estimate the cuff pressure.

4.1. Study protocol and design

The structure of the data collection form was designed by consulting previous studies,[24,26] and drawn up in such a way as to exclude the traceability of the respondent, in compliance with the Italian Privacy Law. The study protocol was approved by the Health Department of the University Hospital of Perugia, USL 1 Umbria, and the President of the School of Nursing of the Perugia University. We presented the study and its aims to nurses. Participation and signing up for the protocol was voluntary. This study did not require informed consent.

4.2. Statistical analysis

The collected data was processed using the statistical program Stata 14 (Copyright 1996–2015 StataCorp LP, 4905 Lakeway Drive,