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Cuff pressure analysis of intensive care unit patients with different inclinations of the head section of the bed

Análise das pressões de balonetes em diferentes angulações da cabeceira do leito dos pacientes internados em unidade de terapia intensiva

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ABSTRACT

Objectives: Correct cuff inflation allows appropriate ventilation, and prevents aspiration pneumonia as well as several tracheal complications. The objective of this study was to evaluate endotracheal cuff pressure and/or tracheotomy tubes at zero, 30 and 60 degrees inclination of the patient's bed head section in adult intensive care units.

Methods: A cross sectional study was carried out evaluating the cuff pressure, the expiratory tidal volume (VT) and the peak airway pressure (PP) at inclinations zero, 30 and 60 degree of the head section of the patients' bed. The 30 degree inclination was considered the standard position used as control to analyze values in the zero and 60 degree positions, which were randomly ordered. The Student's *t* test was used and was considered significant when $p < 0.05$.

Results: A sample of 12 women and 12 men with a mean age of 51.29 ± 19.55 years was surveyed. When inclination of the bed head section was changed from 30 to zero degrees, there was a 16.9% mean reduction of the cuff pressure and 11.8% mean increase of the PP. On the other hand, changing the position from 30 to 60 degrees caused a mean reduction of 18.8% in the cuff pressure and a mean increase of 13.3% in the PP. Findings were significant when $p < 0.05$.

Conclusions: To prevent air leak and risk of aspiration pneumonia, adequate adjustments and monitoring of the patients cuff pressure are necessary when inclination of the bed head section is changed.

Keywords: Pneumonia, aspiration/prevention & control; Inpatients; Intubation, intratracheal/instrumentation; Tracheostomy/instrumentation

INTRODUCTION

Invasive mechanical ventilation is a support offered to the patient with an impaired ventilatory function. For its application an artificial airway must be used aiming to maintain adequate pulmonary ventilation[1-5].

The artificial airways most often used in invasive mechanical ventilation (MV) are the tracheal tubes (TT) and tracheostomy tube. Normally these present with cuffs[2-4] on their lower extremity and their function is to seal the trachea and avoid reflux of gastric content into the lower respiratory tract (a common cause of pneumonia) and inspired gas leak during artificial ventilation[2,5-7].

Mucosa of the tracheobronchial tree is very delicate and formed by a single epithelial layer of ciliated cells, where contact, even if minimal, in a short time period causes injuries[3,5,6]. Aware of this it is important to stress that even maintaining the cuff pressure at values lower than those of the

limit pressure, some degree of obstruction in the arterial, venous and lymphatic tracheal vessel flow may occur[2,3]. Therefore, presence of an artificial airway with cuffs for prolonged periods may eventually cause ischemia in the tracheal region and complications in the airways such as hemorrhage, stenosis, tracheal necrosis, granuloma, and tracheomalacia[2-11].

It is recommended that initially, inflation of the TT or tracheostomy tube cuff be made to generate a "seal pressure"[3,6,7] aiming to seal the airway to stop leakage of the inspired gas volume, however this inflation does not obligatorily block aspiration of the gastric content or of fluids coming from the upper airways[3-5].

According to current literature, folds may form on the walls of the cuff during inflation, influencing formation of small conduits that favor passage and possible aspiration of the pharyngeal content[3]. Therefore, it is recommended that the relation between cuff and the trachea diameter be as near as possible, to avoid formation of these folds and that pressure remains between 15 to 40 cmH_2O[1-8]. A pressure higher than 15 cmH_2O safely avoids gastric aspiration and a pressure higher than 40 cmH_2O already impairs perfusion of the tracheal mucosa[4-8].

In hospital routine it is noted that professionals neglect measurement of cuff pressure[2,4-8]. When verification is carried out, it usually is made by digital palpation of the external cuff (pilot) which is not a reliable measurement[2,5-9]. Therefore, measurement of pressure by methods considered safer and more reliable is required[3,5,6] such as use of a cuff manometer, a specific device for measuring these pressures.

Currently studies have shown the need for measurement and maintenance of cuff pressures within values considered normal[5], however there are few reports in literature as to when they should be analyzed. It should be emphasized that the Brazilian Consensus on Mechanical Ventilation[1] suggests that this pressure be checked daily, however no study was found to orient analysis of this pressure, after changing the angle of inclination of the bed's head section.

The importance of this work is based on assessment of the cuff pressures from zero, 30, and 60 degrees inclination in the head section, which are positions widely used in the intensive care unit (ICU) by the entire multidisciplinary team. Therefore it is justifiable to study and understand if changes in position within these angles cause loss of cuff pressure in patients using artificial airways and mechanical ventilation. With this study, it will be possible to identify such situations and suggest adequate and routine verification of cuff pressures.

METHODS

After approval by the Ethics in Research with Human Beings Committee of UCB (n. 058/2005), a cross sectional descriptive study was carried out in the discipline of Supervised Probation in ICU, of the Physiotherapy Course at "Universidade Católica de Brasília (UCB)" during the second term of 2006.The behavior of cuff pressures was analyzed and compared in different angles (zero, 30 and 60 degrees) of inclination of the head section of the bed of patients who used TT or tracheostomy tubes in mechanical ventilation (MV).

Inclusion criteria were eutrophic; patients, sedated, synchronized with MV; in the controlled mode or assisted-controlled volume; with an, at least 15 days permanence with use of artificial airway with functioning cuff; without diagnosis of former pulmonary disease, with hemodynamic stability; and without any type of restriction for elevating the head section.

Exclusion criteria were: postoperative of specific otorrhinolaryngology or orthopedic surgeries that would hinder mobility of the hip and/or spine and patients who for any other reason had been ruled out of collection.

For patient selection and data collection a specific evaluation card with personal data (name, age, gender), hospital records, ICU bed number, type of artificial airway used (TT/ tracheostomy tube) and their respective number, clinical diagnosis and MV parameters – expired tidal volume (TV), respiratory rate (RR) fraction of inspired oxygen (FIO_2), inspiratory flow, peak airway pressure (PP) and positive end expiratory pressure (PEEP), were used.

To carry out the study protocol, initially the patient was positioned and maintained in the supine position with head/neck in neutral position aligned with the trunk, with a 30º inclination of the head section. Later, the need to carry out aspiration of the airways was analyzed taking into account pulmonary resistance, pulmonary auscultation and analysis of peripheral oxygen saturation that are the main indicators of this procedure[1].

After these cares, cuff pressure was measured in this position (30º), adopted as study control. If this pressure was not within the values considered suitable (between 15 and 40 cmH_2O)[1-8], it was adjusted. This procedure was performed with support of a cuff manometer VBM Medizintechnick Gmbh®, which permitted to measure and if necessary adjust this pressure to avoid peri-cuff air leak. Pressure control can also be associated to two other techniques that permit detection of air leak: visualization of the TV, obtained on the mechanical ventilator display and auscultation in the antero-lateral region of the neck, using

a Littmann Classic II® stethoscope.

After due adjustment of the cuff (balloon) pressure performed for each patient, the value of this parameter, together with TV and PP were collected in the position of 30° inclination of the bed's head section and considered as control values for the 0 and 60° angles. To avoid any possible statistical impact that the same sequence of variation of the inclination might have on results, the sequences were duly randomized. Furthermore, between one measurement and the other angulations, the patient was returned to the control position 30° for a resting period sufficient to stabilize all analyzed parameters in relation to those previously observed in the first measurement. If required cuff pressure was readjusted to the value initially set at the first control measurement, regardless of occurrence or not of air leak.

For the patient's positioning in the suggested angles (zero, 30° and 60°) a goniometer CARCI®, fitted on the lateral articulated side of the bed was used.

All procedures, such as measurement/control/adjustment of the cuff and angle variation of the bed head section are carried out routinely by the physiotherapy team.

Data were analyzed using SPSS software and expressed in mean, standard deviation and percentage. The Student's t test was used to verify if there was a statistically significant difference among data. Values of $p \leq 0.05$ were considered significant.

RESULTS

The sample was comprised of 24 patients12 men and 12 women with a mean age of 51.29 ± 19.55 years (minimum 19 and maximum 83 years).

Values of the variables studied, in the positions zero and 60° were converted into percentage of variation in relation to the value measured in the control position (30°), prior to changing the head section's position. From this conversion resulted the variables: percentage of cuff pressure, percentage of peak airway pressure (%PP) and percentage of exhaled tidal volume (%TV).

Results disclosed that inclination of the bed's head section brought about statistically significant changes in cuff pressure values and in PP, as well as a marginal tendency of impact on exhaled tidal volume.

It was noted that when changing head section inclination from 30° to 0°, cuff pressure had a mean decrease of 16.9% while PP had a mean increase of 11.8%, statistically significant. But in the change from 30° to 60° this pressure showed a mean decrease of 18.8% and PP showed a mean increase of 13.3% ($p \leq 0.05$). Table 1 shows the values found for these variables in the mean and standard deviation and results of the Student's t test with p values.

When comparing rates of alteration of the parameters by inclination angle and gender it was impossible to perceive significant differences in results when men and women were compared.

DISCUSSION

Members of an ICU team are fully aware of the need and importance of tracheal intubation to assure adequate pulmonary ventilation and maintain the patient alive[12].

Thus, maintenance of an artificial airway with cuffs and adequate cuff pressure are necessary to avoid air leak[3,5,6,8], aspiration of the oropharyngeal and gastroesophageal contents and for protection of the trachea against possible injuries that may impair patient' recovery[5-8].

However, a situation that has attracted widespread attention is the absence of routine for measurement of cuff pressures in the ICU[5,8]. Some studies prove that, in most cases only an empirical control of the inflation is carried out by digital palpation of the pilot cuff[3,5,7], not warranting an adequate estimate[5,6,8]. As such, to generate a tight - tracheal "seal " pressure[5,6] use of a cuff manometer is mandatory[6,8] isolated or associated to the tracheal auscultation method[3,5,6].

Table 1 – Variation of the values of the cuff pressure, peak airway pressure and expired tidal volume at the zero and 60° angles in relation to control position (30º)

Inclinations	Variables	Mean± SD	p value
30º to zero	cuff pressure (%)	(-) 16.9 ± 19.7	0.000 *
	PP (%)	11.8 ± 24.86	0.029 *
	TV (%)	6 ± 18.09	0.077
30º to 60º	cuff pressure (%)	(-) 18.8 ± 20.65	0.000 *
	PP (%)	13.29 ± 22.77	0.009 *
	TV (%)	3.42 ± 9.84	0.102

SD - standard deviation, PP - peak airway pressure, TV - expired tidal volume. (-) negative value: represents decrease of values found for the studied variables; *: significance with $p \leq 0.05$

In this study it was observed that when changing the bed's head section inclination from 30° to 0° and from 30° to 60°, there was a mean decrease of 16.9% and 18.8% respectively in the cuff pressures. This leads to the belief that this significant change is an important factor that may affect ideal sealing of the trachea by the cuff, predisposing the mechanically ventilated patient to aspiration of the oropharyngeal content, to air leaks and ventilation damage, which would worsen the clinical setting[4-8].

As a final result of this process, the patient may present inadequate pulmonary ventilation, which will reduce oxygen supply and therefore alter gas exchange[4-8]. Furthermore, it is noteworthy that association of tracheal intubation with changes in the consciousness level of ICU patients allows respectively, occurrence of cough and swallowing reflex depression[13] in addition to reducing efficacy of the upper airways' defense mechanisms such as the oropharyngeal and ciliar epithelium[14,15]. It is well known that these factors increase risk of aspiration of the oropharynx content contributing to development of aspiration pneumonia[13-15], very common in this setting[16] , with a 7 to 21 times higher incidence in intubated patients when compared to those that do not need this device[17].

Based upon findings of this study it was noted that a significant decrease of cuff pressure in the different inclination angles of the bed's head section becomes a risk factor for critically ill patients requiring use of ventilatory prosthesis.

Current literature on the subject suggests a bed's head section inclination of at least 30°, varying to 45° [13]. It is proven that in these positions incidence of aspiration pneumonia is reduced in ICU patients, mainly those using an artificial airway[19-21]. Moreover, lateral positioning was suggested as an adequate procedure to avoid airway infection[13,22,23]. Thus, apparently appropriate drainage and/or prevention of gastric regurgitation are eased[13,19-21,24].

Notwithstanding evidence of efficacy of postural maintenance of the bedridden patients, often when they are mechanically ventilated in intensive care they are not maintained in a position of head section inclination intended to minimize development of nosocomial pneumonia[13]. With this study, it was seen that often during the day in clinical practice the patient is maintained for short periods in the zero degree position. This is routine at hygiene care of patients, when changing decubitus (which takes place every 2 hours) and to carry out certain exams and procedures.

In this sense the study of Ibáñez et al.[25] stated that the head section position at 45 ° would be a way of avoiding pulmonary aspiration, not fully preventing occurrence of gastroesophageal reflux in patients using a nasogastric catheter.

The study by Drakulovic et al.[21] suggests that use of head section inclination at zero degrees while patients receive enteral nutrition should not be a standard in the ICU, because association of these factors (inclination and tube feeding) may favor an increased incidence of aspiration pneumonia[20,21].

Although focus is centered on the consequence of positioning the head at less than 30° which by itself is considered a significant factor facilitating occurrence of nosocomial pneumonia, it cannot be ignored that this position also facilitates depressurization of the cuff, that in the current study decreased by 16.9%. Such depressurization may potentialize appearance of respiratory infections. Faced with this situation every specialized team must be aware of and carry out the appropriate monitoring and adjustment of cuff pressure, whenever this positioning is really needed.

It is also habitual for the ICU team to position the head section at 60°, for different situations, be it for clinical intervention, for oral feeding of patients or for physiotherapeutic treatment as a rehabilitation proposal. In this case, this study showed that a decrease of the cuff pressure takes place (18.8%) only by changing the inclination from 30° to 60°. Thus the need for monitoring and for adjusting cuff pressure in this situation is confirmed also as a means to prevent occurrence of respiratory infections and impairment of ventilation.

In the study it was noted that when the bed's head section inclination was changed from the position of 30° to 0° and from 30° to 60 ° statistically significant changes took place in the values of peak airway pressures, undergoing a mean increase of 11.8% and 13.3% respectively. For these events it would be advisable to hypothesize that modification of the body position may have caused an inadequate position of the tube. Ferreira et al.[26], mentioned that inadequate positioning of the tube may cause alterations of peak pressure and plateau pressure of the airways, in addition to provoke hypoxemia and hypercapnia[26].

Attention must be given to this increase, because peak pressure is a risk factor for barotraumas[27]. Based upon results of this work, the need was observed for more rigorous studies relating peak pressure increase to inclination of the bed's head section.

This study clearly shows that gauging as well as adjustment of the cuff pressure to ideal values is a preventive measure that must become a routine practice in all intensive care centers. Furthermore, the work carried out by van Nieuwenhoven et al.[28] showed that there was a decreased incidence of nosocomial pneumonia during the

last 10 years. They also suggest a continued use of a minimum 20° inclination of the bed' head section for all ICU patients under mechanical ventilation.

CONCLUSIONS

This study discloses that use of different inclinations of the bed's head section – from 30° to 0° and from 30° to 60° - causes a decrease in cuff pressure, which does not permit a "seal" pressure justa-tracheal .

This fact stressed the importance of a routine gauging of this pressure whenever a change in inclination of the bed's head section is required. Preferably a cuff manometer should be used. Such care permits maintenance of the cuff pressure within the values considered ideal thereby preventing air leak and incidence of nosocomial pneumonia.

RESUMO

Objetivos: A correta insuflação do balonete permite ventilação adequada, além de ser uma das formas de prevenção de pneumonia aspirativa bem como de diversas complicações traqueais. O objetivo deste estudo foi avaliar as pressões de balonetes dos tubos traqueais e/ou cânulas de traqueostomia nas angulações de zero, 30 e 60 graus de inclinação da cabeceira do leito de pacientes internados em unidades de terapia intensiva adulta.

Métodos: Realizado estudo transversal, com análise da pressão de balonetes, do volume- corrente expirado (VC) e da pressão de pico das vias aéreas (PP) nas posições de zero, 30 e 60 graus. A angulação de 30 graus foi considerada posição de referência como controle para a análise do comportamento dos valores nas posições de zero a 60 graus, as quais foram escolhidas de forma aleatória. Utilizou-se o teste *t* de Student, sendo considerado significativo quando $p < 0,05$.

Resultados: Amostra composta por 12 mulheres e 12 homens, com média de idade de 51,29 ± 19,55 anos. Ao modificar a inclinação da cabeceira de 30º para 0º, houve redução média de 16,9% na pressão de balonete e um aumento médio de 11,8% na PP. Já na alteração de 30º para 60º, a pressão de balonete reduziu, em média 18,8% e a PP teve aumento médio de 13,3%. Os achados foram significativos ($p < 0,05$).

Conclusões São necessários a monitorização e os ajustes adequados da pressão de balonete, nos momentos em que o paciente for submetido a modificações na inclinação da cabeceira do leito, a fim de prevenir o escape aéreo e o risco de ocorrência de pneumonia por aspiração.

Descritores: Pneumonia aspirativa/prevenção & controle; Pacientes internados; Intubação intratraqueal/instrumentação; Traqueostomia/instrumentação

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