Subjective method for tracheal tube cuff inflation: performance of anesthesiology residents and staff anesthesiologists. Prospectve observational study

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Abstract

Background and objectives: Poor monitoring of tracheal tube cuff pressure may result in patient complications. The objective method of using a manometer is recommended to keep safe cuff pressure values (20–30 cmH2O). However, as manometers are not readily available, anesthesiologists use subjective methods. We aimed to assess appropriateness of a subjective method for attaining cuff pressure and the expertise level of manometer handling among anesthesiology staff and residents in a university teaching hospital.

Methods: Prospective observational study, recruiting participants that performed tracheal intubation and the subjective method for tube cuff inflation. Patients with difficult airway, larynx and trachea anatomic abnormality and emergency procedures were not included. Up to 60 minutes after tracheal intubation, an investigator registered the cuff pressure using an aneroid manometer (AMBU®) connected to the tube pilot balloon.

Results: Forty-seven anesthesiologists were included in the study – 24 residents and 23 staff. Mean (SD) and medians (IQR) measured in cmH2O were, respectively, 52.5 (27.1) and 50 (30–70). We registered 83% of measurements outside the recommended pressure range, with no difference between specialists and residents. The level of expertise with the objective method was also similar in both groups. Pressure adjustments were performed in 76.6% of cases.

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Insuflação de balonete de tubo traqueal por método subjetivo: desempenho de médicos residentes e especialistas em anestesiologia. Estudo prospectivo observacional

Resumo

Justificativa e objetivos: O controle inadequado da pressão dos balonetes dos tubos traqueais pode resultar em complicações. A técnica objetiva com uso de manômetro é a recomendada para manutenção de valores seguros de pressão (20–30 cm H₂O). Mas como este instrumento é pouco disponível, os anestesiologistas recorrem a técnicas subjetivas. O objetivo deste estudo foi avaliar a adequação da técnica subjetiva para obtenção das pressões dos balonetes e o nível de experiência com uso do manômetro entre médicos especialistas e residentes de anestesiologia de um Hospital Universitário.

Método: Estudo observacional prospectivo, com participantes que realizaram intubação traqueal e técnica subjetiva para insuflação dos balonetes. Pacientes com via aérea difícil, anormalidades anatômicas de laringe e traqueia, risco de broncoaspiração e os casos de emergência não foram incluídos. Até 60 minutos após a intubação, um investigador registrou a pressão do balonete utilizando um manômetro aneroide (AMBU®) conectado ao balonete guia do tubo.

Resultados: Quarenta e sete anestesiologistas foram incluídos no estudo – 24 residentes e 23 especialistas. As pressões (cm H₂O) média (DP) e mediana (IQR) encontradas foram respectivamente: 52,5 (27,1) e 50 (30–70). Da amostra, 83% estavam fora da faixa adequada de pressão, sem diferença entre especialistas e residentes. O nível de experiência com a técnica objetiva também foi semelhante entre os grupos. Correção da pressão foi realizada em 76,6% dos casos.

Conclusões: A técnica subjetiva para insuflar os balonetes dos tubos traqueais resultou em alta prevalência de pressões inadequadas, sem diferença no desempenho entre especialistas e residentes.

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manometers to perform the objective method for setting such pressures. The assumption was that tracheal tube cuff inflation using the subjective method would result in a high prevalence of cuff pressures above or below the recommended limits, and that the knowledge of recommended cuff pressure levels and the level of expertise with manometers would be low, with no significant difference between staff and residents.

**Methods**

This observational prospective study was performed between June and November, 2016 at a university teaching hospital, after approval by the Ethics in Research Committee of the organization (CAAE: 44486515.7.0000.5208). All ethical aspects related to research with human subjects were obeyed.

After obtaining patients’ informed consent, 48 subjects with ages ranging from 18 and 65 years underwent general anesthesia with placement of a tracheal tube and the subjective method with inflation and digital palpation of the pilot balloon to establish the cuff pressure. The laryngoscopy, tracheal intubation and cuff inflation were performed by staff physicians with specialization in anesthesia, or by resident year 1 (R1), resident year 2 (R2) or resident year 3 (R3) anesthesia medical residents. Patients presenting anticipated difficult airway, risk of bronchoaspiration, previously known tracheal or larynx anatomic abnormality or emergency procedures were excluded. We used the orotracheal technique in all patients, with 8 or 8.5 mm internal diameter tubes for males and 7 or 7.5 mm for females.

Up to 60 minutes after tracheal intubation, the cuff pressure was measured by the investigators using the objective method with an analogic manometer (AMBU®) connected to the pilot balloon. Data was registered on a dedicated form.

Whenever the pressure was outside the recommended limits, the physician in charge of the case was communicated by the investigator, so the physician could make a decision on correcting the finding.

The sample size was estimated taking into account the total number of residents (R1-R2-R3) in training at operating rooms during the period of the study, added to a similar number of hospital staff anesthesia specialists, to enable paired observations, resulting in a total of 48 participants (24 staff anesthesiologists and 24 anesthesia residents). Each participant (staff or resident) and her or his respective patient had their data collected and registered only once during the study.

For data presentation, qualitative variables were described by absolute and percentage values, while quantitative variables were shown as means, Standard Deviation (SD), medians, minimum and maximum Interquartile Range (IQR). In order to study associations and comparisons between groups, Pearson Qui-Square test and Fisher’s exact test were used for qualitative variables.

Results were considered statistically significant when their descriptive levels (p-values) were below 0.05. Statistical analysis was performed with SPSS for Windows version 21.0 software.

| Variables                                      | n = 47 |
|------------------------------------------------|--------|
| Professional                                   |        |
| Resident (R1)                                  | 8 (17.0%) |
| Resident (R2)                                  | 9 (19.1%) |
| Resident (R3)                                  | 7 (14.9%) |
| Staff                                          | 23 (48.9%) |
| Cuff pressure (cm H2O)                         |        |
| Minimum – Maximum                              | 12–120 |
| Mean (SD)                                      | 52.5 (27.1) |
| Median (IQR)                                   | 50 (30–70) |
| Cuff pressure (cm H2O)                         |        |
| Below recommended                              | 5 (10.6%) |
| Recommended                                    | 8 (17.0%) |
| Above recommended                              | 34 (72.3%) |
| Professional knows recommended pressure        | 28 (59.6%) |
| Occasional use of manometer                    | 30 (63.8%) |
| Routine use of manometer                       | 2 (4.3%) |
| Corrected cuff pressure value outside          | 36 (76.6%) |
| recommended range                              |        |
| Drop of cuff pressure during measurement        | 0 (0%) |
| Tracheal extubation during measurement          | 0 (0%) |
| Cuff damage during measurement                  | 0 (0%) |

SD, Standard Deviation; IQR, Interquartile Range.

**Table 1** Profile of the professionals studied and the cuff pressure for all groups.

[Fig. 1] Percentage of participants, according to recommended (20–30 cm H2O) cuff pressure measured (n = 47).

**Results**

Of the 48 study participants, one staff member case was lost, after realizing data had been collected from the same participant previously (duplication). Thus, we analyzed data collected from 47 participants (24 residents and 23 specialists), whose patients were submitted to general anesthesia, tracheal intubation, and on whom the subjective method was used to inflate the tracheal tube cuff.

**Table 1** describes the profile of participating professionals, values of cuff pressure measured and corrected, the extent of knowledge of the recommended limits for cuff pressure, participants’ manometer use expertise and the adverse events during the study.

[Fig. 1] describes the percentage of participants, according to the presence of recommended cuff pressure measurements.

When staff and residents were compared regarding measured cuff pressures, we found no statistically significant difference between the groups (Table 2).
When comparing answers of staff and residents to questionnaires, in regard to knowledge of the recommended range for tracheal cuff pressure and the occasional or routine use of a manometer to perform the objective method for cuff inflation, we did not find a statistically significant difference between the groups (Table 3).

When comparing residents according to their PGY (R1, R2 and R3), we did not find a statistically significant difference for pressures measured in cuffs inflated by the subjective method (Table 4).

Concerning the knowledge of the recommended maximum and minimum values for cuff pressure there was no difference between R1, R2 and R3. All first, second and third-year residents confirmed having already used manometers, with no differences among them, albeit all residents having stated that manometers are not routinely available for providing general anesthesia care (Table 5).

Discussion

Tracheal intubated patients must always have tracheal tube cuff pressure kept between 20 and 30 cm H2O. In the gold standard method to attain the recommended pressure range, the tube cuff must be inflated via pilot balloon with the help of an analogic or digital calibrated manometer that enables continuous or intermittent measurement of cuff pressure, in real time, allowing its adjustment without interruption of measurement. However, these devices are considered expensive, both for acquisition and maintenance. As a consequence, although unreliable, the subjective method for cuff inflation continues to be the most used one. In the most frequently performed subjective technique a random amount of air is injected, via the unidirectional valve of the pilot balloon using a syringe, and the operator infers if the tube cuff pressure is adequate by digitally palpat ing the balloon. Studies have revealed that this method produces a mean cuff pressure ranging between 35 and 62 cm H2O. The method results in hyperinflation explained by the great variability in the air volume required to achieve adequate cuff pressure due to variations in patient profiles, tube diameters, gases used during mechanical ventilation, and by the health professional’s goal to minimize risks of pulmonary aspiration of the gastric content.

In our study we tested the assumption that there was no compliance to tube cuff pressure range recommendations when a manometer was not used for tube cuff inflation, regardless of the experience of the health professional involved in the procedure. More than 80% of our patients presented an inadequately inflated tracheal tube cuff, showing pressures below, and mainly, above the recommended values by the scientific literature, with no difference between anesthesiology staff and residents.

Many studies with several designs and methods have shown the inappropriateness or subjective methods for cuff tube inflation. Patients intubated either in emergency 21 or in pre-hospital settings 9, 25 without using a manometer for obtaining and maintaining adequate tracheal tube cuff pressure have shown values consistently out, largely above, the recommended range 20 to 30 cm H2O, similar to the results observed in our study.

A prospective study that analyzed subjective tracheal tube cuff inflation using either 10 mL or 20 mL syringes showed that weight, age and height of patients had no effect on tube cuff pressure values. However, larger syringes (20 mL) resulted in statistically significant cuff pressures that were higher and outside the recommended range. Similar to our findings, the authors concluded that the subjective method is unreliable.

Analyzing data related to the prevalence of cuff pressure corrections after using a manometer (76.6%), we can observe that results were similar to previously published lit-
subjective safe registered and physicians all institutions, recommendation as to anesthesiologists, emergency physicians, intensivists and residents.) were compared, regardless of time of professional experience.

Hoffman et al. used an experimental model to assess the skills of faculty physician members of an emergency care medicine department to correctly inflate the tracheal tube cuff and estimate the pressure of cuff previously inflated. Similar to our results, physicians were unable to inflate the tracheal tube cuff at safe pressures using the subjective technique. The physicians were also unable to estimate the tracheal cuff pressure by digital palpation.

The comparable low efficiency of staff and residents to correctly establish the cuff pressure without using a manometer found in our study endorses the results of previously published studies, and confirms the working assumption we formulated at the study’s planning phase. It also highlights the concept that the objective method to inflate the tracheal tube cuff associated with regular measurements and corrections are simple actions requiring minimal time and should be considered as an investment in quality and safety by healthcare services.

It should also be emphasized that staff and residents registered a comparable extent of knowledge on the recommended range of values for tracheal tube cuff pressure and a similar level of unfamiliarity for using manometers. Both findings underscore the need for continuous education, training and acquisition of devices and commitment of all participants of the healthcare system, mainly teaching institutions, for strategies to reduce morbidity and mortality, and to continuously improve care, teaching, research, and continued education.

One limitation of the study was the sample size, as the study was carried out in a single teaching hospital, with a small number of residents for comparison to staff anesthesiologists. Maybe a multicenter trial, with several teaching hospitals could offer more robust results, although previous published studies have confirmed our results.

**Conclusions**

We concluded that tracheal tube cuff inflation using the subjective method does not ensure reaching values of cuff pressure within the recommended range. Staff specialist anesthesiologists and anesthesiology residents do not present the skills to attain correct tracheal tube cuff pressures using the subjective method. They also lack knowledge of the minimum and maximum recommended cuff pressures, and the expertise on using manometers for the objective method. Therefore, we suggest the routine use of the objective technique with a manometer for tracheal tube cuff inflation and cuff pressure monitoring.

**Conflicts of interest**

The authors declare no conflicts of interest.

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