A comparative audit of endotracheal tube cuff pressures across three intensive care units at a tertiary South African academic hospital

N Cretikos, MB ChB, DA (SA); **J Witt,** MB BCh, Dip PEC (SA), DA (SA), FCA (SA), MMed (Anaes);
O Smith, MB BCh, DA (SA), FCA (SA), MMed (Anaes), Cert Critical Care (SA);
M Mer, MB BCh, Dip PEC (SA), FCP (SA), Cert Critical Care (SA), MMed (Int Med), FRCP (Lond), FCCP, PhD

Department of Critical Care, Charlotte Maxeke Johannesburg Academic Hospital and School of Clinical Medicine, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa

Corresponding author: *N Cretikos (ncretikos@gmail.com)*

Background. In many intensive care units (ICUs), endotracheal intubation with cuffed endotracheal tubes (ETTs) is a regular intervention in critically ill patients. Prolonged periods of intubation are common in this cohort of patients, so regular monitoring of the ETT cuff pressures is particularly important. Significant morbidity and mortality can be observed with under- and overinflation of the ETT cuff. Best practice guidelines suggest a safe ETT cuff pressure of 20 - 30 cm H_2O, as measured by an aneroid manometer.
Objectives. To measure and compare ETT cuff pressures in adult intubated patients across three ICUs: trauma, neurosurgical, and multidisciplinary (a multidisciplinary ICU is overseen by the same intensivist; however, it has two separate nursing staff contingents in adjacent wards, so data from this ICU were recorded as 'multidisciplinary team 1 (MDT 1) and multidisciplinary team 2 (MDT 2)') at a tertiary academic hospital, and compare the frequency at which ETT cuff pressures appeared outside the recommended range. The secondary objective was to assess the degree of under- or overinflation and determine whether ETT cuff pressures varied significantly based on the time of day the measurements were taken (morning, afternoon and evening).
Methods. This prospective observational study was conducted at a tertiary Johannesburg academic hospital in Gauteng Province, South Africa. Altogether, 300 ETT cuff pressure measurements were collected from 137 patients across the three ICUs. These measurements were done at three different times during the day, mornings, afternoons and evenings, using a standardised manometer.
Results. Over 90% of the recorded ETT cuff pressures measured across the three ICUs were above the suggested optimal range of 20 - 30 cm H_2O. The trauma ICU had the most overinflated ETT cuff pressures, with most pressures recorded to be >75 cm H_2O. Slightly lower, but still overinflated, ETT cuff pressures were observed in the neurosurgical and multidisciplinary ICUs. Repeated measurements showed consistently elevated pressures, which suggests inadequate monitoring practices.
Conclusion. This study demonstrated a consistent trend of ETT cuff overinflation across all three ICUs, with almost all measurements significantly exceeding the recommended optimal range. No statistically significant differences in cuff pressures were observed based on the time of day the measurements were taken.

Keywords. Endotracheal tube cuff pressure, intensive care, overinflation, manometry, critical care nursing, mechanical ventilation, airway management.

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Study synopsis
What the study adds. This study highlights a shortfall in the routine measurement of endotracheal tube (ETT) cuff pressure measurements in critically ill intubated patients admitted across three intensive care units (ICUs) in a Johannesburg tertiary academic hospital.
Implications of the findings. Regular monitoring of ETT cuff pressure is essential to minimise both short- and long-term morbidity in intubated patients, particularly in intensive care settings where prolonged mechanical ventilation is common. Incorrect cuff inflation, whether over or under, can result in serious complications. These adverse outcomes significantly affect individual patient safety, clinical workflow and healthcare resource use. Accurate, consistent measurement of cuff pressures is therefore a critical component of high-quality ICU care.

The practice of endotracheal intubation dates back >2 000 years and was first described by Hippocrates.[1] In intensive care units (ICUs), using a cuffed endotracheal tube (ETT) is common and essential for patients requiring mechanical ventilation.[2] A cuffed ETT provides a secure airway, facilitates positive-pressure ventilation, and aids in prevention of aspiration of gastric contents, as well as microaspiration.[1] However, while intubation is a critical intervention, the ETT cuff itself can be an additional source of morbidity.[3]

Most adult ETTs in current ICU practice are made of polyvinyl chloride (PVC) and feature a high-volume, low-pressure inflatable cuff at their distal end.[3] The ETT cuff balloon allows for a correlation between the cuff pressure and the tracheal mucosa perfusion pressure beneath it.[4] The pressure exerted by the cuff is transmitted to the tracheal wall and must be sufficient to provide an effective seal for ventilation, without compromising mucosal perfusion.[5] Overinflation, typically defined as cuff pressures >30 cm H_2O, can compress tracheal capillaries and result in various short- and long-term post-extubation complications, including mucosal ischaemia, ulceration and stenosis.[4]

Although several studies have suggested safe ranges for cuff pressure, no comprehensive national or international guidelines currently govern optimal cuff pressures or recommended measurement frequency in ICU settings.[6] A South African (SA) best practice guideline suggests that cuff pressures should be maintained between 20 and 30 cm H_2O when measured with a manometer.[7]

Despite these recommendations, the methods used to monitor cuff pressure vary widely. Non-validated techniques such as pilot balloon palpation, minimal occlusive volume, and minimal leak tests are still commonly used, particularly in resource-limited settings.[8] These methods are unreliable, however, and show poor correlation with actual cuff pressure values. The gold standard for accurate monitoring in ICUs includes manual manometry and automated continuous pressure transducer systems.[3] While continuous systems offer superior real-time pressure control and can detect fluctuations due to patient movement or airway interventions, they are often unavailable in low-resource environments.[9] Consequently, intermittent manual measurement using a portable manometer remains the most feasible approach in many SA ICUs.

The appropriate frequency of cuff pressure monitoring also remains a topic of debate. A 12-hourly monitoring interval was recommended over a decade ago; however, more recent evidence suggests that 6-hourly monitoring may be more effective in maintaining pressures within the optimal range.[9] At present, there are no formal written protocols for cuff pressure measurement frequency in any of the three ICUs at our tertiary academic hospital. Instead, cuff pressures are measured at the discretion of ICU staff, leading to variability in practice and the potential for under- or overinflation to go unrecognised.

The primary objectives of this study were to measure and compare ETT cuff pressures in adult intubated patients across three ICUs – trauma, neurosurgical, and multidisciplinary – at a tertiary academic hospital in Johannesburg, using thrice-daily recordings (morning, afternoon and evening), and to assess the frequency of ETT cuff pressures that fell outside the recommended range. The secondary objective was to evaluate the degree of under- and overinflation, and to assess differences in ETT cuff pressures between the ICUs and across the different time points, relative to the recommended safe range of 20 - 30 cm H_2O.[7]

Methods

This prospective, observational study was conducted in three ICUs at a tertiary academic hospital in Johannesburg, Gauteng Province, SA. Ethical, hospital CEO and head of department approval was obtained before starting data collection. The Human Research Ethics Committee board waived patient consent, as this study was purely observational, and individual consent was obtained from the treating physician and the operational managing heads of nursing staff in the ICUs.

Inclusion criteria included all adult patients (≥18 years old) with cuffed ETTs admitted to the specified ICU for >12 hours. Exclusion criteria included age <18 years and patients with tracheostomy tubes. Three hundred measurements were collected from 137 patients, with repeated measurements taken from patients still admitted in the ICU over a number of days or weeks, using a standardised manometer (AG Cuffill; Hospitech Respiration, Israel). Data collection was distributed across mornings (between 06h00 and 08h00), afternoons (between 14h00 and 16h:00) and evenings (between 20h00 and 22h00). Measurements were collected from every second intubated patient admitted to the ICU at each time interval, to maintain variability and randomisation.

Data collection spanned 90 days, and data were collected by a sole principal investigator. ETT cuff pressures were anonymously recorded on a data collection sheet, and the treating ICU physician/ICU nurse was duly informed if the ETT cuff pressure was out of the optimal range and requested to correct the pressure.

Statistical analysis

Continuous data were summarised using medians and interquartile ranges. Categorical data were summarised as counts (percentages).

All regression models were mixed-effect models, where the inclusion of a patient identifier as a random effect can be used to account for correlations between repeated measurements. ETT cuff pressures were classified as within or above the recommended pressure range (20 - 30 cm H_2O) to complete the analytical component of primary objective 1 (compare the frequency at which ETT cuff pressures occur across three ICUs).

The association between this ordinal outcome variable and ICU was assessed using cumulative link mixed-effect modelling (ordinal regression), with patient ID as the random effect (intercept-only model) and time of day (morning, afternoon, evening) as a fixed-effect covariate. A linear quantile mixed-effect model (modelling the conditional median) was used to complete the analytical component of primary objective 2 (compare ETT cuff pressures in intubated patients across three ICUs). Patient ID was included as the random effect (intercept-only model), and time of day as a fixed-effect covariate.

A p-value <0.05 was used as the threshold for accepting that a statistically significant difference or association had been detected; p-values were corrected for multiple comparisons using the Tukey method. All analyses were performed using R v4.4.0 for Windows (R Core Team, Vienna, Austria).

Results

Primary objective 1: To describe and compare the frequency at which ETT cuff pressures outside the recommended range occur across three ICUs

Table 1 shows the number (percentage) of patients in each ICU with a mean ETT cuff pressure within the optimal range. Almost all patients (>90%) in the trauma and neurosurgical ICUs and one multidisciplinary ICU had a mean ETT cuff pressure above the optimal range, while 78% of patients in the other multidisciplinary ICU had a mean ETT cuff pressure above the optimal range. Only one patient, in the neurosurgical ICU, had a mean ETT cuff pressure below the optimal range.

Pairwise comparisons following the generation of a cumulative link mixed-effects model detected a statistically significant difference between the trauma and multidisciplinary ICUs (p=0.003; trauma > multidisciplinary) after controlling for the time-of-day readings taken (morning, afternoon and evening). For all other pairwise comparisons, there were no statistically significant differences (p>0.05).

Primary objective 2: To describe and compare ETT cuff pressures in intubated patients across three ICUs

Fig. 1 shows the ETT cuff pressures recorded in three ICUs. In all cases, the median cuff pressures were greater than the recommended cuff pressure range (20 - 30 cm H_2O). The greatest median was for ICU trauma (~82 cm H_2O), and the least was for ICU multidisciplinary (~38 cm H_2O).

Fig. 2 shows the change in ETT cuff pressure required to bring it within the recommended cuff pressure range (20 - 30 cm H_2O) in three ICUs. In all cases, and consistent with the data reported for primary objective 2, the median cuff pressures had to, on average, be deflated to reach the recommended pressure range. The greatest median deflation was for ICU trauma (~53 cm H_2O), and the least was for ICU multidisciplinary (~9 cm H_2O).

Discussion

The morbidity associated with both over- and underinflation of ETT cuff balloons in intubated ICU patients is substantial and clinically significant. This audit revealed that most ETT cuff pressures recorded across all three ICUs fell outside the recommended optimally safe range of 20 - 30 cm H_2O,[7] with most values exceeding this range, especially in the trauma ICU. This is consistent with previous SA studies, which have demonstrated poor compliance with recommended cuff pressures and a general lack of standardised monitoring protocols.[9]

Maintaining effective ventilation and preventing aspiration are critical goals in the care of intubated patients.[1] Cuff underinflation compromises airway protection and ventilation, while overinflation risks tracheal injury. Pressures approaching the upper limit of the recommended range may sometimes be required to prevent air leaks; however, exceeding this threshold can impair capillary perfusion of the tracheal mucosa.[1] Capillary blood flow in the trachea is compromised at wall pressures >30 cm H_2O in normotensive adults,[10] and prolonged exposure to such pressures increases the risk of short- and long-term complications, as these are based on the actual cuff pressure as well as the duration of exposure.[3]

In this study, >90% of patients in the trauma, neurosurgical and multidisciplinary ICUs had mean cuff pressures above the optimal range. Median cuff pressures in all ICUs exceeded 30 cm H_2O, with the trauma ICU demonstrating a median of ~82 cm H_2O, far above safe limits and significantly higher than in the neurosurgical (median ~58 cm H_2O) and multidisciplinary ICUs (median ~38 cm H_2O). These inter-unit differences were statistically significant (p<0.001), reinforcing concerns about inconsistent practices between units. Persistently high ETT cuff pressures in the ICUs suggest inadequacy in the frequency of monitoring as well. These findings are in keeping with previous studies conducted in SA, including a retrospective ICU chart review conducted in 2019 by Khan *et al.*[11] at a large Johannesburg academic hospital, which indicated that only 17% of ETT cuff pressures documented were within the recommended optimal range.

Several extensive international studies have quantified the prevalence of complications associated with cuff overinflation. Combes *et al.*[10] showed that cuff pressures >35 cm H_2O for >24 hours led to histologically confirmed mucosal necrosis in ~20% of patients. Short-term post-extubation complications are also common, and include sore throat (reported in up to 75% of intubated patients), hoarseness (40 - 60%), dysphagia (12 - 30%), and post-extubation stridor (6 - 37%).[10]

The prevalence of long-term complications in ICU patients requiring lengthy periods of mechanical ventilation is also significant. Tracheal stenosis is reported in 1 - 2% of general ICU patients, but may occur in up to 5 - 19% of patients intubated for >10 days.[10] Long-term complications are generally more severe and include tracheal ischaemia due to mucosal ulceration, granulation tissue formation with fibrotic healing, tracheal stenosis (which may require interventional management), tracheomalacia, and tracheal rupture.[10]

Importantly, these complications are predictable and largely preventable. Granja *et al.*[12] showed that maintaining cuff pressures at 25 cm H_2O using a manometer significantly reduced laryngotracheal injury rates from 35% to 17%, reinforcing the value of routine pressure monitoring as a simple yet effective strategy to reduce morbidity. Tracheal stenosis is one of the most frequently encountered

Table 1. Frequency at which ETT cuff pressure* was within the optimal range†

	ICU			
Characteristic	**Trauma (*N*=45), *n* (%)**	**Neurosurgical (*N*=32), *n* (%)**	**Multi 1 (*N*=27), *n* (%)**	**Multi 2 (*N*=33), *n* (%)**
Within range	2 (4.4)	1 (3.1)	6 (22)	1 (3.0)
Above range	43 (95.6)	30 (93.8)	21 (77.8)	32 (97.0)
Below range	0	1 (3.1)	0	0

ETT = endotracheal tube; ICU = intensive care unit; Multi = multidisciplinary.
*Mean ETT cuff pressure calculated for each patient as the reference value.
†Optimal ETT cuff pressure range: 20 - 30 cm H_2O.

long-term sequelae following prolonged overinflation, often necessitating costly surgical interventions and leading to reduced patient quality of life.[10]

Conversely, underinflation of the ETT cuff also carries risk to the intubated patient in the ICU. Maintaining effective ventilation and preventing aspiration are critical goals in the care of intubated patients.[1] An inadequate seal may result in inadequate ventilation and hypercarbia, micro- and macroaspiration of gastric contents, and ventilator-associated pneumonia (VAP), which is a well-established complication associated with increased ICU stay and mortality.[13] Adequate cuff inflation reduces the risk of VAP by preventing aspiration and enabling subglottic secretion drainage, an essential preventive strategy in ICU care.[13]

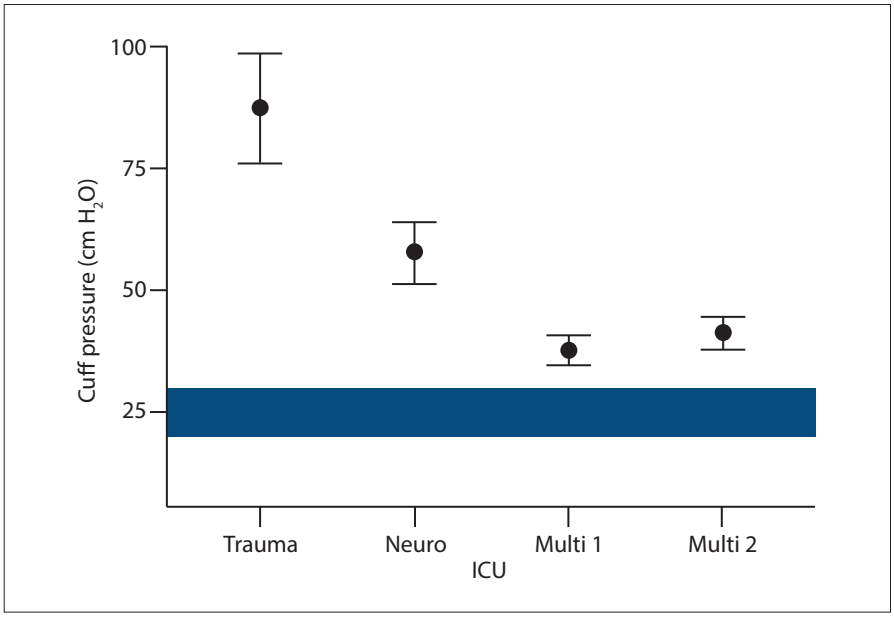

Fig. 1. Median (95% confidence interval) ETT cuff pressure across three ICUs, averaged over the levels of collection time (morning, afternoon, evening). The bar shows the recommended ETT cuff pressure (20 - 30 cm H_2O). (ICU = intensive care unit; ETT = endotracheal tube; Neuro = neurological; Multi = multidisciplinary.)

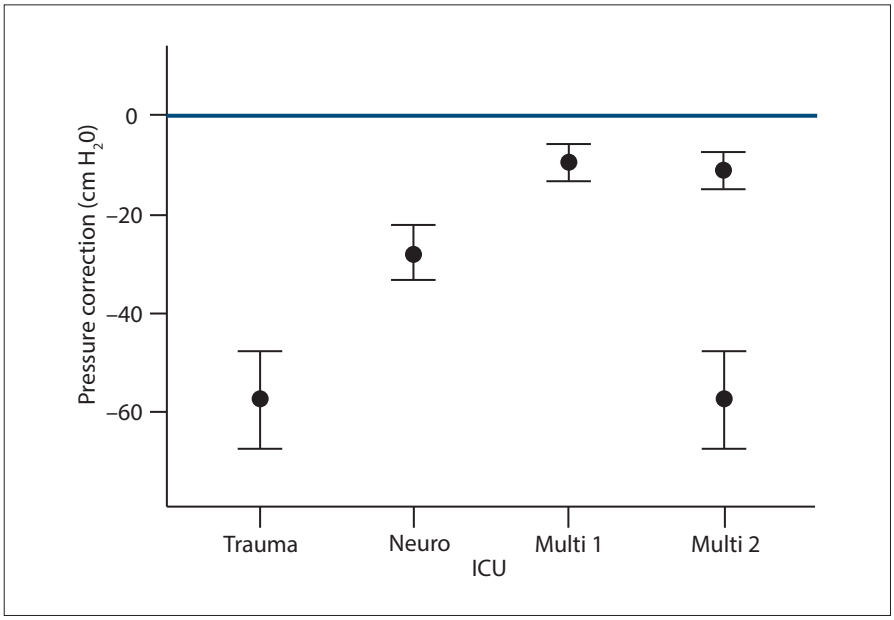

Fig. 2. Median (95% confidence interval) ETT cuff pressure correction across three ICUs, averaged over the levels of collection time (morning, afternoon, evening). Negative values indicate that the cuff needs to be deflated. The solid black line at 0 cm H_2O shows the value at which no correction in ETT cuff pressure is required. (ICU = intensive care unit; ETT = endotracheal tube; Neuro = neurological; Multi = multidisciplinary.)

Although the present study's findings were significant, several limitations must be considered when interpreting them. Firstly, while the study demonstrated that most cuff pressures exceeded the recommended range, it did not include any correlation with clinical outcomes. As such, the potential complications discussed, such as tracheal stenosis or VAP, were inferred from existing literature rather than directly observed in this patient cohort.

The study was also limited to three ICUs within a single tertiary academic hospital, which may not reflect practices in other settings, particularly in rural or private sector facilities. Additionally, cuff pressures were measured intermittently, rather than continuously, which may have missed pressure fluctuations known to occur during patient movement, suctioning, or ventilator adjustments.

Measurement bias is another potential concern. Staff may have altered their usual practice due to awareness of being observed (Hawthorne effect), and variation in measurement technique between staff may have introduced inconsistencies. The type of ETTs used, their cuff design, and the duration of intubation were not standardised or recorded, which may have influenced cuff pressure and risk of complications. Finally, the absence of a formalised institutional protocol for cuff pressure monitoring is likely to have contributed to variability in practices between the units and further highlights the need for standardised, evidence-based guidelines.

The most current evidence supports that routine 6-hourly ETT cuff pressure measurement significantly reduces adverse outcomes compared with less frequent monitoring.[9] Some SA units advocate 4-hourly measurements, particularly in patients at risk of prolonged intubation. Despite this, there is currently no universally accepted national or international guideline specifying the optimal frequency for cuff pressure monitoring in ICU settings. In this context, the portable, reusable manual manometer remains the most feasible and effective tool for regular, intermittent cuff pressure monitoring in SA ICUs.

Nevertheless, as highlighted by this and other recent studies, compliance with even basic monitoring remains suboptimal, often owing to limited training, protocol absence, and resource constraints.[14] Structured education, training and protocol implementation have been shown to significantly improve theoretical knowledge and practical skills among ICU and emergency nurses, as evidenced by local SA studies conducted by Henning *et al.*[15] in 2024[15] and Mpasa *et al.*[16] in 2020.

Conclusion

This audit confirms that many ETT cuff pressures in the ICUs lie outside the recommended safe range, with overinflation particularly prevalent. These findings reinforce the urgent need for evidence-based, context-sensitive and resource-appropriate standardised cuff pressure monitoring protocols. Protocol adoption would be likely to reduce the incidence of pressure-related airway complications and promote more consistent, evidence-based practice across units.

Incorporating ETT cuff pressure monitoring into routine ICU observations and ensuring clear documentation could significantly enhance patient safety and care quality. While 20 - 30 cm H_2O remains the most acceptably safe range, and 6- to 12-hourly monitoring via manual manometry is currently the most feasible standard in our setting, broader adoption of training, regular auditing, and national guideline development are essential to minimise avoidable harm and patient morbidity.

Data availability. The datasets generated and analysed during the present study are available from the corresponding author (NC) on reasonable request.

Declaration. The research for this study was done in partial fulfilment of the requirements for NC's MMed (Anaes) degree at the University of the Witwatersrand. MM is a member of the editorial board.

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Author contributions. NC was the principal investigator and responsible for all aspects of the research. JW, OS and MM were the study supervisors and contributed to data interpretation and critical revision of both the protocol and the final manuscript.

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1. Sultan P, Carvalho B, Rose BO, Cregg R. Endotracheal tube cuff pressure monitoring: A review of the evidence. J Perioper Pract 2011;21(11):379-386. https://doi.org/10.1177/175045891102101103
2. Talekar CR, Udy AA, Boots RJ, Lipman J, Cook D. Tracheal cuff pressure monitoring in the ICU: A literature review and survey of current practice in Queensland. Anaesth Intensive Care 2014;42(6):761-770. https://doi.org/10.1177/0310057X1404200612
3. Jordan P, van Rooyen D, Venter D. Endotracheal tube cuff pressure management in adult critical care units. South Afr J Crit Care 2012;28(1):13-16.
4. Seegobin RD, van Hasselt GL. Endotracheal cuff pressure and tracheal mucosal blood flow: Endoscopic study of effects of four large volume cuffs. Br Med J Clin Res Ed 1984;288(6422):965-968. https://doi.org/10.1136/bmj.288.6422.96
5. Feng TR, Ye Y, Doyle DJ. Critical importance of tracheal tube cuff pressure management. World J Anesthesiol 2015;4(2):10-12. https://doi.org/10.5313/wja.v4.i2.10
6. Danielis M, Benatti S, Celotti P, de Monte A, Trombini O. Continuous monitoring of endotracheal tube cuff pressure: Best practice in intensive care unit. Assist Inferm Ric 2015;34(1):15-20. https://doi.org/10.1702/1812.19746
7. Perrie H. Nesibopho Best Practice Guideline on Tracheal Tube Cuff Pressure Monitoring. Johannesburg: Nesibopho Healthcare (Pty) Ltd. D4 1-5, 2010.
8. Al-Metwalli RR, Al-Ghamdi AA, Mowafi HA, Sadek S, Abdulshafi M, Mousa WF. Is sealing cuff pressure easy, reliable and safe technique for endotracheal tube cuff inflation? A comparative study. Saudi J Anaesth 2011;5(2):185-189. https://doi.org/10.4103/1658-354X.82795
9. Memela ME, Gopalan PD. Variations in endotracheal tube cuff pressure: Is 8-hourly monitoring enough? South Afr J Crit Care 2014;30(2):35-40. https://doi.org/10.7196/SAJCC.159
10. Combes X, Schauvliege F, Peyrouset O, et al. Intracuff pressure and tracheal morbidity. Anesthesiology 2001;95(5):1120-1124. https://doi.org/10.1097/00000542-200111000-00015
11. Khan AB, Thandrayen K, Omar S. Tracheal tube cuff pressure monitoring: Assessing current practice in critically ill patients at Chris Hani Baragwanath Academic Hospital. South Afr J Crit Care 2019;35(1). https://doi.org/10.7196/SAJCC.2019.v35i1.373
12. Granja C, Faraldo S, Laguna P, Góis L. Control of the endotracheal cuff balloon pressure as a method of preventing laryngotracheal lesions in critically ill intubated patients. Rev Esp Anestesiol Reanim 2002;49(3):137-140.
13. Nseir S, Lorente L, Ferrer M, et al. Continuous control of tracheal cuff pressure for VAP prevention: A collaborative meta-analysis of individual participant data. Ann Intensive Care 2015;5(1):43. https://doi.org/10.1186/s13613-015-0087-3
14. Gopalan PD. Goldilocks and endotracheal tube cuff pressure management: Not too high, not too low. Just right… South Afr J Crit Care 2019;35(1). https://doi.org/10.7196/SAJCC.2019.v35i1.401
15. Henning J, Hindle L. The knowledge and skills of emergency department registered nursing staff at an academic hospital in South Africa, on endotracheal tube cuff manometry, before and after a training session. Afr J Emerg Med 2024;14(3):156-160. https://doi.org/10.1016/j.afjem.2024.06.001
16. Mpasa F, van Rooyen DRM, Venter D, Jordan P, Ten Han-Baloyi W. Improving nurses' knowledge of managing endotracheal tube cuff pressure in ICUs: A quasi-experimental study. Health SA 2020;25:1479. https://doi.org/10.4102/hsag.v25i0.1479

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