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ORIGINAL ARTICLE

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

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ABSTRACT

Introduction: Accurate management of endotracheal tube cuff pressure is essential to prevent patient morbidity and mortality. Due to increased length of stay of critically ill patients in emergency departments, it has become an increasingly important skill among Emergency Department nurses.

Methods: This prospective longitudinal interventional study was performed among registered nurses at the emergency departments in a Johannesburg Academic Hospital. The study aimed to determine their current knowledge and practical skills on endotracheal tube cuff manometry and assess the effectiveness of a training program. The training program was provided once, in the form of a narrated PowerPoint presentation developed by the researchers and involved theoretical and practical components. The participants' theoretical knowledge and practical skills were measured by using questionnaires and skill assessments. The theoretical and practical scores were compared pre- and post-training.

Results: Of the 63 registered nurses employed in the emergency departments, 95 % (60) participated in this study. 86 % reported having never received any formal training on endotracheal tube cuff manometry. Only 38.9 % used cuff manometry as standard practice and only 12.8 % checked it at appropriate 12-hourly intervals. The pre-training median score on theory was 4.5 (IQR=3.0) and improved to 7.0 (IQR=3.0) post-training. The maximum achievable score was 11 with a pre-training average of 41.8 % and post-training of 64.5 % ($p = 0.001$).

The practical pre-training median score was 1.0 (IQR=8.0) and improved to 12.0 (IQR=2.0) post-training. The maximum achievable score was 12 with a pre-training average of 29.1 % and a post-training average of 93.3 % ($p = 0.001$).

Conclusion: This study showed inadequate knowledge and skills on endotracheal cuff pressure manometry among registered nurses in the emergency department. It also correlates with other evidence that supports the need for ongoing training programs. Our training program led to significant improvement among participants in both knowledge and practical skills. This training program was well received by participants and deemed to be practice changing. The recommendation after this study will be for South African emergency units to consider using this study and training material as a guide for annual in-service training.

African Relevance

- Endotracheal cuff manometry is often overlooked and underutilized in busy overcrowded emergency departments. An unfortunate reality in many of our resource-constrained African emergency departments.
- The length of stay for patients within the emergency department, especially the critically ill (intubated) patients, has been consistently increasing over the years. Many factors related to limited healthcare resources lead to the increased patient length of stay. This emphasizes the need for accurate and timely management of endotracheal tube cuff pressures in the emergency departments.
- Complications secondary to inadequate endotracheal tube cuff pressure management e.g. ventilator pressure leak, ventilator-associated pneumonia, tracheal stenosis, or rupture are well described and recognized. Preventing these complications will be a

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key cost- and time-saving strategy in an already strained African healthcare system.
- Having easily implementable and repeatable education programs in Africa is key to providing widespread standardized teaching. The utilization of high-quality narrated PowerPoint presentations (as used in this research) could be a cost-effective strategy for achieving that.

Introduction

The endotracheal tube (ETT) cuff is used to create a seal between the tracheal mucosa and the ETT. Underinflation of the cuff during positive pressure ventilation can lead to a ventilator pressure leak, aspiration, or ventilator-associated pneumonia [1–3]. Overinflation can lead to complications like post-extubation hoarseness, sore throat, recurrent laryngeal nerve damage, tracheal ulceration, tracheal stenosis, tracheo-oesophageal fistula, and tracheal rupture [4,5]. Accurate management of ETT cuff pressure is essential to prevent complications [1–5]. Many South African emergency departments (EDs) are faced with overcrowding and access block [6]. Mashao et al [7] reviewed the reasons for the increased length of stay in an ED at a Pretoria Academic Hospital in South Africa in 2021. By using the Input-Throughput-Output model they found throughput (16h25min) and output (54h7min) to be the major contributing factors. Throughput refers to the diagnostic and treatment components within the ED and output refers to the disposition of patients. Delays are attributed to clinical workup and decision-making, specialist referral, administrative processes, and lack of available admission beds, especially in intensive care units [7]. This may lead to an increased length of stay in the ED for intubated patients [6,7]. Thus, accurate management of ETT cuff manometry is essential to EDs care.

A South African nursing guidelines recommend 12 hourly cuff pressure checks and a cuff pressure range of 25–30cmH_2O [3]. The American Heart Association Paediatric Advanced Life Support guidelines of 2015 recommend using manufacturer specifications for cuff pressure [8]. A review of the literature and manufacturer specifications shows a generally acceptable range of 20–30cmH2O [1–5,8–12]. The current best practice to monitor cuff pressures would be a transducer with continuously displayed pressures on a patient monitor [13]. In South Africa, this is not readily available or feasible, therefore a single measurement during a 12-hour nursing shift using a cuff manometer is the current practice recommended by South African guidelines [3].

Many different techniques to estimate the cuff pressure have been trialed including minimum occlusive volume, minimum leak, predetermined volume, and pilot balloon palpation. These techniques have all been found to be unreliable and unsafe [14–16]. A lack of awareness and knowledge around ETT cuff manometry has been shown in several studies performed in critical care settings both locally and internationally [17–20]. A local study performed with intensive care unit (ICU) nursing staff showed only 62 % knew about current critical care cuff pressure guidelines and only 53 % reported routinely measuring cuff pressures [17].

Implementation of basic training programs on the measurement of cuff pressure has shown improved awareness, knowledge, and skills leading to improved patient outcomes [21–23]. A recent study regarding endotracheal tube cuff manometry performed among critical care nurses working at an adult ICU in a teaching hospital in Malaysia showed significant knowledge retention at 9 months post-educational intervention [23]. Another quality improvement project on endotracheal cuff manometry in theatre at the San Antonio Military Medical Centre showed significant improvement post-intervention [22]. International research on endotracheal tube cuff manometry with a focus on ED nursing staff is lacking. This study assessed the registered emergency nursing staff's current endotracheal tube cuff manometry knowledge and skills at a tertiary hospital in the public sector. We also aimed to identify their current practice, implement a training program, and re-assess them thereafter.

Methods

This prospective longitudinal interventional study was performed at the ED of a Johannesburg Academic Hospital. The ED consist of a medical adult emergency unit (MEU) and a trauma emergency unit (TEU). The study population consisted of professional registered nurses (RNs) working in the EDs. There were 63 RNs employed at the time of the data collection (October and November 2021). The University of Witwatersrand's Human Research Ethics Committee granted ethical clearance (Clearance number: M210602).

Sessions were run during October and November 2021. Each session aimed to determine the pre-training knowledge and skills of the RNs, provide them with training, and then re-assess them post-training.

Data was collected in the form of questionnaires and a spreadsheet for the scores of the practical component. A demographics questionnaire was used to collect basic data and level of training and experience. The pre- and post-training questionnaires were the same and consisted of 8 multiple choice questions with a total of 11 marks. Questions 1–4 had multiple correct answers and were individually negatively marked for incorrect options. Questions 5–8 were the single best answer.

The practical component consisted of a test on 3 pre-intubated manikins, labelled A, B, and C. At each mannikin the RNs were assessed on technique, whether they achieved a correct measurement, and if they were able to inflate and deflate the cuff using the cuff manometer. Four marks were given at each mannikin, giving a total of 12 marks. The cuff at Mannikin A was inflated to a normal value (20 – 30 cmH20). Mannikin B was overinflated (40 – 60 cm H2O) and C was underinflated (10 – 15 cm H2O). The researcher did practical assessments on an individual basis in a screened area to allow for privacy for the participant and to avoid confounding.

Each participant received the same training, consisting of a 10-minute narrated PowerPoint presentation translating core knowledge and demonstrating the correct way to perform the skills. A training video described the ETT tube cuff and its function, the cuff manometer, best practice guidelines, and the risks of under and overinflation as well as a practical video demonstration on how to perform the skills correctly. At the end of each session, participants were asked to complete a training evaluation form.

The theoretical and practical assessments as well as the training material were developed by the authors in conjunction with the University of Witwatersrand's Emergency Medicine Department. The pre- and post-training assessments were the same and performed during the same session. The answers to the questionnaire and correct interpretation and performance of the skills were not discussed directly during the session. Each session lasted approximately 90 min.

Data was captured on Microsoft Excel spreadsheets and analysed using IBM SPSS statistics version 28. Descriptive statistics are presented as frequencies and percentages for categorical variables. The Kolmogorov-Smirnov test indicated that the data on the pre- and post-training scores deviated from a normal distribution. Therefore, the descriptive statistics on continuous variables are reported as median scores with an interquartile range. The Wilcoxon sign rank test was used to examine if there were significant changes in the RNs post-training versus pre-training scores on both the theory and practical training elements. The Kruskal Wallis test was used to examine if the post-training score improvements varied significantly between RNs at the MEU and trauma departments as well as the RNs working experience and previous training. Statistical significance testing was set at the 95 % confidence level.

Results

Of the 63 RNs employed in the ED, 60 (95 %) consented to

participate in the study. Of these, 57 % worked in MEU and 43 % in Trauma. Most nurses had between 1 and 10 years of working experience. Of the nurses surveyed 14 % had received formal training on cuff manometry. Only 38.9 % used cuff manometry as their technique and only 12.8 % are checking it at appropriate 12 hourly intervals (Table 1).

The pre-training median score on theory was 4.5 (IQR=3.0) and improved to 7.0 (IQR=3.0) post-training (Fig. 1). The maximum achievable score was 11 with a pre-training average of 41.8 % and post-training of 64.5 % (Fig. 2). This was a statistically significant improvement ($p < 0.05$).

The practical pre-training median score was 1.0 (IQR=8.0) and improved to 12.0 (IQR=2.0) post-training (Fig. 1). The maximum achievable score was 12 with a pre-training average of 29.1 % and post-training of 93.3 % (Fig. 2). This was also a statistically significant improvement ($p < 0.05$).

There were no statistically significant differences in the level of post-training theory improvement by department, years as a registered nurse, years of experience managing intubated patients, previous training on ETT cuff pressure measurement, or experience with intubated patients.

There were statistically significant differences in the level of post-training practical improvement by years of experience managing intubated patients($p = 0.03$), previous training on ETT cuff pressure measurement ($p = 0.00$), and previous experience checking ETT cuff pressures ($p = 0.00$). Nurses with 1–10 years of experience, previous formal training, and those who have checked ETT cuff pressure before showed the biggest improvement (Table 2).

The training program was well received by the participants. Most participants felt that the training was relevant and will impact on their daily practice and that this training should be provided regularly in the form of in-service training. Of note 32 % of participants felt that this training should also be provided in languages other than English (Table 3).

Table 1
Participant demographics.

	N%
Years of practice	
<1	9 (15.5)
1–10	27 (46.6)
10–20	21 (36.2)
>20	1 (1.7)
Years managing intubated patients	
<1	14 (23.7)
1–10	32 (54.2)
10–20	13 (22.1)
>20	0 (0)
Formal training on ETT cuff manometry	
Yes	14 (23.3)
No	46 (76.7)
Type of training	
Post-graduate studies	8 (57.2)
In-service training	1 (7.1)
Work experience	5 (35.7)
Current technique used to check ETT cuff pressure	
Cuff manometry	14 (38.9)
Pilot balloon palpation	12 (33.4)
Minimal occlusive volume	3 (8.3)
Unspecified	7 (19.4)
Frequency of ETT cuff tube pressure checks in unit	
Hourly	12 (30.7)
4 hourly	3 (7.7)
6 hourly	2 (5.1)
12 hourly	5 (12.8)
Daily	4 (10.3)
Once post-intubation	4 (10.3)
Unspecified	9 (23.1)

ETT - Endotracheal Tube.

Discussion

This study is one of few to look at ETT cuff manometry knowledge and skills among ED nursing staff. We conclude that there is inadequate knowledge and skills on endotracheal cuff manometry among ED RNs at the hospital surveyed. A lack of existing training programs was identified with only 14 % of participating RNs having received any formal training before this research. We found that significant improvements in theory and skills could be made after a short training program.

Only 38.9 % of the nurses in the study were currently using cuff manometry, and only 12.8 % were using it at the correct 12 hourly intervals (Table 1). This implies that current practice may put critically ill ventilated patients in the ED at risk. Due to the increased length of stay of intubated patients within EDs, endotracheal cuff pressure manometry has become an essential skill among registered nurses in the ED [24].

Data from ICU and theatre research worldwide have previously shown a lack of awareness, knowledge, skills, and training among nurses on cuff pressure manometry [17,21,23,25–27]. A study performed among 591 ICU nurses in Belgium showed that 53 % were checking cuff pressures 8 hourly and that they were unaware of the indications [27]. A local study performed in ICU at a tertiary hospital showed that only 53 % of nurses report checking cuff pressures routinely [17]. Their findings were consistent with ours among a cohort of ED nursing staff.

When pre-training testing was done in our study, we found a 41.8 % average for knowledge and a 29.1 % average for practical skills. By implementing a basic training program consisting of a narrated PowerPoint presentation, significant improvements were noted in both knowledge and skills (Fig. 1,Fig. 2). A 22,7 % ($p < 0.05$) improvement in their knowledge and 64.2 % ($p < 0.05$) improvement in skills were noted (Fig. 2). Anecdotally, awareness and implementation of cuff pressure monitoring were noted within the units as the training program was being rolled out. Our findings of improved awareness, knowledge, and skills after a training program were consistent with previous research [21–23].

In our study, RNs without prior experience measuring cuff pressures or previous formal training showed the most improvement. This is likely because they performed sub-optimally in the pre-training evaluations and had the biggest potential margin for improvement. A local study performed among nursing staff in 13 ICUs in Johannesburg showed that nurses receiving formal training on clinical nursing skills will perform much better compared to those with work experience alone [25]. Continuous formal training programs among nurses have been shown to assist in improving awareness, knowledge, and skills to further improve patient care [26,28]. This emphasizes the need for continuous formal training programs when nursing skills are critical for patient outcomes.

The study also found that the training program was well received by the participants and appropriate to their daily practices (Table 3). Training programs themselves need to be assessed to ensure fitness for purpose and acceptability to the relevant group.

Limitations

This research was only performed at one hospital among a small cohort of emergency nurses. However, it involved both medical and trauma emergency units and participation in the study was high. Although nurses were asked about their current practice this study was not able to independently verify this information as this was not one of the study aims. There could be an element of familiarity with the questions since the same questionnaires were used before and after training. No long-term assessment was performed on the retention of knowledge and skills. Several studies have shown skill retention tends to decline steadily over 12 months with maximal decline after 1 year [29–31]. Ideally, the training would be repeated at intervals to ensure skill retention.

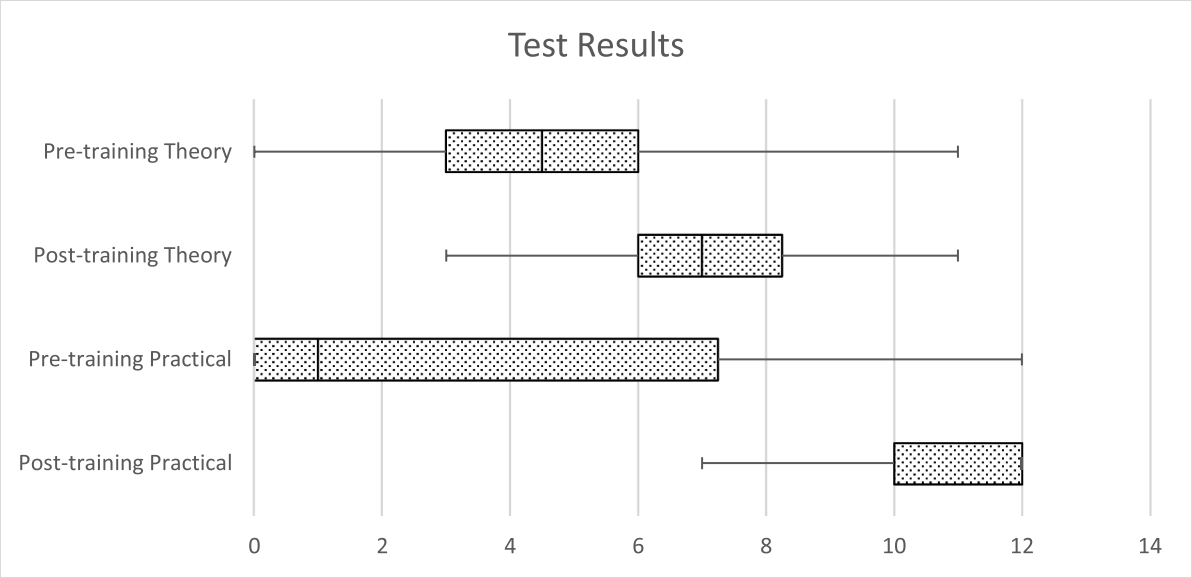

Fig. 1. Pre- and Post- training results: Theory and Practical median scores.

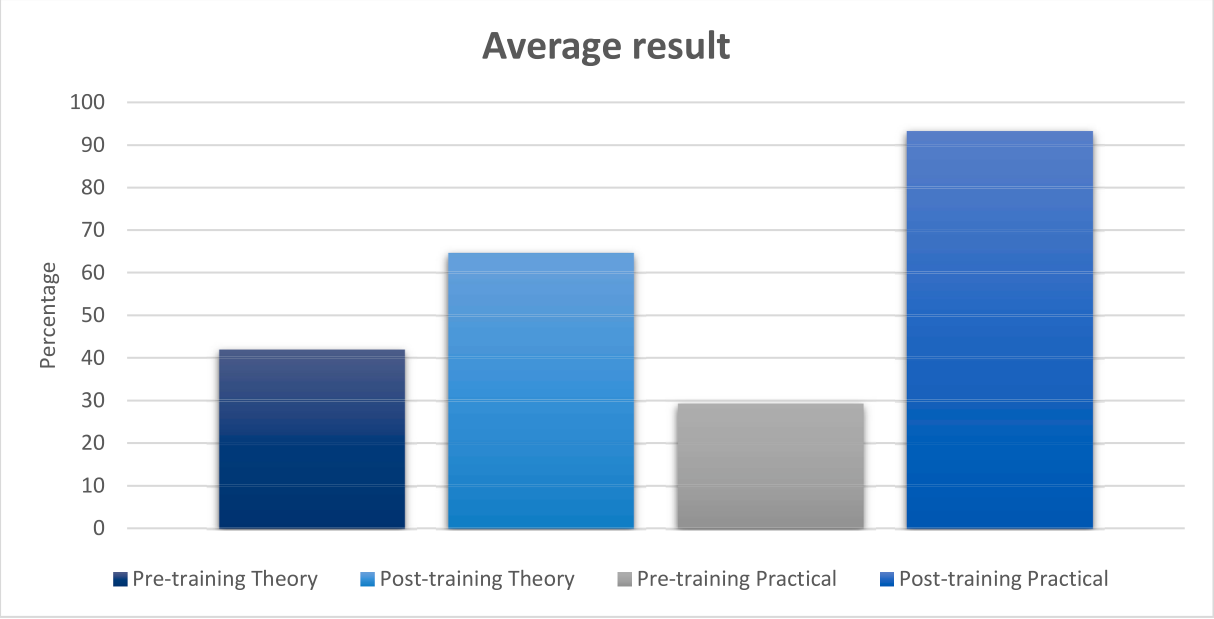

Fig. 2. Pre- and Post-training results: Theory and Practical averages.

Conclusion

To our knowledge, this is one of the first studies putting the focus of ETT cuff manometry on emergency registered nursing staff. This study showed inadequate knowledge, skills, and formal training when it comes to ETT cuff manometry, which is an essential ED nursing task. By implementing a narrated PowerPoint training presentation, significant improvements were noted in awareness, knowledge, and skills. The training program was also found to be acceptable and relevant by the nurses. The recommendation after this study will be for South African EDs to consider using this study and training material as a guide for annual in-service training. This would need to be implemented along with a unit protocol for the management of cuff pressures in the ED and improved access to tools needed to measure endotracheal tube cuff manometry.

Dissemination of results

Results from this study were shared with the ED nursing team at Chris Hani Baragwanath Hospital via the operational and unit managers. They would like to use the narrated PowerPoint as an annual in-service training session. The plan is to disseminate this article and research results to neighbouring EDs and to provide them with access to the training material.

Author contributions

Authors contributed as follow to the conception or design of the work; the acquisition, analysis or interpretation of data for the work; and drafting the work or revising it critically for important intellectual content: JH 70 % and LH 30 %. All authors approve the version to be published and agreed to be accountable for all aspects of work.

Table 2
Demographics vs Post-training practical improvement.

Variable	N	Post-training practical score improvement		P-Value
		Median	IQR	
Years working as a registered nurse				
<1 year	9	10.0	4.0	0.44
1–10 years	27	10.0	8.0	
10–20 years	21	7.0	6.0	
Years managing intubated patients				
<1 year	14	10.0	4.0	**0.03***
1–10 years	32	9.0	8.0	
10–20 years	13	6.0	4.0	
Previous training on cuff manometry				
Yes	14	4.0	5.0	**0.00***
No	46	10.0	5.0	
Ever checked cuff manometry before				
Yes	36	6.5	7.0	**0.00***
No	24	11.0	4.0	

Table 3
Training evaluation.

Training elements evaluated	Percentage ($n = 60$)		
	Strongly agree	Agree	Disagree
Topics discussed were relevant to my daily practice	95 %	5 %	0 %
I found the time for training to be sufficient	70 %	28 %	2 %
This will have an impact on my daily practice	90 %	8 %	2 %
This would be a good continuous training program for in-service training of nurses	97 %	3 %	0 %
Content was fair and appropriate for my level	87 %	13 %	0 %
Questions in the questionnaires were fair and appropriate for my level	75 %	25 %	0 %
Content and training should be provided in languages other than English	15 %	17 %	68 %

Declaration of competing interest

The authors declared no conflicts of interest.

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