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Operating room nurses' adherence to pneumatic tourniquet safety standards: A cross-sectional study

Abstract

Background: Pneumatic tourniquets are among the most frequently used devices in operating rooms. A study on the compliance of operating room personnel with safety protocols in the application of pneumatic tourniquets will enhance patient safety and reduce workplace hazards.

Method: The setting of this descriptive, cross-sectional study was three major teaching hospitals in Shiraz, Iran. The study was conducted between 2023 and 2024. The participants consisted of 300 operating room nurses selected by census sampling. Data were collected via questionnaire – the Pneumatic tourniquet work safety scale. The collected data were analysed using descriptive statistics, t-test, Pearson correlation and chi-square tests at a significance level of 0.05 in SPSS v. 21.

Results: The mean scores of the male and female participants in using pneumatic tourniquets were approximately equal, respectively 144.27±17.80 and 144.77±17.35 ($p = 0.816$), and at an average level. The results also showed a statistically significant correlation between participant scores in using pneumatic tourniquets and their participation in workshops about the safety standards for application of pneumatic tourniquets ($P < 0.05$).

Conclusion: The findings of the study highlight the importance of evaluating the application of pneumatic tourniquets by operating room personnel. Workshops can contribute to the knowledge and practice of operating room personnel in the safe application of pneumatic tourniquets.

Keywords: pneumatic tourniquet, operating room personnel, operating room, nurses

Introduction

Pneumatic tourniquets are among the most frequently used haemostatic devices in surgeries on limbs. Every day, pneumatic tourniquets are used in over 15 000 surgeries worldwide[1]. Tourniquets are routinely used in orthopaedic and plastic limb surgeries, as well as in intravenous regional anaesthesia (IVRA). They are employed for closed fracture fixation, intramedullary nailing, diabetic foot amputations, microvascular and transplant surgeries and trauma cases to reduce limb hemorrhage[2].

These devices reduce bleeding, improve surgical field visibility and enhance the safety and efficiency of surgeries[3]; however, unsafe pneumatic tourniquet application correlates with major complications[4]. Incorrect application of pneumatic tourniquets can result in neurological and muscular injuries (40%)[5], limb paralysis with either complete recovery (68%) or partial recovery (18%), post-tourniquet pain (50%), chemical burns (16%) and post-tourniquet syndrome (15%)[6].

Despite the relative simplicity of tourniquet application, non-standard practices remain prevalent. These include inappropriate cuff selection, loose application, incorrect pressure settings, prolonged inflation time, failure to remove prepping solutions prior to inflation and improper deflation techniques[3]. Results from a recent systematic review and meta-analysis revealed that fixed-pressure approaches persist in 68 per cent of cases despite elevated complication risks[7]. Existing clinical guidelines emphasise limb circumference and systolic blood pressure as primary considerations for tailoring

tourniquet pressures. Adherence to protocols guided by limb occlusion pressure (LOP) correlates with a 41 per cent decrease in ischemia-reperfusion injuries[3].

One of the main responsibilities of the surgical team is to follow safety protocols when providing care and applying surgical equipment[8]. According to a study by Boya et al.[9], many surgical interns receive no formal training in tourniquet application. Moreover, most surgeons are not familiar with safe tourniquet practices. To address this gap, the authors recommend mandatory training courses on safe tourniquet use for all operating room personnel once every six months[9]. Surgical teams must conduct pre-operative assessments, including tourniquet specifications (type and size), placement and pressure settings, and bilateral evaluation of patient neurovascular status (pulses, temperature, capillary refill, sensory/motor function)[3].

In hospitals in Iran, operating room nurses are responsible for the application and management of pneumatic tourniquets. Operating room nurses are required to comply with the safety guidelines for the application of pneumatic tourniquets and document their measures before, during and after surgeries. The annual on-the-job training courses currently provided for these nurses emphasise basic device operation and only provide a superficial overview of equipment settings. These sessions do not address critical safety components such as pre-operative equipment inspection, intra-operative monitoring techniques, post-operative assessment procedures, proper documentation standards and potential tourniquet-related complications. In addition, in their four years of education for a bachelor degree, operating room nurses are introduced to pneumatic tourniquets only in two theory sessions of two hours duration.

The authors of the present article, through years of experience in the operating room, have repeatedly witnessed the unsafe use of pneumatic tourniquets by their colleagues and the consequences of this for patients. Accordingly, the present study was conducted to evaluate the application of pneumatic tourniquets by operating room personnel with a study sample of operating room nurses.

Methods

This cross-sectional study was carried out in three major teaching hospitals in southern Iran in 2024. The study was conducted and reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

Sample and data collection

The research sample was selected by quota sampling from operating room nurses at the three hospitals. There were a total of 375 respondents who met the study inclusion criteria – 174 from Hospital 1 (46.4%), 115 from Hospital 2 (30.7%) and 86 from Hospital 3 (22.9%). The target sample size was 300; therefore, in accordance with quota sampling, the number of participants required from Hospital 1 was 139 (46.4% of 300), the number required from Hospital 2 was 92 (30.7% of 300) and the number required from Hospital 3 was 69 (22.9% of 300).

Data collection continued at each hospital until these predetermined quotas were reached. During recruitment, 25 initially eligible participants declined to participate without providing explicit reasons, resulting in an initial refusal rate of 6.7 per cent. To maintain the planned sample size, 25 replacement participants from the three hospitals were invited to participate in the same proportions as previously. Ultimately, 300 complete questionnaires were included in the analysis.

The first author visited the hospitals during the morning, afternoon and night shifts and invited nurses who met the inclusion criteria to participate in the study. The questionnaires were personally submitted to the participants in their workplace. The operating room nurses were sampled until the quota for each hospital was obtained.

Overall, 350 operating room nurses who applied pneumatic tourniquets and met the inclusion criteria were selected. None of the nurses who met the inclusion criteria opted to withdraw from the study for personal reasons (non-response rate = 0). Fifty of the participants had not responded to all the items on the questionnaire and these were excluded from the study. Thus, 300 questionnaires were included in the statistical analysis stage.

Inclusion criteria

The inclusion criteria were having a minimum of an associate degree in operating room nursing, having worked in operating rooms for a minimum of six months and being willing to participate in the study.

Instrument

Data were collected using the Pneumatic tourniquet work safety scale, a questionnaire developed by Fanoudi et al.[10] in 2024 based on a review of literature and interviews with a panel of experts. The face validity (qualitative and quantitative), content validity (qualitative and quantitative), construct validity (exploratory factor analysis, or EFA) and reliability (homogeneity and internal consistency) of the scale have been tested and found to be satisfactory. The EFA results showed the factor loadings of all the items to be between 0.334 and 0.722, all of which were significant[10]. The seven identified subscales were all verified by satisfactory values. The reliability of the scale was measured in terms of its internal homogeneity and found to equal a Cronbach's alpha of 0.85 for the entire instrument. The test–retest method was used to determine the intra-class correlation of the instrument, which was found to be 0.95, proving the scale to be consistent.

The Pneumatic tourniquet work safety scale consists of 41 items, grouped into seven subscales – 'testing the functioning of pneumatic tourniquets' (5 items), 'contraindications for the use of pneumatic tourniquets' (4 items), 'considerations on selecting the right cuff' (3 items), 'safe application of pneumatic tourniquets before surgery' (11 items), 'safe application of pneumatic tourniquets during surgery' (5 items), 'safe application of pneumatic tourniquets after surgery' (4 items) and 'record keeping and documentation' (9 items). Items are scored on a 5-point Likert scale, with responses ranging from 'always' to 'never'. The score range of the scale is between 41 and 205. A score of 41 to 95 indicates the respondent performs poorly when using pneumatic tourniquets, 96 to 150 indicates average performance and 151 to 205 indicates satisfactory performance.

Statistical analysis

Data were analysed using SPSS version 21. The participants' demographics and performance in complying with the safety standards of pneumatic tourniquets were described using descriptive statistics (frequency, percentage, mean and standard deviation). Independent t-test and one-way analysis of variance (ANOVA) were used to investigate the relationship between the demographic variables and the participants' total performance scores. In the present study, the significance level was set at 0.05.

Ethical considerations

The present study has been approved by the ethics committee of Shiraz University of Medical Sciences in Iran ((IR.SUMS.NUMIMG.REC.1402.034, Grant no: 28220). Prior to data collection, all necessary permissions were obtained from the participating educational hospitals affiliated to the university. Participants were informed about the research objectives, voluntary nature of participation, their right to withdraw, and confidentiality of their information, and subsequently filled out and signed the informed consent form. The research was carried out in accordance with relevant guidelines and regulations of the Declaration of Helsinki.

Table 1: Distribution of demographic variables study participants (N = 300)

Variables		Frequency (%)
Gender	female	203 (67.7)
	male	97 (32.3)
Age	20–30 years	134 (44.7)
	31–40 years	120 (40.0)
	41–50 years	37 (12.3)
	> 50 years	9 (3.0)
Educational level	associate degree	21 (7.0)
	bachelor's degree	261 (87.0)
	master's degree	18 (6.0)
Work experience	0–3 years	87 (29.0)
	4–10 years	82 (27.3)
	11–15 years	58 (19.3)
	> 16	73 (24.3)
Employment type	temporary	64 (21.3)
	contractual	47 (15.7)
	permanent	189 (63.0)
Have encountered complications in using a pneumatic tourniquet	no	228 (76.0)
	yes	72 (24.0)
Have participated in training workshops on the safe use of pneumatic tourniquets	no	241 (80.3)
	yes	59 (19.6)

Table 2: Descriptive statistics for the seven subscales of participant performance

Dimensions of performance	N	Lowest score	Highest score	Mean ± SD
Testing the functioning of pneumatic tourniquets	300	8.00	24.00	14.48±2.81
Contraindications for the use of pneumatic tourniquets	300	8.00	20.00	16.62±3.12
Considerations on selecting the right cuff	300	5.00	15.00	10.59±1.37
Safe application of pneumatic tourniquets before surgery	300	27.00	55.00	45.10±1.37
Safe application of pneumatic tourniquets during surgery	300	9.00	25.00	19.49±3.35
Safe application of pneumatic tourniquets after surgery	300	4.00	20.00	14.46±3.40
Record keeping and documentation	300	9.00	45.00	23.68±6.69
Total performance	300	83.00	193.00	144.43±17.63

Results

The participants of the study were 300 operating room nurses who were in practice in teaching hospitals. Table 1 shows the demographic characteristics of participants. Participants' ages ranged from 23 to 57 years, with a mean of 33.66±7.78. The majority were female (67.7%), had a bachelor's degree (87.0%) and had permanent employment (63%). Most participants (76.0%) reported no prior encounters with complications from unsafe tourniquet use, and most (80.3%) had never attended a workshop about using pneumatic tourniquets.

The mean performance score (144.43±17.63) indicated moderate compliance with safety standards. The lowest (10.59±1.37) and highest (45.10±1.37) mean scores were related to subscale three (considerations on selecting the right cuff) and subscale four (safe application of pneumatic tourniquets before surgery), respectively (see Table 2).

Regarding the first subscale (testing the functioning of pneumatic tourniquets), the results showed that 80.0 per cent of participants rarely or never ensured tubing or cables were not stretched (Item 3) and 77.3 per cent rarely or never disinfected contaminated cuffs (Item 5). In the fourth subscale (safe application of pneumatic tourniquets before surgery), 93.7 per cent rarely or never fastened cuffs at the most muscular proximal site (Item 16). For subscale seven (record keeping and documentation), 90.0 per cent rarely or never recorded device model or calibration data (Item 34). The frequency distribution of participant responses to all questionnaire items is shown in the supplement.

The independent t-test results showed that the mean scores for compliance with the safety standards in application of pneumatic tourniquets were approximately equal for female and male respondents, 144.27±17.80 and 144.77±17.35, respectively ($p = 0.816$).

The results of the Pearson correlation test demonstrated that the correlation between the operating room nurses' mean scores, on the one hand, and demographic characteristics (including age, level of education, work experience and type of employment), on the other, was not statistically significant. However, there was a statistically significant correlation between the nurses' performance and participation in workshops about safe application of pneumatic tourniquets ($p < 0.05$, see Table 3).

Discussion

The present study was conducted, using self-reporting, to evaluate operating room personnel practices when applying pneumatic tourniquets, with operating room nurses as representative study participants. The majority of the participants were female and had a bachelor's degree, which finding is consistent with the results of several other studies, indicating the predominance of females in nursing, especially in operating rooms. For example, another study in Iran, by Lebni et al.[11], reported that more than 70 per cent of the operating room nurses were female, and most of them had a bachelor's degree. These results suggest a consistent demographic profile in operating room nurses, characterised by female dominance and bachelor's degree attainment.

The results of the present study highlight the necessity of evaluating operating room staff performance regarding adherence to safety principles during tourniquet use. Therefore, ensuring adequate training and establishing protocols for acceptable tourniquet usage standards must be implemented. A study by Yalçınkaya et al.[12], in Turkey, showed that orthopaedic surgeons use higher-than-normal pressure to inflate the tourniquet cuff in surgical procedures. The results of a study by Cunningham et al.[13], in Ireland, also indicate that the tourniquet cuff pressure used in orthopaedic surgeries is higher than necessary. A study by Tuncali et al.[14] revealed significant discrepancies among surgeons regarding certain aspects of tourniquet use. These variations, particularly concerning pressure settings and proper training in pneumatic tourniquet application, may substantially increase the risk of significant adverse effects[9]. Therefore, guidelines should be established to optimise cuff pressure in order to minimise the risk of complications related to pneumatic tourniquets[14].

In the present study, 82 per cent of participants had not attended a workshop on pneumatic tourniquets. Also, the nurses' mean score on the scale showed that their compliance with the safety standards of pneumatic tourniquets was average. Similarly, in a study by Keleekai et al.[15] most of the nurses did not participate in perfunctory workshops and, thus, obtained low scores for compliance with standard protocols. A study of nurses' application of medical equipment by Ewertsson et al.[16] found that non-participation in training courses had a positive correlation with the inefficiency of safety protocols, stressing the need for educational workshops. Findings from a study by Albaker[5], in Saudi Arabia, indicated that modifying medical residents' training programs to enhance knowledge and awareness leads to reduced complication rates.

Several organisations, including the British Orthopaedic Association (BOA)[17], the British Society for Children's Orthopaedic Surgery (BSCOS)[18] and the Australian College of Perioperative Nurses (ACORN)[19] have issued guidelines recommending safe pressure levels for pneumatic tourniquet use. A recent meta-analysis by Chan et al.[7] revealed a 32 per cent increased risk of nerve injury when tourniquet pressures exceed 50 mmHg above limb occlusion pressure (LOP), underscoring the need for standardised protocols. Similarly, the Association of Surgical Technologists (AST)[20] and the Association of periOperative Registered Nurses (AORN)[21] emphasise that the members of surgical teams must receive proper training in the use of pneumatic tourniquets. This training should include correct application techniques, appropriate timing and the potential risks associated with pneumatic tourniquet use. Relevant, practical training is essential for enhancing nurses' knowledge and skills. However, researchers should investigate the underlying reasons for nurses' reluctance to attend such workshops and develop effective measures to encourage their participation.

In the present study, the participants' mean age was 33 years, which indicates that youth prevails in the nursing population. However, despite their young age and satisfactory level of education,

Table 3: Relationships between participant demographic variables and total performance

Variables		N	Mean (±SD)	P value
Gender	female	203	144.27 (±17.80)	0.816
	male	97	144.77 (±17.36)	
Age	20–30 years	134	143.19(±17.65)	0.556
	31–40 years	120	144.63(±17.13)	
	41–50 years	37	147.51(±18.23)	
	> 50 years	9	147.55(±22.35)	
Educational level	associate degree	21	146.86 (±17.73)	0.800
	bachelor's degree	261	144.29 (±17.20)	
	master's degree	18	143.67 (±23.83)	
Work experience	0–3 years	87	140.77 (±18.08)	0.130
	4–10 years	82	146.13 (±16.51)	
	11–15 years	58	144.97 (±17.81)	
	> 16	73	146.47 (±17.85)	
Employment type	temporary	64	142.22 (±17.94)	0.150
	contractual	47	148.62 (±16.02)	
	permanent	189	144.14 (±17.83)	
Have encountered complications in using a pneumatic tourniquet	no	228	144.25 (±16.62)	0.750
	yes	72	145.00 (±20.64)	
Have participated in training workshops on the safe use of pneumatic tourniquets	no	241	142.18 (±17.61)	0.000
	yes	59	153.64 (±14.55)	

the nurses' performance in complying with the safety standards of pneumatic tourniquets was average. In addition, 80 per cent of the participants declared that they had never encountered the consequences of unsafe application of pneumatic tourniquets. This may stem from underreporting, lack of exposure to complications or non-adherence to protocols. According to a study by Hågensen et al.[22], in general hospitals in Norway, nurses' negligence in making reports has caused many patient complications to go unnoticed.

The majority of the participants in the current study obtained considerably low scores in the seventh subscale of documentation and keeping records. This is consistent with a study by Tajabadi et al.[23] who found that nurses were usually negligent in recording and documenting patients' medical records, which could lead to medical errors. Similarly, Jaafar et al.[24] reported that a lack of awareness about the significance of documentation correlated with a decline in the quality of services.

In the current study, the participant performance was similar across nurses of different genders, meaning there was not a significant difference between the male and female nurses' performance. This finding indicates that demographic factors alone do not affect nurses' application of pneumatic tourniquets. On a similar note, the results of a study by Kahya and Oral[25] showed that male and female nurses' performance in applying medical equipment was almost the same.

In the present study, the correlation between participant performance and age was not significant, indicating that nurses' age alone cannot guarantee better performance in the application of pneumatic tourniquets. Therefore, continuous skill validation is essential, as assuming competence based solely on years of service is clinically unsafe and inconsistent with professional accountability[26]. It seems that updating training courses designed to improve nurses' theoretical knowledge and practical skills can help improve nurses' performance more than their age and work experience.

The findings of the present study have implications for education, research, policy and clinical practice. As operating room nurses' performance in applying pneumatic tourniquets was average, education planners and administrators should incorporate training in the safety standards of pneumatic tourniquets into nursing students' education. In addition, managers can contribute to nurses' safe application of pneumatic tourniquets by arranging periodic on-the-job training programs and developing comprehensive protocols for clinical practice.

Documentation, monitoring and organisational culture should be promoted to decrease the negative consequences of unsafe application of medical equipment, which will, in turn, improve the quality of services. The findings of this study can be a springboard for future interventional studies that measure the impact of education about the safety standards of pneumatic tourniquets on patient safety. Also, investigation into the contributing factors in nurses' failure to comply with the safety standards of pneumatic tourniquets can result in a better understanding of the existing obstacles. By analysing educational barriers, management processes and cultural influences in other settings, researchers can pave the way for a safer application of pneumatic tourniquets.

Limitations

One limitation of this study was its reliance on self-reported data, which may have resulted in inflated participant

scores and potential response bias. Additionally, the questionnaire-based design introduced the possibility of social desirability bias, as participants might have favoured higher Likert scale scores, thereby influencing their responses. To address these limitations, the researchers emphasised the study's objectives, guaranteed data anonymity and confidentiality, and increased the sample size to improve reliability. Moreover, although the questionnaire used in this study demonstrated acceptable reliability and validity, the absence of confirmatory factor analysis (CFA) means the underlying factor structure was not empirically verified for this specific sample. Future research should validate the scale's factor structure using CFA.

> Editor's note: The results of subsequent CFA of the scale are reported elsewhere in this issue.

Conclusion

The findings of the study showed operating room nurses' performance in applying pneumatic tourniquets to be average. Nurses must be presented with up-to-date knowledge about the safety standards of these devices in periodic workshops. Hospitals should improve the existing protocols and organise regular programs to update their nurses' knowledge and skills. Also, the importance of documentation and archiving medical records should be stressed in clinical environments. The findings of the study can be used as a guideline for the development of effective educational programs, ultimately enhancing the quality of services and patient safety in clinical environments.

Conflict of interest and funding statement

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Data availability statement

Data will be made available upon reasonable request to the corresponding author.

Authorship contribution statement

HF: Conceptualisation, data curation, writing – original draft preparation, methodology, formal analysis, and investigation; CT: Visualisation, validation, data curation, methodology, supervision, and project administration; MR: Writing – reviewing and editing, validation, methodology, supervision. GHSH: Visualisation, validation, supervision, writing, reviewing, and editing.

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