Original Article

Journal of Iranian Medical Council, Volume 4, Issue no. 1
http://dx.doi.org/10.18502/jimc.v4i1.5740

Check for updates

Effects of Feedback and Education on Nurses' Clinical Competence in Mechanical Ventilation and Accurate Tidal Volume Setting

Samira Norouzrajabi[1], Shahrzad Ghiyasvandian[1], Alireza Jeddian[2], Ali Karimi Rozveh[3] and Leila Sayadi[4*]

1. School of Nursing and Midwifery, Tehran University of Medical Sciences, Tehran, Iran

2. Digestive Disease Research Institute, Tehran University of Medical Sciences, Tehran, Iran

3. Shariati Hospital, Tehran University of Medical Sciences, Tehran, Iran

4. Nursing and Midwifery Care Research Center, School of Nursing and Midwifery, Tehran University of Medical Sciences, Tehran, Iran

*** Corresponding author**

Leila Sayadi, PhD
Nursing and Midwifery Care Research Center, School of Nursing and Midwifery, Tehran University of Medical Sciences, Tehran, Iran
Email: l-sayadi@sina.tums.ac.ir

Received: Sept 30 2020
Accepted: Nov 25 2020

Citation to this article:

Norouzrajabi S, Ghiyasvandian Sh, Jeddian A, Karimi Rozveh A, Sayadi L. Effects of Feedback and Education on Nurses' Clinical Competence in Mechanical Ventilation and Accurate Tidal Volume Setting. *J Iran Med Counc*. 2021; 4(1):30-38.

Abstract

Background: Patients under mechanical ventilation are at risk of ventilator-associated complications. One of these complications is lung injury due to high tidal volume. Nurses' competence in mechanical ventilation is critical for preventing ventilator-associated complications. This study assessed the effects of feedback and education on nurses' clinical competence in mechanical ventilation and accurate tidal volume setting.

Methods: This single arm pretest-post-test interventional study was conducted in 2019 at Shariati hospital affiliated to Tehran University of Medical Sciences.

Participants were 75 conveniently selected nurses. Initially, nurses' clinical competence in mechanical ventilation and ventilator parameters of 250 patients were assessed. A mechanical ventilation -based feedback and education intervention was implemented for nurses. Finally, mechanical ventilation clinical competence of nurses and ventilator parameters of 250 new patients were assessed. Moreover, patients' height was estimated based on their ulna length and then, their predicted body weight was calculated using their estimated height. Accurate tidal volume was determined per predicted body weight.

Results: The mean score of nurses' clinical competence increased from 8.27±3.09 at pretest to 10.07±3.34 at post-test ($p<0.001$). The mean values of both total tidal volume and tidal volume per kilogram of predicted body weight were significantly reduced respectively from 529.84±69.11 and 9.11±1.73 (*ml*) at pretest to 476.30±31.01 and 7.79±1.14 (*ml*) at post-test ($p<0.001$).

Conclusion: The feedback and education intervention is effective in promoting nurses' clinical competence in mechanical ventilation and reducing tidal volume. Thereby, it can reduce lung injuries associated with high tidal volume and ensure patient safety.

Keywords: Body weight, Clinical competence, Educational status, Lung injury, Tidal volume

Introduction

Each year, many patients need advanced respiratory support and Mechanical Ventilation (MV) due to affliction by critical conditions (1). Despite the increasing prevalence of Non-Invasive Ventilation (NIV), Invasive MV (IMV) is still used in many clinical settings (2,3). Moreover, in some countries like Iran, there are various barriers to the use of NIV and hence, IMV is routinely used (4).

Inappropriate ventilator settings can result in Ventilator-Associated Lung Injury (VALI). VALI happens due to barotrauma, volutrauma, biotrauma, atelectrauma, cyclic atelectasis, and oxygen toxicity (5,6). The prevention and management of VALI depend on the use of Lung Protective Strategies (LPSs) with appropriate ventilator setting (6,7). An important strategy for VALI prevention among patients under MV is accurate determination of the tidal volume (Vt).

Vt should be determined based on patients' ideal or Predicted Body Weight (PBW) which should be calculated based on patients' height and gender (8,9). Moreover, Vt for all patients under MV should be set at low values (10). Previously, Vt for patients receiving positive pressure ventilation was set as high as 10–15 (*ml/kg*) in order to prevent atelectasis. However, current LPSs recommend that a low Vt of 6-8 (*ml/kg* PBW) reduces the risks of VALI and death (8,11)

Despite the importance of accurate Vt determination, some studies revealed its inaccurate determination. For instance, a study in the United Kingdom showed that healthcare providers had limited knowledge about PBW-based Vt determination and calculated Vt based on patients' actual weight (12). Similarly, several studies reported the wide prevalence of inaccurate Vt determination based on the visual estimation of weight or height which in most cases was associated with overestimation of body weight (9,13). Moreover, studies showed that LPSs and low Vt were not routinely used for patients under MV (14,15).For example, a study on 1905 patients in six Intensive Care Units (ICUs) in the United States reported that 40% of them received a Vt of more than 8 (*ml/kg* PBW) (16).

Although primary ventilator settings should be determined by medical specialists, most attending physicians and nurses are involved in determining and controlling ventilator settings. During their daily practice, nurses control and document ventilator settings and inform physicians about them because nurses are responsible for providing top quality care, preventing adverse consequences (17), ensuring patient safety, and detecting errors, negligence, and potential risks (18,19) These responsibilities are especially important in case of care delivery to patients under MV who either have altered consciousness or are unable to talk (17). Nurses' wise MV-related decisions can reduce complications among patients, facilitate the early diagnosis of MV-related problems, and improve the accuracy of ventilator setting (20).

Adequate knowledge and skills are the most basic prerequisites for accurate Vt determination and effective VALI prevention. Nonetheless, various studies reported nurses' limited MV-related knowledge and skills. A study in South Africa showed that the level of MV competence among ICU and non-ICU nurses was 50 and 38%, respectively (21). Another study in Australia reported that although nurses had good knowledge about LPSs, they had different levels of confidence and autonomy in their implementation (22). Similarly, a study on emergency nurses in Canada showed limited in-service education, lack of competence evaluation, and irregular use of guidelines and protocols as the main safety concerns for patients under MV in emergency departments (23).

Feedback and education are important strategies for promoting nurses' clinical competence in MV. Feedback is a key component of education, without which errors are not corrected and learning is not effective. A constructive feedback on weaknesses can modify clinical practice, enhance care quality, and improve patient outcomes (24). Some earlier studies evaluated the effects of feedback and education on clinical outcomes. For instance, a study on physicians and nurses in Netherlands found that feedback and education were effective in reducing the rate of high Vt (25). Another study in Australia showed that audit, feedback, and education were effective in improving access to best practice models of rehabilitation services among hospitalized patients with stroke (24). However, a study showed that audit and feedback had small effects on anticoagulant use among patients with atrial fibrillation and hence, recommended multi-component interventions consisting of audit, feedback, education, and inter-professional dialogue for producing better results (26).

Most previous studies into the effects of education and feedback were conducted in developed countries and on physicians or physicians and nurses. In other words, there are limited data on the effects of education and feedback on nurses in developing countries like Iran. Therefore, the current study was conducted to narrow this gap.

The aim of the study was to evaluate the effects of feedback and education on nurses' clinical competence in MV and accurate Vt.

Materials and Methods

Design

This single arm pretest-post-test interventional study was conducted in April–September 2019 in Shariati Hospital affiliated to Tehran University of Medical Sciences.

Setting and sample

Study setting consisted of all medical-surgical wards, critical care units, and emergency departments of Shariati Hospital, Tehran, Iran. There were two emergency departments, and five critical care units in the study setting. Moreover, the medical-surgical wards of the hospital were orthopedics, neurology, rheumatology, cardiology, gastroenterology and endocrinology, surgery, respiratory, urology, nephrology, and hematology. There was a critical care team in the hospital for care delivery to patients who received MV in general wards.

The main study participants were 35 nursing staff and 40 in-charge nurses, head nurses, and supervisors. Head nurses and supervisors were included because they supervised nurses' MV-related practice. Inclusion criteria were bachelor's degree or higher in nursing and consent for participation. Exclusion criteria were voluntary withdrawal from the study, retirement, or service abandonment. Moreover, 500 adult patients aged more than eighteen years who were receiving volume-controlled IMV were included for Vt assessment before (n=250) and after (n=250) the study intervention. The only inclusion criterion for patients was no injury in the forearms and arms.

Effect size was used for determining sample size. Accordingly, with a power of 0.90, a confidence level of 0.95, and an effect size of 0.55, the sample size calculation formula (Figure 1) revealed that 35 nurses were required for the study. At least, two nurses were conveniently selected from each of the wards of the study setting. The same sample size calculation formula (Figure 1) also revealed that with a power of 0.90, a confidence level of 0.95, and an effect size of 0.21, 238 patients were needed. Accordingly, 250 patients were selected for pretest Vt assessment and another 250 patients were selected for post-test Vt assessment.

$$\frac{(Z_\alpha + Z_\beta)^2}{(Effect\ size)^2}$$

Figure 1. Sample size formula.

Data collection

Nurses' data were collected using a demographic questionnaire and a researcher-made MV clinical competence scale. The items of the demographic questionnaire were on age, gender, educational level, history of participation in MV-related continuing education programs, work experience, and organizational position. The MV clinical competence scale was developed through reviewing the existing literature. It had two main parts. The first part had just one self-report item on nurses' perceived competence in working with ventilator scored on a 1-10 scale. Its second part contained eighteen items in two dimensions, namely "ventilator setting and MV-related complications" and "two scenarios for setting ventilator for two patients". The first scenario was related to a patient with no lung injury who needed postoperative MV for 24 hours. The second scenario was related to a patient with chronic obstructive pulmonary disease who was under MV. Each correct answer to items was scored 1 and each wrong or blank answer was scored zero. Therefore, the total score of the second part of the scale was 0-18, with higher scores showing greater clinical competence in MV. Nurses were asked to complete the demographic questionnaire and the MV clinical competence scale through the self-report method.

Patients' data were also collected using a demographic questionnaire and a ventilator data sheet. The items of the demographic questionnaire were on age, gender, height, hospitalization ward and the items of the ventilator data sheet were on ventilation mode, respiratory rate, Fraction of inspired oxygen (FiO2), Vt, trigger, inspiratory flow rate, PEEP, and pressure support. For accurate Vt determination, PBW of each patient was initially calculated based on height, gender, and age. Height was determined through measuring ulna length using a tape measure and gender- and age-adjusted PBW tables proposed in a former study (27). After that, PBW was calculated (8,9) and finally, the Vt value on ventilator was divided by PBW in order to determine Vt per kilogram of PBW. Patients' demographic data were collected from their medical records. Initial data on their Vt, respiratory rate, FiO2, inspiratory flow, PEEP, trigger, and pressure support parameters were collected from ventilator screen or were collected from their medical records.

The face and content validity of the study instruments were assessed by ten faculty members in nursing, anesthesiology, and pulmonology. For assessing the reliability of ulna length measurement, two of the authors independently measured the ulna length of ten patients and Kappa coefficient was 1. The reliability of the nurses' MV clinical competence scale was also assessed through the test-retest method, in which ten nurses completed the scale twice with a two-week interval. Test-retest correlation coefficient was 0.80.

Intervention

Study intervention consisted of feedback and education. Initially, nurses' clinical competence in MV was assessed, the data were analyzed, and findings were presented to them in the form of tables and diagrams in order to inform them about their current status. Then, a three-hour MV-related educational session was held for nurses (from 08:30 to 12:00) with a thirty-minute interval. At the beginning of the session, nurses were provided with the findings of the primary assessment of their clinical competence in MV. Accordingly, they became aware of their MV practice. Then, they were provided with educations about accurate ventilator setting, VALI, injuries associated with inaccurate Vt determination, the formula for accurate Vt determination, accurate PBW calculation based on height, and accurate height calculation based on ulna length. Educations were provided through the lecture method and using teaching aids and participants exercised ulna length measurement, height calculation based on ulna length, and PBW calculation based on height. After the educational session, the first author independently or together with the members of the critical care team of the hospital attended different hospital wards and provided other nurses with educations about ulna length measurement, height calculation, PBW calculation, and accurate Vt determination based on PBW. Educations were provided in-person or in groups and while nurses were providing care to patients under MV or while they were in nursing station. Moreover, educational posters related to ulna length measurement, height calculation, PBW calculation, and accurate Vt determination based on PBW were hung in the wards. The intervention lasted two months. After the intervention, nurses' clinical competence in MV was reassessed using the MV clinical competence scale and their Vt determination skill was reexamined through assessing the ventilator settings of 250 new patients.

Data analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS) software (Version 16.0). The independent-sample *t* and the Chi-square tests were used to compare the two groups of patients recruited for pretest and post-test Vt assessment respecting their demographic and clinical characteristics. The pretest and post-test mean values of Vt were also compared using the independent-sample *t* test, while the pretest and post-test mean scores of nurses' clinical competence in MV were compared using the paired-sample *t* test. p values less than 0.05 were considered significant.

Ethics and research approvals

This study was approved by the institutional research ethics committee at School of Nursing and Midwifery and Rehabilitation of Tehran University of Medical Sciences, Tehran, Iran (Code: IR.TUMS.FNM.REC.1398.026). Informed consent was obtained from all nurses and they were assured that their data would be managed confidentially.

Results

The means of participating nurses' age and work experience were 34.01±8.56 and 11.23±8.31 years, respectively. Most nurses were female (85.3%) and worked in medical-surgical wards and emergency departments (68%) (Table 1).

There were no statistically significant differences between the two groups of patients respecting their age, gender, hospitalization ward, and calculated height based on ulna length. However, the mean of post-test PBW was significantly greater than the pretest PBW (p=0.002). Most patients in both groups received MV with a respiratory rate of 10-12 per minute. Only 14% of patients at pretest received MV with a respiratory rate of 13-15 per minute. At post-test, this value increased to 32.4%. The between-group difference respecting respiratory rate was significant (p<0.0001). The post-test mean values of trigger and pressure support were significantly less than their corresponding pretest mean values (p<0.05), while the post-test mean value of PEEP was significantly greater than its pretest mean value (p<0.001) (Table 2).

The mean score of nurses' clinical competence significantly increased from 8.27±3.09 at pretest to 10.07±3.34 at post-test (p<0.001). However, there

Table 1. Participating nurses' characteristics

Characteristics		N (%) or Mean±SD
Age (Years)		34.01±8.56
Gender	Male	11(14.7)
	Female	64(85.3)
Work experience (Years)		11.23±8.31
ICU work experience (Years)		4.13±5.37
Educational level	Bachelor's	67(89.3)
	Master's	8(10.7)
Participation in critical care continuing education programs	Yes	31(41.3)
	No	44(58.7)
Ward	ICU	24(32)
	Medical-surgical or emergency	51(68)

Table 2. Comparison of participating patients' demographic and clinical characteristics

Time Characteristics			pretest N (%) or Mean±SD	post-test N (%) or Mean±SD	p value
Age (Years)			53.22±18.26	55.92±16.0	0.089*
Gender	Male		137(54.8)	148(59.2)	0.366^
	Female		113(45.2)	102(40.8)	
Ward	ICU		209(83.6)	196(78.4)	0.138^
	Medical-surgical or emergency		41(16.4)	54(21.6)	
Height based on ulna length (*Centimeters*)			163.68±16.01	166.12±16.46	0.093*
PBW based ulna length (*Kilograms*)			59.37±8.81	61.87±8.79	0.002*
Ventilator setting	Respiratory rate	10–12	215(86.0)	169(67.6)	< 0.001^
		13–15	35(14.0)	81(32.4)	
	Trigger		4.33±3.77	3.64±0.936	0.005*
	PEEP		4.76±1.17	5.24±1.45	< 0.001*
	Flow		57.59±13.99	56.60±11.92	0.394*
	Pressure Support		12.65±2.86	11.85±2.44	0.001*
	Fio$_{2}$		53.66±8.90	54.02±9.63	0.665*
	Mode	Assist	4(1.6)	8(2.4)	0.474^
		CMV	4(1.6)	3(1.2)	
		SIMV/SIMV+PS	242(96.8)	239(95.6)	

*: The results of the independent-sample *t* test; ^The results of the Chi-square test

Table 3. Comparing the pretest and the post-test values of nurses' clinical competence and Vt-related outcomes

Time Characteristics		pretest N (%) or Mean±SD	post-test N (%) or Mean±SD	p value
Nurses' competence in MV	Perceived (in the range of 1–10)	6.38±2.15	6.68±2.34	0.322^
	Total (in the range of 1–18)	8.27±3.09	10.07±3.34	< 0.001^
Vt value on ventilator (*ml*)		529.84±69.11	476.30±31.01	< 0.001*
Vt (*ml/kg* PBW)		9.11±1.73	7.79±1.14	< 0.001*
Vt (*ml/kg* PBW)	> 8 (*ml/kg* PBW)	172(68.8)	90(36.1)	< 0.001**
	≤ 8 (*ml/kg* PBW)	78(31.2)	160(63.9)	

*: The results of the independent-sample *t* test; **: The results of the Chi-square test; ^: The results of the paired-sample *t* test

was no statistically significant difference between the mean scores of their perceived clinical competence (p=0.322) (Table 3).

The mean value of total Vt was also 529.84±69.11 (*ml*) at pretest which was significantly reduced to 476.30±31.01 (*ml*) at post-test (p<0.001). Moreover, the mean value of Vt per kilogram of PBW was 9.11±1.73 (*ml*) at pretest which was significantly reduced to 7.79±1.14 (*ml*) at post-test (p<0.001). As MV protocols recommend the initiation of MV with a Vt of 8 (*ml/kg*) and gradually reducing to 6 (*ml/kg*) (28), initial Vt data was divided into the two categories of equal to or less than 8 and more than 8. Findings revealed that 68.8% of patients at pretest received MV with a Vt of more than 8 (*ml/kg* PBW). This value significantly decreased to 36.1% at post-test (p<0.001) (Table 3).

Discussion

This study sought to evaluate the effects of feedback and education on nurses' competence in MV and accurate tidal volume. Results showed that the feedback and education intervention significantly improved nurses' clinical competence in MV and reduced Vt for patients under MV.

Before the intervention, most patients in the study setting received MV with a high Vt of more than 8 (*ml/kg* PBW). High Vt can cause different complications such as inflammatory lung conditions, alveolar overdistension, and even death (6,29,30). A study on 1905 patients hospitalized in six ICUs in the United States showed that although the mean of Vt was 6.8 (*ml/kg* PBW), 40% of patients received MV with a Vt of more than 8 (*ml/kg* PBW) (16). A multicenter study in sixteen ICUs in the United Kingdom also showed that the mean of Vt for patients under MV was 7.2±1.4 (*ml/kg* PBW) (31). Another study on 433 patients in three emergency departments in the United States revealed that 60.3% of them received protective MV with low Vt (32). These findings, which are contrary to our findings, highlight the importance of MV with low Vt in developed countries.

Study findings also showed that the feedback and education intervention of the study was effective in significantly reducing Vt from 9.11±1.73 (*ml/kg* PBW) at pretest to 7.79±1.14 (*ml/kg* PBW) at post-test and hence, most patients at post-test received MV with a Vt of less than 8 (*ml/kg* PBW). The significant effects of the feedback and education intervention might have been due to the focus of this intervention on the existing problems (11) In line with these findings, a study in Netherlands showed that feedback-education for physicians and nurses significantly reduced Vt for patients under MV (25). Another study in the United States showed the effectiveness of a lung protective intervention implemented using journal club review, lectures, and education in significantly reducing Vt for patients under MV (33). Moreover, a study conducted from 2007 to 2014 on 2185 patients in emergency departments of United States showed that the mean of initial Vt was 9±1.4 (*ml/kg* PBW) which was significantly reduced after eight-month quality improvement interventions. These interventions consisted of lecture-based education for physicians and height-adjusted Vt cards attached to all ventilators (34). A study in the United Kingdom also indicated that the use of large screens which displayed Vt delivered to patients significantly reduced Vt from 7.7±2.1 to 7.0±2.0 (*ml/kg* PBW) (35). Another study in Netherlands revealed the effectiveness of feedback and education respecting lung protective MV in significantly reducing Vt from 9.8±2.0 to 8.1±1.7 (*ml/kg* PBW) (11). Our findings also showed the effectiveness of the feedback and education intervention in significantly increasing PEEP value set on ventilator. LPSs state that PEEP value should be increased when Vt is decreased (6,36). Moreover, study findings showed significant increase in respiratory rate and significant decrease in trigger and PS after the feedback and education intervention. These findings are attributable to the fact that before the present study, there were no lung protective guidelines in the study setting and most physicians and nurses relied on their experiences for setting MV parameters.

It was also found that before the intervention, nurses had limited competence in accurately determining MV parameters. A former study on critical care nurses in South Africa also showed that most of them had limited competence in MV (37). Another study on emergency nurses in Australia showed that they had different levels of confidence and autonomy in using lung protective strategies (22). Although nurses' perceived clinical competence in MV did not significantly change in the present study, their mean score of clinical competence in MV significantly increased after the study intervention. A study in India also showed that education significantly increased nurses' knowledge about ventilator-associated complications (38). Studies on other care-related outcomes also reported the positive effects of feedback and education. For instance, a study in the United Kingdom showed feedback and education improved proper antibiotic choice for patients with hip fracture surgery by 94% (39). Another study showed that feedback and education for nurses during the placement of peripheral venous catheter significantly improved their peripheral venous catheter insertion skill (40). Our findings also indicated that most of the recruited nurses had not participated in critical care continuing education programs and did not have the basic qualifications for critical care practice. These findings highlight the importance of providing critical care nurses with quality education about MV, particularly accurate Vt determination. Nurses are the only healthcare providers who constantly deal with hospitalized patients. Therefore, they need to have adequate knowledge about MV in order to prevent VALI (41).

Conclusion

Nurses have an important role in preventing lung injuries of patients under ventilator due to their regular clinical presence. The feedback and education intervention is effective in significantly promoting nurses' clinical competence in MV and improving their Vt determination skill. Therefore, this intervention can be used in healthcare settings to improve patient outcomes and patient safety and reduce VALI.

Acknowledgements

We express our gratitude towards the critical care team of Shariati hospital affiliated to Tehran University of Medical Sciences for their generous assistance. We would like to thank all nurses who participated in this study. This study was part of a research supported by Nursing and Midwifery Care Research Center, School of Nursing and Midwifery, Tehran University of Medical Sciences, Tehran, Iran (Grant No: 98-01-99-41678 and ethics code: IR.TUMS.FNM.REC.1398.026).

References

1. Slutsky AS. History of mechanical ventilation. From vesalius to ventilator-induced lung injury. Am J Respir Crit Care Med 2015;191(10):1106-15.

2. De-Miguel-Díez J, Jiménez-García R, Hernández-Barrera V, Zamorano-Leon JJ, Rosa Villanueva-Orbaiz R, Albaladejo-Vicente R, et al. Trends in mechanical ventilation use and mortality over time in patients receiving mechanical ventilation in Spain from 2001 to 2015. Eur J Intern Med 2020;74:67-72.

3. Mehta AB, Syeda SN, Wiener RS, Walkey AJ. Epidemiological trends in invasive mechanical ventilation in the

United States: A population-based study. J Crit Care 2015;30(6):1217-21.

4. Safari S, Lotfi AH, Hekmatafshar M. The importance of non-invasive mechanical ventilation: current status in Iran. Ann Anesth Crit Care 2017;2(1):e10570.

5. Joseph A, Khan MF, Rajendram R. Strategies to prevent ventilator-associated lung injury in critically Ill patients. Indian J Respiratory Care 2018;7(1):4-13.

6. Slutsky AS, Ranieri VM. Ventilator-induced lung injury. N Engl J Med 2014;370(10):980.

7. Marret E, Bonnet F. Lung protective ventilation and thoracic anesthesia. J Thorac Dis 2019;11(Suppl 9):S1426-S7.

8. Castellanos I, Martin M, Kraus S, Bürkle T, Prokosch HU, Schüttler J, et al. Effects of staff training and electronic event monitoring on long-term adherence to lung-protective ventilation recommendations. J Crit Care 2018;43:13-20.

9. Sasko B, Thiem U, Christ M, Trappe HJ, Ritter O, Pagonas N. Size matters: An observational study investigating estimated height as a reference size for calculating tidal volumes if low tidal volume ventilation is required. PloS One 2018;13(6):e0199917.

10. Rackley CR, MacIntyre NR. Low tidal volumes for everyone? Chest 2019;156(4):783-91.

11. Wolthuis EK, Korevaar JC, Spronk P, Kuiper MA, Dzoljic M, Vroom MB, et al. Feedback and education improve physician compliance in use of lung-protective mechanical ventilation. Intensive Care Med 2005;31(4):540-6.

12. Holden S, Nichani R. Low tidal volume ventilation. J Intensive Care Soc 2018;19(2):171-2.

13. Deane AM, Reid DA, Tobin AE. Predicted body weight during mechanical ventilation: using arm demispan to aid clinical assessment. Crit Care Resusc 2008;10(1):9-14.

14. Rose L. Clinical application of ventilator modes: Ventilatory strategies for lung protection. Aust Crit Care 2010;23(2):71-80.

15. Patel JM, Baker R, Yeung J, Small C, West Midlands-Trainee Research and Audit Network (WM-TRAIN). Intra-operative adherence to lung-protective ventilation: a prospective observational study. Perioper Med (Lond) 2016;5(1):8.

16. Sjoding MW, Gong MN, Haas CF, Iwashyna TJ. Evaluating delivery of low tidal volume ventilation in six ICUs using electronic health record data. Crit Care Med 2019;47(1):56-61.

17. Sundqvist AS, Anderzen-Carlsson A, Nilsson U, Holmefur M. Protective nursing advocacy: translation and psychometric evaluation of an instrument and a descriptive study of Swedish registered nurse anesthetists' beliefs and actions. J Perianesth Nurs 2018;33(1):58-68.

18. Liu X, Zheng J, Liu K, Baggs JG, Liu J, Wu Y, et al. Hospital nursing organizational factors, nursing care left undone, and nurse burnout as predictors of patient safety: A structural equation modeling analysis. Int J Nurs Stud 2018;86:82-9.

19. Usher K, Woods C, Parmenter G, Hutchinson M, Mannix J, Power T, et al. Self-reported confidence in patient safety knowledge among Australian undergraduate nursing students: a multi-site cross-sectional survey study. Int J Nurs Stud 2017;71:89-96.

20. Halcomb E, Stephens M, Bryce J, Foley E, Ashley C. Nursing competency standards in primary health care: an integrative review. J Clin Nurs 2016;25(9-10):1193-205.

21. Botha L. Level of Nurses' Competence in Mechanical Ventilation in Intensive Care Units of two tertiary health care institutions in Gauteng. Masters of Science in Nursing, University of the Witwatersrand, Johannesburg. 2012.

22. Cornish S, Wynne R, Klim S, Kelly AM. Protective lung strategies: A cross sectional survey of nurses knowledge and use in the emergency department. Australas Emerg Nurs J 2017;20(2):87-91.

23. Rose L, Ramagnano S. Emergency nurse responsibilities for mechanical ventilation: A national survey. J Emerg Nurs 2013;39(3):226-32.

24. Vratsistas-Curto A, McCluskey A, Schurr K. Use of audit, feedback and education increased guideline implementation in a multidisciplinary stroke unit. BMJ Open Qual 2017;6(2):e000212.

25. Wolthuis EK, Kesecioglu J, Hassink LH, Determann RM, Korevaar JC, Schultz MJ. Adoption of lower tidal volume ventilation improves with feedback and education. Respir Care 2007;52(12):1761-6.

26. Geary L, Hasselström J, Carlsson AC, Schenck-Gustafsson K, von Euler M. An audit & feedback intervention for improved anticoagulant use in patients with atrial fibrillation in primary care. Int J Cardiol 2020;310:67-72.

27. O'Brien ID, Shacklock E, Middleditch A, Bigham C. Inaccuracies in calculating predicted body weight and its impact on safe ventilator settings. J Intensive Care Soc 2016;17(3):191-5.

28. Schmidt GA. Managing acute lung injury. Clin Chest Med 2016;37(4):647-58.

29. Pinheiro de Oliveira R, Hetzel MP, dos Anjos Silva M, Dallegrave D, Friedman G. Mechanical ventilation with high tidal volume induces inflammation in patients without lung disease. Crit Care 2010;14(2):R39.

30. Mohr N, Fuller B. Low tidal volume ventilation should be the routine ventilation strategy of choice for all emergency department patients. Ann Emerg Med 2012;60(2):215-6.

31. Newell CP, Martin MJ, Richardson N, Bourdeaux CP. Protective mechanical ventilation in United Kingdom critical care units: A multicentre audit. J Intensive Care Soc 2017;18(2):106-12.

32. Wilcox SR, Richards JB, Fisher DF, Sankoff J, Seigel TA. Initial mechanical ventilator settings and lung protective ventilation in the ED. Am J Emerg Med 2016;34(8):1446-51.

33. Fuller BM, Ferguson IT, Mohr NM, Drewry AM, Palmer C, Wessman BT, et al. A quasi-experimental, before-after trial examining the impact of an emergency department mechanical ventilator protocol on clinical outcomes and lung-protective ventilation in acute respiratory distress syndrome. Crit Care Med 2017;45(4):645-52.

34. Prekker ME, Donelan C, Ambur S, Driver BE, O'Brien-Lambert A, Hottinger DG,et al. Adoption of low tidal volume ventilation in the emergency department: A quality improvement intervention. Am J Emerg Med 2020; 38(4):763-7.

35. Bourdeaux CP, Birnie K, Trickey A, Thomas MJ, Sterne J, Donovan JL, et al. Evaluation of an intervention to reduce tidal volumes in ventilated ICU patients. Br J Anaesth 2015;115(2):244-51.

36. Curley GF, Laffey JG, Zhang H, Slutsky AS. Biotrauma and ventilator-induced lung injury: clinical implications. Chest 2016;150(5):1109-17.

37. Perrie H, Schmollgruber S, Bruce JC, Becker PJ. Knowledge of intensive care nurses in selected care areas commonly guided by protocols. Southern African J Critical Care 2014;30(1):14-8.

38. Maurya S, Mishra SB, Azim A, Baronia AK, Gurjar M. Ventilator-associated complications: A study to evaluate the effectiveness of a planned teaching program for intensive care unit staff nurses—an Indian experience. Am J Infect Control 2016;44(11):1422-3.

39. Bodansky D, Oskrochi Y, Judah G, Lewis M, Fischer B, Narayan B. Change the habit to change the practice: Do audits really ever change anything? Injury 2017;48(9):1999-2002.

40. Fakih MG, Jones K, Rey JE, Takla R, Szpunar S, Brown K, et al. Peripheral venous catheter care in the emergency department: education and feedback lead to marked improvements. Am J Infect Control 2013;41(6):531-6.

41. Grossbach I, Chlan L, Tracy MF. Overview of mechanical ventilatory support and management of patient-and ventilator-related responses. Crit Care Nurse 2011;31(3):30-44.