Australasian Emergency Nursing Journal 20 (2017) 87–91

Contents lists available at ScienceDirect

Australasian Emergency Nursing Journal

ELSEVIER

journal homepage: www.elsevier.com/locate/aenj

Research paper

Protective lung strategies: A cross sectional survey of nurses knowledge and use in the emergency department

Sarah Cornish[a,*], Rochelle Wynne[b], Sharon Klim[c], Ann-Maree Kelly[c,d]

[a] Emergency Department, Sunshine Hospital,Furlong Road, St. Albans Victoria 3021, Australia
[b] School of Nursing & Midwifery, Deakin University,Gheringhap Street, Geelong, Victoria 3220, Australia
[c] Joseph Epstein Centre for Emergency Medicine Research, Western Health,176 Furlong Road, St. Albans Victoria 3021, Australia
[d] Department of Medicine, Melbourne Medical School – Western Precinct, The University of Melbourne, St. Albans, Vic, 3021 Australia

ARTICLE INFO

Article history:
Received 8 November 2016
Received in revised form 31 January 2017
Accepted 31 January 2017

Keywords:
Respiration, Artificial
Emergency nursing
Tidal volume
Protective lung strategies
Emergency Department

ABSTRACT

Background: Mechanical ventilation (MV) is commonly used in emergency departments (EDs). Protective lung strategies (PLS), comprising of low tidal volume (6 mL/kg), control of oxygen and plateau pressures, and administration of positive end expiratory pressure (PEEP) has been shown to reduces the risks associated with MV but there is little evidence exists about nurses' knowledge or application of PLS. Our aim was to explore nurses knowledge and application of PLS in Australian EDs.
Methods: Descriptive, exploratory design utilising an online questionnaire. A convenience sample was recruited via the College of Emergency Nursing Australasia mailing list and secondary snowball sampling was used to optimise response rate.
Results: There were 157 participants. PLS are being used in most EDs ($n = 104$, 75%) and clinical practice guidelines (CPG) are often available ($n = 86$, 62%). Most ED ventilators are capable of implementing PLS, but measurement of plateau pressures was infrequent ($n = 46\%$). Participants demonstrate appropriate knowledge, but reported varying levels of confidence and perceived autonomy when implementing PLS in the ED.
Conclusion: PLS are being used in Australian EDs, aligning with best available evidence. Nursing staff have good levels of PLS knowledge. Development of an evidence-based CPG may improve confidence when implementing PLS and may pave the way for ED nurses to expand their scope of practice.
© 2017 College of Emergency Nursing Australasia. Published by Elsevier Ltd. All rights reserved.

Introduction

Mechanical ventilation (MV) is a frequently applied therapeutic intervention in the Emergency Department (ED). Application of MV is not without risk, and there is a range of associated complications including lung trauma and the development of acute respiratory distress syndrome (ARDS). The concept of a protective lung strategy (PLS) (delivery of a low tidal volume (6 mL/kg), aggressive control of positive end expiratory pressure (PEEP), fraction of inspired oxygen and plateau pressures) has developed over the last 15 years as an approach to reduce risks associated with MV. Emerging evidence with a focus on MV in the ED context suggests that measures to prevent the development of ARDS should begin in the ED [1,5]. Despite increasing recognition of the relationship between MV and the development of ARDS, studies show that ED patients are continuing to receive injurious tidal volumes, and implementation of PLS still not routine [1,2].

Implementing PLS poses unique challenges in the ED context, as there are technical aspects that may inhibit ED clinician's ability to implement PLS. Inspiratory plateau pressures are infrequently monitored and are not considered a standard ventilator observation in the ED [2]. ED ventilators are most commonly transport ventilators, and are often unable to measure plateau pressures, which is an integral element of a PLS [3]. Anecdotal evidence suggests major metropolitan centres still regularly use ventilators that do not have the capacity for plateau pressure measurement and have limited capacity for titration and delivery of oxygen. There is also increasing recognition that decisions made early in the resuscitation phase whilst in the ED, such as initial and ongoing ventilator settings may impact on clinical outcomes [1,2]. Underlying pathophysiological processes associated with ventilator associated lung injury from injurious tidal volumes in patients with ARDS can occur within hours, which is particularly relevant to the ED context. The

* Corresponding author at: Emergency Department, Sunshine Hospital, 176 Furlong Rd., St Albans, 3012, Australia.
E-mail address: sarah.cornish@wh.org.au (S. Cornish).

http://dx.doi.org/10.1016/j.aenj.2017.01.004
1574-6267/© 2017 College of Emergency Nursing Australasia. Published by Elsevier Ltd. All rights reserved.

Table 1
Comparison of Initial Settings For Clinical Scenarios (n = 119).

	1. Female 70 kg, SAH[a]	Commonly accepted settings	2. Female, 60 kg, asthma	Commonly accepted settings	3. Male, 80 kg, OD[b]	Commonly accepted settings
Tidal volume (mL)	452.8 (SD 66.9) (6.45 mL/kg)	420	381.8 (SD 53.8) (6.35 mL/kg)	360	516.7 (SD 88.7) (6.45 mL/kg)	480
Starting rate	13.6 (SD 2.6)	16–17	14 (Q1 10, Q3 18)	8–10	13.2 (SD 2)	16–17
Theoretical minute volume	6140 mL	Aim for 7000 mL, based on weight	5345	Aim for 6000 mL, but potentially less as lower rates required	6820 mL	Aim for 8000 mL, based on weight
Level of PEEP (cmH20)	5 (Q1 5, Q3 5)	5–10	5 (Q1 0, Q3 5)	0–5	5 (Q1 5, Q3 5)	5–10
FiO2 (%)	75.5 (SD 26.9)	80–100	94 (SD 14.8)	80–100	89 (SD 21.5)	80–100
Plateau pressure		30 cm H_2O or less		30 cm H_2O or less		30 cm H_2O or less
30cmH²0 or less	72 (67%)		70 (64%)		70 (66%)	
Unsure	22 (20%)		29 (26%)		25 (24%)	
Would not use	14 (13%)		11 (10%)		11 (10%)	

[a] SAH-subarachnoid haemorrhage.
[b] OD-overdose.

development of ARDS is associated with increased mortality, duration of mechanical ventilation, non-pulmonary organ failure and increased lengths of stay [4].

In the Australian context, ED nurses play a pivotal role in managing patients who are mechanically ventilated. Clinical decision making (particularly ventilator settings), care and management is shared by medical and nursing staff [3]. This differs somewhat internationally; in North America (United States and Canada) most ventilator management decision making is in the realm of the Respiratory Technician or Therapist, with nurses having a secondary role [6]. This role of the Respiratory Therapist is unique to North America, there is no Australian or European equivalent.

Safe practice for patients receiving this highly complex intervention requires ED nurses to have an in-depth understanding of the technology, and the clinical application including effects on lung physiology [7]. With increasing ED lengths of stay, it is vital that strategies for optimal management of ventilation are implemented [8]. The only published research around Australian ED ventilation practices was in 2007; a contemporary investigation of current ventilation practices was timely. The aim of the study was to identify clinical practice patterns and explore the current knowledge of Australian emergency nurses related to the implementation of PLS in adult mechanically ventilated patients.

Methods

Study design

The study utilised a descriptive, exploratory design utilising a self-reporting cross-sectional survey administered via an online survey platform. A three-part survey was developed that collected demographic information, sought information on clinical practice patterns and explored nursing knowledge using validated clinical scenarios. The survey was reviewed for clinical acceptability, face validity and was pilot tested. The sample was obtained from two sources; the College of Emergency Nursing Australasia mailing list and by secondary snowball sampling. Consent was implied through completion of the on-line survey. Anonymity was maintained as data was non-identifiable.

Sample

The sample population was Australian Registered nurses (Division 1) who work regularly in an ED (at least one shift/month), and who have been credentialed to independently to nurse mechanically ventilated patients by their organisation. The single exclusion criteria was registration as an Enrolled nurse (Division 2). As this was a descriptive study, no sample size based on comparative data could be calculated. The challenge of setting a target sample size was also complicated by the fact that the number of eligible (credentialed) nurses in Australia was unknown. We considered that a sample of 150–200 would give adequate data for analysis. Study recruitment was via two sources; the College of Emergency Nursing (CENA) mailing list and snowball sampling through professional networks.

Data collected

The three-part survey collected the following information. Part one focused on general demographic information including age, state, type of ED and source of sample. Part two had questions on clinical practice patterns, which included questions on modes of ventilation available, availability of ventilator guidelines, ventilator functionality (including plateau pressures), ventilator observations and calculation of tidal volume and ideal body weight. Participant knowledge of PLS was also explored, with participants asked to self-rate levels of confidence and conceptual understanding of PLS. Information was also sought on the participants level of involvement around ventilator decisions. Part three used three validated clinical scenarios that asked participants to choose initial ventilator settings (tidal volume, frequency, fraction of inspired oxygen and PEEP) and plateau pressure aims based on the clinical picture (Table 1).

Outcomes measures

1. Current clinical practice patterns relating to the implementation of PLS
2. Knowledge of ED nurses on the implementation of PLS

Ethics

The study design met the criteria for a Quality Assurance project and adheres to National Statement on the Conduct of Human Research by the Australian National Health and Medical Research Council, and was approved by the Western Health Human Research Ethics Committee.

Analysis

Data was analysed using IBM SPSS Version 22. Categorical data was summarised using frequency counts (*n*) and proportions (%). Continuous data was summarised using measures of central tendency, with mean (*M*) and standard deviation (SD) if normally distributed, and median (*Med*) and quartiles (Q1, Q3) if abnormally distributed. Differences between participants were analysed using chi-squared for categorical variables and ANOVA for continuous variables. Confidence intervals were calculated on the premise of binomial distribution and the denominator for these calculations excluded missing responses. Qualitative data from free text responses was examined using a content analysis framework and frequency counts.

Results

Sample characteristics

There were a total of 157 participants. The highest proportion of age reported was in the 25–34 year category ($n=64$, 41%) and the majority of participants ($n=123$, 78%) were female. Most participants worked in a metropolitan ED ($n=115$, 73%), with 32 (20%) working in a regional ED, and 10 (7%) in a rural ED. Participants worked a mean of 31 h per week (*SD* = 8.2) and had a varying range of ED nursing experience in terms of years worked (*Med* = 8, Q1 5, Q3 12.5). There were 87 participants (55%) from the CENA mailing list and 70 (45%) from snowball sources. Overall, 157 participants completed part 1, 139 completed Part 2 and 119 completed part 3 of the questionnaire.

Main results

Clinical practice patterns

Just over half ($n=86$, 62%,) of participants ($n=139$) reported a practice guideline specifically related to ventilation available for use and 25% ($n=35$) reported that there were no ventilation related guidelines available in their unit, with 13% ($n=18$) being unsure. The frequency of participants caring for mechanically ventilated patients varied considerably; 32% ($n=45$) care for ventilated patients at least weekly, 48% ($n=67$) care for ventilated patients at least monthly, with 3% ($n=4$) having no exposure in the last 12 months.

The majority ($n=67$, 48%) indicated that they often contributed to decision-making regarding MV often (>70% of cases), with 27% ($n=37$) indicating sometimes (20–70% of cases) and 14% ($n=9$) indicating infrequently (<20% of cases). Only a small proportion of participants felt that appropriately credentialed nursing staff had full autonomy regarding routine ventilator management decisions ($n=28$, 20%). However, it was important to note that no nurses reported never contributing to MV decisions in ED.

Protective lung strategies

Participants ($n=104$, 75%) reported using PLS in their ED ($n=139$). Three of the key elements of a PLS are control of plateau pressures, 'low' tidal volumes (6 mL/kg) based on ideal/predicted body weight and the application of positive end expiratory pressure (PEEP). The majority of participants ($n=110$, 79%) had ventilators that were able to measure plateau pressures, however only 33% ($n=46$) reported measurement of plateau pressures as a standard ventilator observation. Application of PEEP was considered a standard approach by most ($n=124$, 89%). Using a formal tool to determine optimal tidal volume was also common with 80% ($n=112$) using a millilitre per kg (mL/kg) formula. Alternative options used were standard tidal volume for all patients (usually 500 mL in adults) ($n=10$, 7%), treating clinician's determination ($n=16$, 12%) or arterial blood gas ($n=1$, 1%). However only 20% ($n=28$) of participants reported always using a formal tool to calculate ideal/predicted body weight.

Ventilation in a volume mode was by far the most frequent approach ($n=123$, 89%), with pressure or other modes being used rarely ($n=15$, 11%). Of the volume modes, synchronised intermittent mandatory ventilation (SIMV) was the most common ($n=118$, 85%). A wide range of modes are available to clinicians for use as outlined in Table 2.

Table 2
Modes of ventilation available to ED participants.

Mode (N, %, 95% CI)	Results ($n=139$)
Volume Synchronised Intermittent Mandatory Ventilation	136, (98, 93–99%)
Continuous Positive Airway Pressure	121, (87, 80–92%)
Volume Control Mandatory Ventilation	94, (67, 59–75%)
Pressure Control Ventilation	91 (65, 60–73%)
Volume Assist Control	70, (20, 41–59%)
Pressure Synchronised Intermittent Mandatory Ventilation	60, (43, 23–39%)
Adaptive Support Ventilation	30, (21, 15–29%)
Not sure	3, (2, 0–6%)
Other	3, (2, 0–6%)

Table 3
Question: What is a protective lung strategy? (N, %, 95% CI).

Protective lung strategies	Results ($n=139$)
Use of PEEP	119 (86, 78–90%)
Tidal volume 6–8 mL/kg	116, (83, 76–89%)
Titrated oxygen delivery	106, (76, 68–83%)
Control of plateau pressures	97, (70, 61–77%)
Not protective lung strategies	
Use of pressure control modes	78, (56, 47–64%)
Use of in-line suction equipment	69, (50, 41–58%)
Controlled minute volume ventilation	68, (48, 40–57%)
Avoiding administration of paralysing agents	63, (45, 36–54%)
Attending regularly to oral hygiene	52, (37, 29–46%)
Use of volume control modes	47, (34, 26–42%)
Permissive hypercarbia	42, (30, 22–38%)
Low respiratory rate ventilation	36, (25, 18–34%)
Ventilation in prone position	31, (22, 15–30%)
Prophylactic administration of proton-pump inhibitor	13, (9, 5–15%)
Tidal volume 8–10 mL/kg	7, (5, 2–10%)
Tidal volume 10 mL/kg	5, (3, 1–8%)

Participant knowledge of protective lung strategies

Participants were asked to select from a list of items what they considered to be a PLS ($n=139$). The responses are outlined in Table 3. Of the options, only four are considered a formal PLS. The remaining 12 responses are options that can be used in mechanically ventilated adult patients, but are not considered PLS *per se*. The majority of participants selected the four options considered to comprise PLS (PEEP, tidal volume 6–8 mL/kg), titrated oxygen delivery and control of plateau pressures) correctly (Table 3).

Three validated clinical scenarios were also chosen to explore knowledge and clinical decision-making related to ventilatory settings in the ED. Participant results are outlined in Table 1.

Discussion

The results from this study show that PLS are being used in Australian EDs to inform decisions around MV. The only available evidence describing Australian ED ventilation to compare practice patterns was the seminal work by Rose and Gerdtz [3] that explored mechanical ventilation practices in Australian EDs in 2007. No other recent studies looking at Australian practices were identified, and few international studies specifically exploring ED ventilation are available.

ED nurses are required to have comprehensive knowledge in the complexities of MV and demonstrate a high level of clinical skill to safely manage these patients [7]. The 1:1 nature of care for the ventilated patient means that the ED nurse is always present to dynamically respond to changes in the patient's clinical condition and are in a key position to ensure timely implementation of

PLS. ED ventilation decisions are thought to influence patient outcomes, as the pathophysiology triggered by injurious ventilation processes occurs within hours [1,9]. The study results demonstrate that ED nurses have a good knowledge of PLS. The accepted standard of 6 mL/kg as the basis of determining a tidal volume is being well understood with responses for all three clinical scenarios having tidal volume settings very close to this level. Participants also set clinically appropriate levels of PEEP in two out of the three scenarios. Assessment of nurses knowledge of titration of oxygen is limited in this study as the clinical scenarios sought information about a single point in time, however all participants selected appropriate levels of oxygen during their scenarios. Given the choice to use plateau pressures, the majority of participants used clinically appropriate plateau pressures (<30 mmHg) as a clinical practice aim.

Management of the mechanically ventilated asthma patient was identified as an area for future research and education. Asthma patients are some of the most challenging patients to ventilate in an ED due to complexity of settings, clinician experience and severity of illness. Asthma was perceived to be the most important in terms of using a PLS, but participants demonstrated knowledge gaps in patient settings The mean rate set in Scenario 2 was almost 16 breaths per minute, which goes against current practice recommendations of low rate (8 breaths per minute) [10]. This low rate alters the inspiratory/expiratory ratio and extends expiratory time to reduce auto-PEEP and gas trapping, which is a key issue in improving ventilation outcomes in the critically unwell asthma patient [11]. This low rate, combined with low tidal volume ventilation also helps to control minute volume as increases in minute ventilation in patients with asthma can worsen dynamic hyperinflation and auto-PEEP [12,13]. This conflicts with recommendations by Leatherman and Mosier, who suggest a starting rate of 10–12 breaths per minute [12,14]. Further research and education around asthma ventilation is needed, and further emphasises the need for PLS specific clinical practice guidelines.

Using an evidenced based approach to determine optimal tidal volume does occur, with 68% ($n=95$) of participants in this study using a millilitres per kilogram formula. However up to 20% of participants were delivering tidal volumes calculated in the absence of an evidence based formula, including 7% ($n=10$), who still used a standard volume approach. This is concerning as ED ventilation decisions may influence patient outcomes. Awareness of the importance of using calculated ideal or predicted body weight in determining the tidal volume is increasing, but the use of such tools is not yet universal. Only 20% ($n=28$) of participants always used a formal tool to calculate ideal/predicted body weight. Despite this, when given clinical scenarios that provided an ideal body weight, the average tidal volumes selected were very close to the 6 mL/kg of a PLS. The measurement and analysis of actual patient settings was outside the scope of this study. However the findings suggest that using a PLS approach to determine tidal volume is being used to inform clinical decisions at point of care in Australian EDs.

A theory-practice disconnect was identified regarding the use of plateau pressures. Most participants state that they use PLS to inform clinical decision-making, and are able to physically measure plateau pressures. This represents a significant advance in available technology in the past nine years, as in 2007 most Australian ED ventilators were unable to measure plateau pressures [3]. The ability to apply this key functionality in the clinical environment remains limited, as only 33% ($n=46$) of participants reported actual measurement of plateau pressures. This infrequent measurement of plateau pressures in the ED context has also been reported in the literature [1,4].

Clinical practice patterns related to ventilation identified by Rose and Gerdtz [3] have not changed significantly since 2007. Application of PEEP continues to be a standard adjunct in ventilator settings, a key element of a PLS. The most commonly reported mode continues to be volume-controlled synchronised intermittent mandatory ventilation (V-SIMV), with pressure-controlled modes rarely used. In terms of nursing autonomy, Rose and Gerdtz [15] found responsibility for the selection of initial and ongoing settings was shared by ED nurses and physicians. The findings from this study mirror this result, as the majority of the participants felt that nurses actively participated in ventilation decisions (at least 70% of the time), with a small proportion indicating that appropriately credentialed nursing staff had complete autonomy in the context of routine ventilator management decisions. This finding is limited in that it relies on self-reporting from the nursing perspective; for a true reflection medical staff would need to be surveyed but this was beyond the remit of this study. This collaborative approach to ventilation between medical and nursing staff has been well researched in the ICU context, with shared interprofessional responsibility occurring in both Australia and internationally, particularly the United Kingdom, Switzerland and Germany [16].

Decision-making processes for MV are complex and multifaceted. Achieving a low tidal volume strategy, or implementing a more comprehensive PLS needs careful consideration of the many clinical issues at stake including ensuring adequacy of minute ventilation, correction of acid-base imbalances and ongoing adjustments to settings based on patient condition and clinical response to ventilation. The literature focuses on tidal volume as a standalone component, however in reality it is one of suite of settings the clinician chooses in the initial and ongoing management of a mechanically ventilated patient. Given the complexities of the clinical decisions required, development of a clinical practice guideline (CPG) specifically tailored for the initiation and implementation of ventilation using PLS is recommended. CPGs relating to MV are commonly available, with 62%, ($n=86$) reporting formal departmental guidelines but there is variability in whether or not these guidelines stipulate incorporating a PLS focus. Local guidelines or protocols are recommended as tools to guide clinicians, particularly those with infrequent exposure to ventilation [15]. Participants reported varying levels of exposure, with the majority reporting only monthly exposure to ventilated patients (with the mean working hours of 32/week), which is relatively infrequent. This may be reflective of the rotation of ED nurses into different areas of the ED (such as triage, general cubicles, fast track areas) on a shift by shift basis; not every day is spent working in the resuscitation area where mechanically ventilated patients are usually cared for. With this in mind, specific clinical practice guidelines should foster the implementation of best practice from the time of ED admission.

Participants acknowledged that they are always involved in the process of making decisions about ventilation. Australian ED nurses are also well prepared to care for invasively ventilated patients, as the majority of nurses who are responsible for these patients have postgraduate qualifications. Emergency nursing postgraduate courses in Australia usually include principles and practices of mechanically ventilated patients as a major topic of learning and clinical assessment. The 1:1 nature of the care of the ventilated patient means that ED nurses are best placed to be active participants in ventilator settings. Given that some participants have complete autonomy to make decisions, is it time to revisit the question of nursing scope of practice around MV? With an appropriate level of credentialing, supported by a robust clinical practice guideline, nurses could independently manage the ventilator including initial and ongoing settings based on clinical condition whilst in the ED. This could occur at the state or local organisational level. An alternative is the nurse practitioner (NP) approach, with NP's working in a number of advanced roles including the assessment, prescription and administration of thrombolysis in acute stroke patients, which would have been unthinkable 10 years ago in the Australian context. Patients managed by Critical Care Nurse Practitioners in the United States have positive clinical trends to patient outcomes, length of stay and readmission rates [17]. However, there may be some practical limitations to this model including the unpredictability in presentation of mechanically ventilated patients to an ED and the limited cost-effectiveness.

Limitations

The sample of nurses obtained represents a cross-section of ED nurses, with a range of experience, qualifications and states represented. The majority of participants completed the questionnaire in its entirety, which suggests an appropriately designed and timed questionnaire. However, there is poor generalisability of results due to the high level of sample bias inherent in the nature of convenience sampling. Whilst the sample target was reached, it still could be considered a low response rate. Due to time constraints, pre-validated clinical scenarios were used which meant that limited information was able to be added, which limited the participants ability to provide in-depth answers such as titration of oxygen. The clinical scenarios used were designed to test participant knowledge, and cannot be assumed to be a true measurement of settings that are occurring in the clinical environment. Despite these limitations this work provides current evidence on use of PLS in the ED context. Although the findings have highlighted a gap in relation to asthma management, it is clear that ED nurses have the capacity to implement PLS in adult emergency department patients who receive MV.

Conclusion

PLS are currently being used by Australian ED nurses to inform the clinical care of adult mechanically ventilated patients, which aligns with the best available evidence. Australian ED nursing staff have good levels of knowledge regarding this approach to MV. Australian EDs are appropriately equipped to implement PLS in terms of functionality of ventilators, but understanding and measurement of plateau pressures is an area of focus for future education and clinical practice improvements. Future research should focus on the development and testing of guidelines tailored for specific disease processes, mechanisms for observation and reporting and strategies for multidisciplinary clinical education. Such guideline development may improve ED nurses confidence in implementing such strategies, and provide a benchmark for future clinical practice that will facilitate research in this area, and potentially improve patient outcomes.

Authorship

S.C. and R.W. conceived and designed the study. SC, RW and SK developed the study protocol. S.C., S.K., A.M.K. and R.W. designed and tested the study instruments. S.C. and R.W. supervised data collection. S.C. and R.W. analysed the data. S.C., R.W., S.K. and A.M.K. prepared and approved the manuscript.

Disclosures

S.C. used this study towards completion of a Masters of Nursing (minor thesis).

S.C. received scholarship support from the Australian College of Nursing and from Western Health towards the completion of a minor thesis.

Funding

S.C. received scholarship support from the Australian College of Nursing and from Western Health towards the completion of a minor thesis.

Acknowledgments

Thanks to Dr. Louise Rose and Dr. Marie Gerdtz for the use of their validated clinical scenarios.

Thanks to the ED nursing staff at both Footscray and Sunshine EDs and the Centre for Education, Western Health for their support

References

[1] Fuller BM, Mohr NM, Miller CN, Deitchman AR, Levine BJ, Castagno N, et al. Mechanical ventilation and ARDS in the ED: a multicenter, observational, prospective, cross-sectional study. Chest 2015;148(2):365–74.
[2] Fuller BM, Mohr NM, Dettmer M, Kennedy S, Cullison K, Bavolek R, et al. Mechanical ventilation and acute lung injury in emergency department patients with severe sepsis and septic shock: an observational study. Acad Emerg Med 2013;20(7):659–69.
[3] Rose L, Gerdtz M. Use of invasive mechanical ventilation in Australian emergency departments. Emerg Med Australas 2009;21(2):108.
[4] Fuller BM, Mohr NM, Drewry A, Carpenter C. Lower tidal volume at initiation of mechanical ventilation may reduce progression to acute respiratory distress syndrome: a systematic review. Crit Care 2013;17(1):R11.
[5] Fuller BM, Mohr NM, Hotchkiss RS, Kollef MH. Reducing the burden of acute respiratory distress syndrome: the case for early intervention and the potential role of the emergency department. Shock 2014;41(5):378–87.
[6] Rose L, Ramagnano S. Emergency nurse responsibilities for mechanical ventilation: a national survey. J Emerg Nurs 2013;39(3):226–32.
[7] Rose L, Gerdtz M. Invasive ventilation in the emergency department: part 1: What nurses need to know. Aust Emerg Nurs J 2007;10(1):21–5.
[8] Bernard SA. Airway and ventilation management. In: Textbook of adult emergency medicine; 2015. p. 14–70 [Internet]. 4th [cited 04/03/2015].
[9] Serpa Neto A, Simonis FD, Barbas CS, Biehl M, Determann RM, Elmer J, et al. Lung-protective ventilation with low tidal volumes and the occurrence of pulmonary complications in patients without acute respiratory distress syndrome: a systematic review and individual patient data analysis. Crit Care Med 2015;43(10):2155–63.
[10] Douros G. Guide for initial settings for Oxylog 3000 plus ventilator: Life in the Fast Lane; 2011. Available from: http://cdn.lifeinthefastlane.com/wp-content/uploads/2011/09/VC.pdf.
[11] Cairo JM. Pilbeam's mechanical ventilation: physiological and clinical applications. 5th ed. USA: Mosby; 2012.
[12] Mosier JM, Hypes C, Joshi R, Whitmore S, Parthasarathy S, Cairns CB. Ventilator strategies and rescue therapies for management of acute respiratory failure in the emergency department. Ann Emerg Med 2015;66:529–41.
[13] Restrepo RD, Tate A, Gardner DD, Wittnebel LD, Wettstein R, Khusid F. Current approaches to the assessment and treatment of acute severe asthma. Indian J Respir Care 2015;4(1):521–41.
[14] Leatherman J. Mechanical ventilation for severe asthma. CHEST J 2015;147(6):1671–80.
[15] Rose L, Gerdtz M. Mechanical ventilation in Australian emergency departments: survey of workforce profile, nursing role responsibility, and education. Aust Emerg Nurs J 2009;12(2):38–43.
[16] Rose L, Blackwood B, Egerod I, Haugdahl HS, Hofhuis J, Isfort M, et al. Decisional responsibility for mechanical ventilation and weaning: an international survey. Crit Care 2011;15(6):R295.
[17] Fry M. Literature review of the impact of nurse practitioners in critical care services. Nurs Crit Care 2011;16(2):58–66.