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Emergency Medicine Physician and Registrars Knowledge of Mechanical Ventilation in Cape Town, South Africa.

By

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Student number: KLLMOO001

SUBMITTED TO THE UNIVERSITY OF CAPE TOWN

In partial fulfilment of the requirements for the degree

Master of Medicine Emergency Medicine

Faculty of Health Sciences

UNIVERSITY OF CAPE TOWN

DECEMBER 2011

SUPERVISORS:

Dr AA Parker

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DECLARATION

I, **Moosa Kalla**, hereby declare that the work on which this dissertation/thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

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University of Cape Town

PART A: Research Protocol

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1. Abstract

1.1. Introduction:

The advent of mechanical ventilation in the 1950's revolutionised the management of the acute and critically ill patient. Early intubation and mechanical ventilation is advocated in the management of the critically ill patient. With the high occupancy and low turnover rate of ICU beds, it is found that there is an increase in the frequency of initiation of mechanical ventilation and duration of stay of the mechanically ventilated patient in the Emergency Centre. The onus of responsibility of management for the mechanically ventilated patient is now that of the Emergency Physician (EP). Knowledge of mechanical ventilation forms an integral component of the Emergency Physicians arsenal. Optimal ventilation of the mechanically ventilated patient can reduce morbidity and decrease duration of mechanical ventilation. The aim of this study is: *to determine whether Emergency Physicians have knowledge to optimally mechanically ventilate the intubated patient.*

1.2. Methodology

A questionnaire based cross-sectional study will be performed using a 19-point validated questionnaire. Outcome measure is a score to determine level of knowledge. There are 40 Emergency Medicine registrars registered in Cape Town between University of Cape Town and University of Stellenbosch. There are 23 Specialist EP registered and working in and around Cape Town. This brings the total combined sample size to 63. Citing from literature we anticipate a mean score of 75% amongst EP (SD = 10), and the anticipated mean score for registrars to be 65% (SD = 10). This will yield a statistical power of 97% in order to detect a significant difference between EP and EM registrars. This is based on a level of significance of 0.05

1.3. Conclusion

Information gained from this study will assist in determining if there is a need for change of educational models.

2. Background

Emergency Medicine (EM) is a newly recognised speciality in South Africa. The Emergency Centre personnel led by the Emergency Physician (EP) are the first point of contact for acutely ill patients arriving at a hospital. With the advent of HIV/AIDS, and the scourge of violence in South Africa, higher numbers of acutely ill and trauma patients are attending Emergency Centres (EC).[1,2] Acutely ill patients can decompensate physiologically, requiring intubation and Mechanical Ventilation, or they arrive from the pre-hospital environment already intubated.

With the current epidemic of hospital overcrowding, and the over-utilisation of already strained EC resources, there are delays in the identification and treatment of patients with emergent conditions. This increases the likelihood of poor clinical outcomes.[3,4] The causes of overcrowding are complex and multi-factorial. Due to limited Intensive care Unit (ICU) resources and the increasing pressure on ICU beds,[5] critically ill patients are being intubated and ventilated in the overcrowded EC.[6] Previously, patients who required mechanical ventilation were taken to the ICU and mechanical ventilation was initiated there.[7]

Any patient requiring constant therapy and evaluation throughout their disease process may be deemed as receiving critical care, “this definition extends to any location anywhere, such that critical care is defined physiologically rather than geographically”. [6] Critical care is no longer confined to the inner sanctum of the ICU or post-operative recovery rooms.[3]

It is the one of the duties of the EP to optimally care for the critically ill patients in the EC, and thus the EP needs to be equipped with the necessary skills to identify the acutely ill or critically ill patient and to commence and facilitate the appropriate treatment pathway.[8,9]

The EP initiates, sustains and occasionally weans the patient off mechanical ventilation in the emergency centre.[10] The use of mechanical ventilation in the emergency centre requires adequate resources in order to maintain patient safety and avoid potential risks.[10]

Upon intubation of the acutely ill patient, the optimal ventilatory strategy is of paramount importance. The choice of the mode of ventilation can be daunting across the spectrum of pathologies seen in South African ECs'. [1] Optimal mechanical ventilation can improve the morbidity of ventilated patients.[8]

It is unknown how well the EP is equipped to mechanically ventilate a patient adequately as no studies have been conducted. An extensive search was performed electronically using PubMed, MEDLINE and GOOGLE Scholar. Only 3 relevant studies were found, by Cox et al in 2003, Brescia et al in 2009 and an unpublished study by Botha in 2009. The first two studies showed that there is a lack of knowledge of mechanical ventilation amongst senior internal medicine residents. Botha in 2009 showed a definite difference in knowledge of mechanical ventilation between ICU-trained to non-ICU trained sisters.[11,12]

Assessing the level of knowledge among EP and EM registrars will determine the need for a change in educational models with respect to mechanical ventilation.

3. Introduction and literature review

Mechanical ventilation is a dynamic science. Practices in mechanical ventilation are ever changing.[13,14] In order to optimally implement a ventilatory strategy, sound knowledge of the mechanics and physiology of ventilation is required.[1,15] With the increasing demand for intensivists internationally, and the increased waiting time for ICU beds, there is a tendency towards emergency physician facilitated critical care in the emergency centre.[6,15]

It is imperative that mechanical ventilation in the emergency centre for critically ill patients is evidenced based and conforms to current knowledge of safe mechanical ventilation and international best practices.[13] Knowledge of modes of ventilation and pathophysiology of disease will aid EP in choosing an appropriate ventilatory mode and initial ventilator settings to optimally benefit patients with respiratory insufficiency due to various causes.[15,16] Understanding respiratory mechanics may help in minimising ventilator associated lung injury.[17]

Traditional bedside teaching and the “see one, do one, teach one” philosophy doesn’t hold true for mechanical ventilation. Real time live patients are dealt with whilst manipulating dials on a ventilator. Rodriguez goes on to say, “in the process of acquiring new skills, physicians-in-training may expose patients to harm because they lack the required experience, knowledge and technical skills”. [17]

In 2003, Cox et al showed that senior internal medicine registrars were not gaining enough education to provide essential evidence based care for the mechanically ventilated patients.[11] Recommendations from their study included evidence based learning objectives. A follow up study in 2009 by Brescia et al showed that there was still a lack in knowledge of mechanical ventilation. This study however does not indicate why recommendations by Cox et al were not implemented.[12]

Indications for endotracheal intubation and mechanical ventilation are not necessarily the same. A patient may be intubated because of i) poor oxygenation, ii) poor ventilation, iii) airway protection, or iv) anticipated clinical deterioration with airway loss. The application of positive pressure to the respiratory tract significantly alters ventilatory physiology. With normal ventilation a negative intrathoracic pressure is required to draw air into the lungs, with mechanical ventilation air is delivered to the lungs via positive pressure. The overall goal in acute respiratory failure is to achieve adequate oxygenation and ventilation with minimal peak airway pressures.[1,15]

Positive pressure ventilation can be delivered in two ways, mandatory (all work of breathing and breath delivery is performed by the machine) or assisted (patient-triggered breathing with support

from the ventilator). Furthermore each breath can be pressure controlled or volume controlled, depending on the mode and aim of ventilation.

Mechanical ventilation is a skill that all EPs should possess. It is a common life-saving intervention in the EC. With prolonged stay of ventilated patients in ECs, it is imperative that EP and EM registrars have a good understanding of techniques to optimize mechanical ventilation and minimize complications.[16]

It is difficult to objectively evaluate anyone's knowledge. But the basics of mechanical ventilation can be evaluated by simple questions and clinical vignettes.

4. Research question

Do EP and EM registrars possess sufficient knowledge of mechanical ventilation to optimally initiate and maintain mechanical ventilation in the EC whilst a patient is awaiting transfer to ICU or a high care unit?

5. Aim

This study endeavours to establish if EP and EM registrars have knowledge of mechanical ventilation.

6. Objective

The objective of the study is to determine the knowledge of EP and EM registrars as pertaining to mechanical ventilation.

7. Methodology

7.1. Study design:

A 19-item clinically based test which has been validated by a panel of 8 intensivists in the study by Cox (11). This questionnaire has been confirmed by South African adult intensivists appropriate and consistent with accepted practice. It was then adapted for use in this study. Permission has been gained from the author of the original study to use part or all of the questions and to adapt questions for this study.

The questionnaire will be personally handed out and collected from participants after an allotted 45 minutes to complete the questionnaire.

7.2. Study population:

The study will be conducted on all EM registrars registered for training in Cape Town, namely at the University of Cape Town (UCT) and the University of Stellenbosch (SUN). The EM training programme has 40 registrars.

The study will also survey all EP working in the Western Cape public sector and all Emergency Medicine Practitioners who have completed registrar training but have not completed the final examinations as yet.

7.3. Inclusion criteria:

All EM registrars training in Cape Town, and all Specialist EPs and Emergency Practitioners who have completed their registrar training time, working within the public sector in Cape Town.

EPs who work within both the public and private sector will be included.

7.4. Exclusion Criteria:

All other speciality registrars and all other specialities

EM registrars and EPs outside of Cape Town and specialists not practicing within the public sector

7.5. Sample size:

There are 40 EM registrars registered in Cape Town between University of Cape Town and University of Stellenbosch. There are 23 EPs and EM practitioners registered and working in and around Cape Town. This brings the total combined sample size to 63.

7.6. Time scale:

Data will be collected at EM registrar teaching days. Those registrars and specialists absent on teaching dates will be contacted and arrangements made for them to complete the questionnaire. There is an estimated 6 week period for completion and collection of questionnaires, starting from 1 April 2011 until 15 May 2011 and one month to put the data together and analyse it for reporting.

7.7. Method of data collection:

The details of all potential participants will be determined from the Division of Emergency Medicine at UCT and SUN.

The survey will be in the form of a self-administered questionnaire. This will be personally handed out by the primary researcher to the participants and personally collected from the participants after an allotted forty-five minutes to complete the questionnaire.

The data will be collected at EM registrar teaching on a 3 weekly basis. There are only 63 candidates. Teaching is compulsory for registrars, and most consultants attend teaching sessions. The primary researcher will make use of a register of those who have completed the questionnaire. All registrars and specialists who have not completed the questionnaire at the first session will be contacted so as to make alternate arrangements for completion. The register will consist of the date and registrar or specialists name.

7.8. Data collection and analysis of results:

Excel software will be used to capture data from questionnaires, and Stata statistical software will be used to analyse the data.

Citing from literature we anticipate a mean score of 75% amongst specialist EP (SD = 10), and the anticipated mean score for registrars to be 65% (SD = 10). This will yield a statistical power of 97% in order to detect a significant difference between specialist EP and EM registrars. This is based on a level of significance of 0.05.

Assessment of the main outcome measure will be done using the Shapiro-Wilk Test. The appropriate parametric or non-parametric statistical test will be applied to compare the scores between specialist EP and EM registrars. Univariate statistics such as mean, median, standard deviation and proportions for categorical data will be applied.

8. Ethical Considerations:

Participation in this study is voluntary. Informed consent will be taken from all participants beforehand. The questionnaire will be designed to help differentiate consultants from registrars. All questionnaires will be answered anonymously and no mention of individual participants will be made at any point of the study. All data will be captured onto an Excel spreadsheet on a password protected computer.

9. Limitation

1. Only registrars and specialists in the public sector in Cape Town will be evaluated and will exclude registrars in other parts of the country and specialists in the private sector.
2. Different ICU rotations may be completed by registrars with variation in the personal ventilation preferences of the intensivists concerned.
3. Incomplete questionnaires would hamper the reliability of results.

10. Budget

Paper	R250
Photocopy and printing	R750
Fuel	R500
Total	<u>R1500</u>

All the above expenses will be incurred by the primary researcher thus no external funding will be needed.

11. Distribution of results:

The final analysis will be collated and an article describing the results will be written. This will be submitted to a peer reviewed journal for publication.

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PART B: LITERATURE REVIEW

Introduction

The advent of Mechanical Ventilation (MV) has revolutionised medical care of the critically ill patient. The art of MV has evolved into a succinct science, and has become an integral component of the treatment modalities and strategies utilised in the management of the critically ill patient.

History of Mechanical Ventilation

The defining event of critical care medicine was the Polio epidemic of 1952 in Denmark. Patients with respiratory paralysis secondary to Poliomyelitis were artificially ventilated by the cumbersome “iron lung” ventilator which was commonly used in the first half of the 20th century.[1] Almost all the patients died. Dr Bjorn Ibsen, a young proactive anaesthetist, demonstrated better outcomes by the application of positive pressure ventilation via a tracheostomy. Subsequently hundreds of patients were admitted to ICU and were ventilated 24 hours a day for several months by medical students, nurses and physiotherapists.[2] This spurred on a plethora of research, which, coupled with the advances in technology, culminated in a better understanding of respiratory physiology and pathology and improved mechanical ventilator design and function.[3] The size of ventilators have become smaller and more complex, and our knowledge of mechanical ventilation and ventilatory strategies has improved dramatically.

Mechanical ventilation

Mechanical ventilation is a method of rendering respiratory support via artificial means. This can be automated (as in the use of a ventilator), or manual (as with the use of a bag-valve mask). The respiratory support that is given may be either invasive (for example placing an endotracheal tube) or non-invasive (for example with a tight-fitting face mask).[4]

There is an abundance of terminology that describes and defines Non-invasive Positive Pressure Ventilation (NPPV) and the different modes. Whilst some authors consider Continuous Positive Airway Pressure (CPAP) Bi-level Positive Airway Pressure (Bi-PAP) under a single banner, others consider them as separate entities.[4]

CPAP, as the name implies, is the application of positive pressure throughout the respiratory cycle. This is done by using a tight-fitting face mask (nasal prongs are used in neonates and

in some traditional home-based apparatus). Bi-PAP ventilation provides an Inspiratory Positive Pressure (IPAP) and an Expiratory Positive Pressure (EPAP). The rationale for using NPPV is to attempt to avoid not the complications associated with invasive MV, and to attempt to 'tide' a patient over.[4,5]

NPPV requires that the patient have an intact sensorium, and is able to maintain and protect their airway. The main indications for NPPV in the EC are mainly 1) acute exacerbation of COPD, and 2) acute cardiogenic pulmonary oedema. The other uses of NPPV are in a patient in hypoxemic respiratory failure, as an adjunct to improve oxygenation prior to intubation (as with delayed sequence intubation). There is a growing body of evidence that it could also be utilised in the emergent setting for patients with acute exacerbation of asthma.[4,5]

Contraindications to the use of NPPV include, amongst others, the patient with an altered level of consciousness, an inability protect and clear the airway, severe head and/or facial trauma or surgery and severe upper gastrointestinal bleeding.[5]

Invasive Mechanical Ventilation can be delivered to the patient via two modes. These are: pressure regulated or volume regulated. In pressure regulated ventilation, each breath is delivered at a predetermined pressure level, thus the inspiratory volume will vary from breath to breath.[6,7] This includes:

- Pressure Control Ventilation (PCV) which is a variable Tidal volume (TV) at a preset maximum pressure.
- Pressure support Ventilation (PSV) which is an adjunct used with SIMV and CPAP in a patient that is breathing spontaneously. The patient determines the rate of respiration and the TV, the ventilator assists with preset pressure support.
- Airway Pressure release Ventilation (APRV) is similar to Bi-PAP ventilation. This is a relatively new mode of ventilation. There is a pre-set pressure high and a pressure low, similar to IPAP and EPAP. The patient spends pre-determined durations of several seconds each at either pressure setting.[6,7]

The second mode is volume regulated ventilation; here the volume of inspired air is pre-determined by the physician. Thus the preset volume will be delivered in each breath regardless of the pressures required to do so. Furthermore, each breath delivered may be mandatory (where all breaths are delivered by the ventilator at a set respiratory rate) or assisted (where patient triggered breaths are augmented by the ventilator). [7,8]

There are various volume-targeted modes:

- Controlled mandatory Ventilation (CMV) is the oldest mode, and no longer used. The ventilator delivers a set TV at a pre-set respirator rate. Patient initiated respiration is not sorted, and no breath other than the pre-set rate is delivered.
- Assist Control (AC) is also an old mode which is now infrequently used. Here a pre-set tidal volume is delivered at a pre-set rate. However, any respiratory effort initiated by the patient will result in the delivery of a full pre-set TV.
- Intermittent Mandatory Ventilation (IMV) is a mode in which a pre-set TV is delivered at fixed rate. However, any patient initiated respiratory effort will initiate the delivery of a breath the TV of which will be proportional to the respiratory effort of the patient. The ventilator will then reschedule breaths according to the patients demand or effort.
- Synchronised IMV is similar to IMV. However the ventilator synchronises the pre-set breaths with the patient's respiratory efforts.[6,7]

The development of the microchip processors has made the development of new modes of ventilation possible.[8,9] These complex arrays of MV modes and strategies being practiced combine pressure regulated and volume regulated ventilation.[4] Essentially a TV will be delivered so as not to exceed a pre-set pressure. So a guaranteed TV will be delivered according to the patient's respiratory effort. Many of the different modes to be found are simply a variation of each other. These modes include Pressure Regulated Volume Control (PRVC), Variable Pressure Support (VPS), Variable Pressure Control (VPC), Adaptive Support Ventilation (ASV) and Volume Ventilation plus (VV+).[6] Other more complex novel ventilatory modes like Neurally Adjusted Ventilatory Adjust ventilation (NAVA) have also been developed.

The reasons for Mechanical ventilation encompass a vast array of Medical and Surgical conditions. These indications can broadly be classified into four main categories:

- 1) Failure to protect the airway. This includes causes of impending airway loss, for example as in severe anaphylaxis or severe bleeding from neck or facial trauma. This category includes failure to maintain the airway due to an inability to maintain airway reflexes, as is evidenced in situations where one is unable to protect the airway against for example aspiration if there is an altered level of consciousness.
- 2) Failure to ventilate. This evidenced by hypercapnoea (an increase in PaCO₂) due to respiratory fatigue and failure secondary to prolonged increased respiratory effort. Examples of this include severe exacerbation of COPD, respiratory depression due to drugs, or respiratory muscle weakness.
- 3) Failure to oxygenate. This is essentially an inability of optimal gaseous exchange resulting in hypoxemia. This is usually due to pathologies that

result in ventilation-perfusion mismatch, for example ARDS, massive pulmonary embolus severe pneumonia or toxins and metabolic derangements.

- 4) Anticipated airway loss due to clinical deterioration. This is usually seen in patients for example patients in septic shock, and patients with severe trauma, as seen in severe head injuries or stab wounds to the neck with expanding haematomas.[6,7,10]

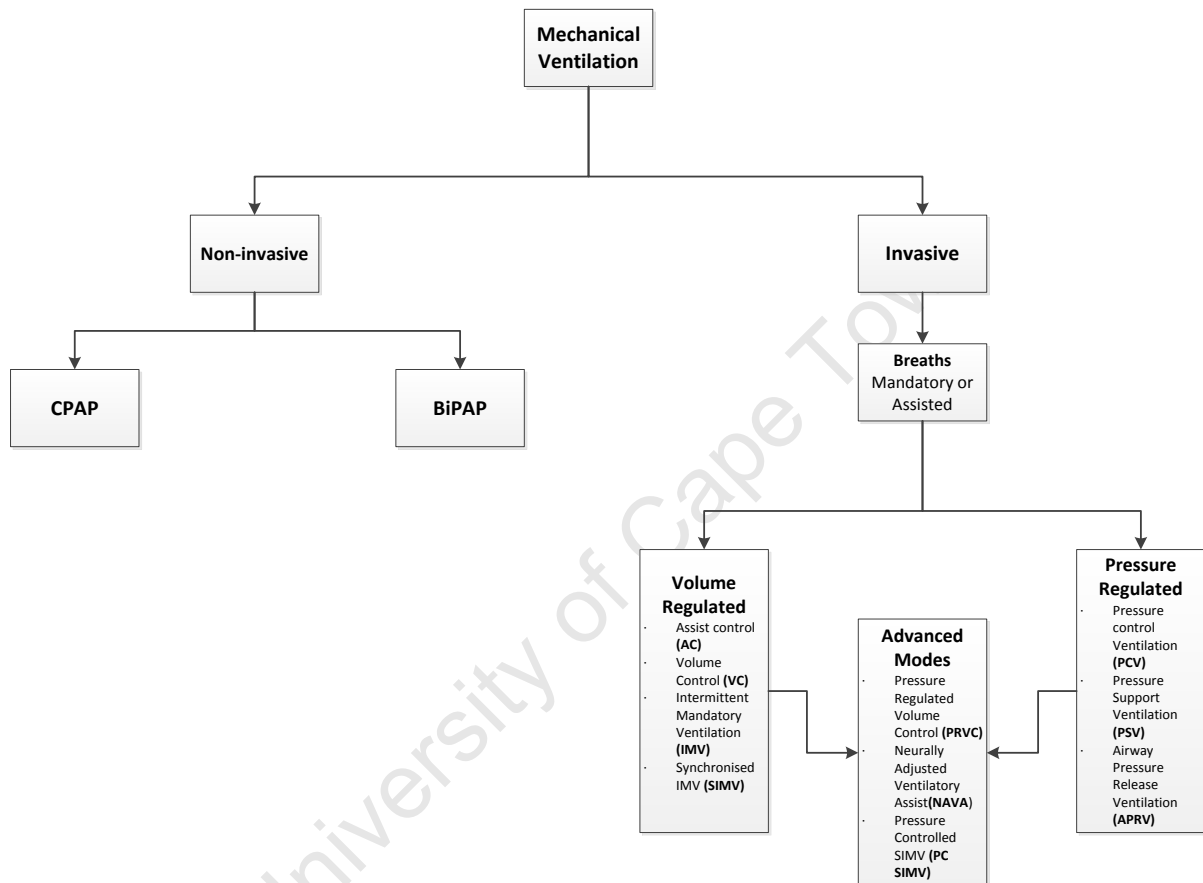


Figure 1. Overview of ventilatory modes

Impact of hospital overcrowding

The Emergency Physician (EP) is often the first point of contact for the critically ill patient entering the hospital precinct. With the current epidemic of hospital overcrowding, and the over-utilisation of already strained Emergency Centre (EC) resources, there are delays in the identification and treatment of patients with emergent conditions.[11-13] This increases the likelihood of poor clinical outcomes.[9,11,14,15] The causes of overcrowding are complex and multi-factorial. These aggravating factors are not unique to the South African Health System. The quadruple issue of hospital overcrowding, hospital diversion and closure,

prolonged boarding in the EC and lack of infrastructure and personnel, is crippling the effective management of EC's on a global scale.[16-19]

Once a decision has been made to intubate and mechanically ventilate a patient, a cascade of events is initiated which usually culminates in the patient being admitted to the Intensive Care Unit (ICU) or High Care Unit (HCU) of the hospital.[6]

Due to limited ICU resources and the increasing pressure on ICU beds, critically ill patients are being intubated and ventilated in the overcrowded EC.[20,21] It is thus incumbent on the Emergency Physician (EP) to identify and initiate appropriate management of the critically ill or acutely decompensated patient.[6]

Critical care in the Emergency Centre

Any patient requiring constant therapy and evaluation throughout their disease process may be deemed as receiving critical care, "this definition extends to any location anywhere, such that critical care is defined physiologically rather than geographically".[21] Critical care is no longer confined to the inner sanctum of the ICU or post-operative recovery rooms.

EC diagnosis and management of critically ill patients is a daily occurrence. EPs are managing critically ill patients in the EC long after the initial resuscitation of the patient. It is one of the duties of the EP to optimally care for these challenging critically ill patients in the EC because delays in these patients management can lead to acute decompensation with cardiopulmonary collapse followed by arrest and eventually death. The EP initiates, maintains and occasionally weans the patient off mechanical ventilation in the emergency centre.[22] Thus the EP needs to be equipped with the necessary skills to identify the acutely ill or critically ill patient and to commence and facilitate the appropriate treatment pathway.[17,23,24]

The EP needs to have a thorough knowledge and understanding of mechanical ventilation, lung protective ventilatory strategies, knowledge of weaning strategies and alternatives to invasive mechanical ventilation.[8,15,25]

The use of mechanical ventilation in the emergency centre requires adequate resources in order to maintain patient safety and avoid potential risks as these patients consume a disproportionately large amount of medical personell and resources.[22,26]

Upon intubation of the acutely ill patient, the optimal ventilatory strategy is of paramount importance. The choice of the mode of ventilation, as described above, can be daunting.

Emergency Medicine scope of Practice

Emergency Medicine is forging its way by establishing itself as a speciality. The most important step in the development of Emergency Medicine is “the recognition that emergency medicine incorporates a unique body of knowledge requiring specialized practitioners or emergency physicians”.^[27] The Emergency Medicine scope of practice in South Africa is still being defined. It is multidisciplinary and is concerned with “resuscitation, stabilisation, and appropriate disposition of patients”.^[28]

South Africa is a new democracy and is still in transition 17 years after first democratic elections. Cape Town is experiencing a changing pattern of pathologies and mortality, and this is mirrored by the disparity in socio-economic status of Cape Town. The burden of disease in Cape Town is essentially made up of: violence and trauma, HIV/AIDS, infectious diseases and chronic diseases of lifestyle.^[29] Approximately one third (35% males and 12% females) of admissions to EC in South Africa are due to injuries. Comparatively these figures are much higher than global trends.^[30,31]

Emergency Physicians care for high volumes of critically ill patients and trauma patients with little knowledge of their background medical history. Often these patients arrive unannounced to the EC.^[32] Rarely do patients attend the EC with a known diagnosis. Patients present with signs and symptoms, and the EP has learned to identify these patterns in presentations. This patient “red flag” identification has become the “hallmark” and “cornerstone” of the practicing EP.^[27,33]

South African Triage Scale

All patients attending the EC in South Africa are categorised according to The South African Triage Scale (SATS) into groups utilising physiological parameters. Accordingly patients are classified as follows:

- 1) Green: minor injury or illness, to be attended to within 240 minutes,
- 2) Yellow: physiologically stable with a reasonable serious medical or surgical condition, to be attended to within 60 minutes,
- 3) Orange: these patients are those with potentially unstable physiology with high likelihood to decompensate acutely, to be attended to within 10 minutes,
- 4) Red: these are patients who are physiologically unstable or requiring active resuscitation, to be attended to immediately.^[34,35]

Cape Town Burden of Disease

Several studies have been conducted to assess the case-mix of patients presenting to ECs' in Cape Town. The objectives' of these studies were to evaluate the case-mix and acuity of patient's attendance to the ECs', and to attempt to facilitate improved service delivery at the EC's based on the data. The Cape Town metropolis has 9 Community Health Centres (CHC's) that operate an EC on a 24 hour basis. These provide primary or first-line treatment to the population of Cape Town. Patients who are deemed to require higher levels of medical intervention are then referred on to secondary or tertiary Health Care.

Twomey and Wallis in 2007 conducted an audit on four Community Health Centre (CHC) emergency centres. They looked at primary level usage of EC and the acuity of presentation of patients. The mean patient presentation to each EC on a daily basis was 75 patients. There was no significant discrepancy in triage scaling representations of adult to paediatric patients. Patients were triaged as follows: 4% Red, 28% Orange, 34% Yellow, and 30% Green. The top 3 presentations were 1) trauma and violence 2) acute shortness of breath and 3) diarrhoeal disease in children. A significant proportion of the population presenting to CHC facilities fell into the emergency and urgent category.[36] And almost 30 % of emergency patients were referred to secondary and tertiary level health institutions for higher levels of medical or surgical intervention.[36]

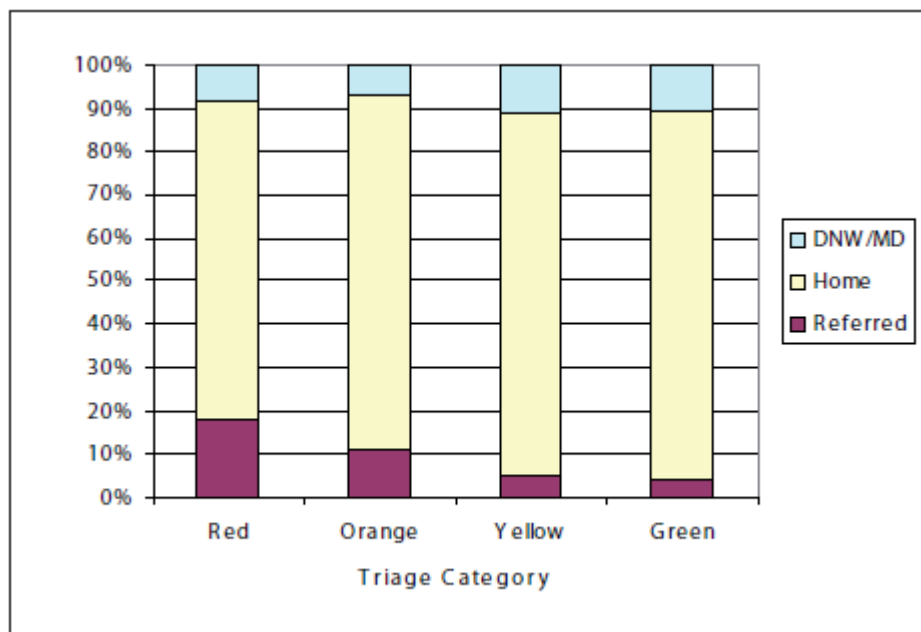


Figure2. Disposal of adult patients (%) (DNW=did not wait, MD=missing data) [39]

Hodkinson et al, in 2007 over a one month period evaluated patient attendance to New Somerset Hospital (NSH) in Cape Town. NSH is a secondary level hospital. A mean of 102 patients per day attended the EC. Of this 18% were paediatric patients. Patients were

triaged using the SATS. Amongst adult patients, 2% were Red, 27% were Orange, 48% were Yellow, and 23% were green. Conversely, the data for the paediatric population showed: 2% Red, 45% orange, 37% Yellow, and 16% green patients. The top three presentations were: 1) 26% trauma and violence, 2) 15% respiratory disease and 3) 14% gastrointestinal complaints.[37]

The top three presentation results of Hodkinson and Wallis were mirrored by a study in 2008 by Hanewinckiel, et al at Paarl Hospital. Paarl hospital is a rural hospital 60km from Cape Town, serving a population of over 600 000 people in a geographical area spanning almost 22500 square kilometres. A 5 month retrospective study was conducted from January 2008. 17000 patients attended the hospital EC. Random samples of 1781 patient charts were reviewed. The acuity of patients triaged were as follows: 1) 5% Red, 2) 14% orange, 3) 67% Yellow and 4) 14% Green. The top three presentations were 1) trauma and violence (36%), 2) abdominal complaints (15%) and 3) respiratory symptoms (13%).[38]

It can be postulated from the studies by Hodkinson and Hanewinckiel that there are similar distribution of patient acuity and presentation at the other secondary hospitals in Cape Town. Furthermore, it can be deduced from the study by Wallis that of the approximate 30% of urgent patients that are referred for higher level of intervention, that the acuity of their conditions will have deteriorated further. This could result in the emergence of a deleterious situation.

The top 10 causes of mortality in Cape Town are showed in figure 1 as percentages.[39] As can be seen, the pandemic of and HIV/AIDS and TB complex (25.6%), has inundated the ECs, not only in Cape Town. This is followed closely by violence and trauma (18.1%).

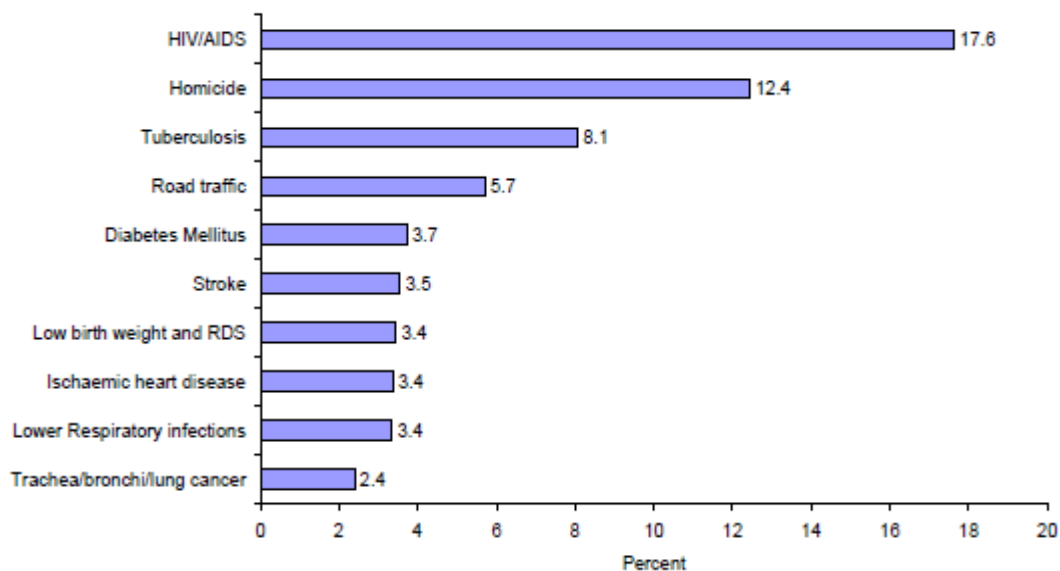


Figure3. Top 10 causes of premature mortality for Cape Town [39]

An attempt was made to correlate the incidence of intubation and initiation of MV in the Emergency Centres. However, there are no studies indicating this figure. An informal audit of data at Khayelitsha Hospital in Cape Town demonstrates a figure of approximately 1% of all attendees to that EC (Personal communication Dr S Lahri). This audit did not attempt to see if there was any correlation with the Burden of disease of Cape Town. Nor was there an attempt made to define the case load presentations to this EC.

Evidence of knowledge

Literature search strategy

Relevant literature was searched for using Pub Med, Medline, and Google scholar. A thorough search was done using words and combinations of; mechanical ventilation, knowledge, physician, emergency medicine, respiratory therapy and ICU. All data was scrutinised to assess for relevancy. Only 5 articles relevant to knowledge of Mechanical Ventilation were found, 2 on physician knowledge of MV, 1 on nurses in ICU knowledge of MV (unpublished data), 1 on staff in ICU knowledge of MV, and the last on the education of MV amongst Fellows in ICU.

All the studies were questionnaire based.

In 2001 Botha conducted a study amongst nurses working in the ICU.[40] The aim of her study was to describe the knowledge of nurses in ICU with regards to basic Mechanical Ventilation. Her study further attempted to establish if there was any difference in knowledge of MV amongst ICU and non-ICU trained sisters and the years of experience. The study by Botha showed that there is a disparity in knowledge amongst ICU and non ICU trained nursing sisters. However it also showed that a perception of competency with regards to actual scores was unrealistic. Botha further goes on to suggest that the teaching and learning models for MV be reviewed.

Alfonso in 2005 had a sample size of 61; the questionnaire was circulated amongst respiratory therapists, pulmonologists, nurses and registrars.[9] The impact of this study is that it highlights the lack of knowledge of MV amongst staff involved in the care of the patient on Mechanical Ventilation. Mean scores improved amongst Post Graduate Year (PGY) 1 to PGY 3 registrars, with slight differences in PGY3 and Fellows' scores.

Cox and Carson in 2003 had a sample size of 259, with a 75% response rate to the questionnaire.[41] The mean score was 74% with SD of 14, score ranged from 37.5 to 100%. This study evaluated overall scores as well as incorrectly answered questions which were also analysed individually. The study showed that Internal Medicine residents are probably not receiving adequate evidence based teaching, and they recommended trying different teaching models.

Brescia in 2009 had 25 Internal Medicine respondents.[42] Questions were structured at resident and consultant level, the mean scores obtained was 40.2% +/- 16.7%. Residents were uniformly unable to recognise critical clinical situations. Residents perceived this to be a good exercise and wanted more of this type of teaching. Brescia also showed that suggestions by Cox et al in 2003, 6 years earlier, had not been implemented.

All the studies cited display the inadequacy in knowledge of MV. This visible lack of knowledge is not inherent in only one sphere of the medical fraternity, but is reflected across the spectrum of health care professionals caring for the ventilated patient.

Disturbingly what becomes apparent is the perception of poor level of confidence displayed by participants.

Brescia also highlighted that there is no uniformity in education of MV amongst Fellows. She recommended, as Cox had in 2003, that a well-structured programme is necessary to teach MV.

Teaching Mechanical Ventilation

Clinical teaching forms an integral component of medical education. Although there is an abundance of medical literature on how to teach in the working environment and in wards, there is essentially no guide on how to teach in the EC.[43] This is more important with regards to Mechanical Ventilation. There are no clear-cut guidelines on the minimum required knowledge-base of MV. Traditionally MV was a subject taught during undergraduate years in the form of a few didactic lectures during rotations in Anaesthesiology. The inadequacies of this grounding knowledge is supplemented by limited bed-side teaching in the EC, observation of ventilator setting preferences of senior Medical Officers, and self-driven teaching by utilizing medical literature in the form of journal articles, medical texts and internet based learning. Hence the EP should embrace this opportunity to facilitate teaching MV in the EC by utilising novel methods and new technologies.

Registrars enrolled in the Emergency Medicine Programmes in Cape Town, rotate through 2 of 6 different Intensive Care Units (ICU). These are closed units at Academic Hospital and regional Hospital Level. Some of these beds are ICU beds, whilst others are High Care Beds. Only 2 of the units have Intensivist cover. There are no standardised protocols that are followed. The number and acuity of patients vary from unit to unit. Hence exposure and experience varies, and this affects the knowledge of ventilation strategies. There is thus a need to attempt to establish standardised teaching methodology, which would encompass Evidence-Based Medicine approach with Competency Based Training and Assessment (CBTA) to teaching Mechanical Ventilation initiation, maintenance, and weaning strategies.

In recent years competency based training has come to the fore-front of medical education. The fundamental principle is not about passing or failing, it is to establish an understanding of knowledge base of the trainee, and a translation of this knowledge practically. It further ascertains the progress and development of the trainee. “The competency based approach consists of functional analysis of occupational roles, translation of these roles into outcomes, and assessment of trainees' progress on the basis of their demonstrated performance of these outcomes”.[44]

It is based on the theory of Millers pyramid, which is essentially a metamorphosis of knowledge from knowing how to execute a task through to being able to performing the said task. Essentially Millers Pyramid is a bridge between cognitive function and behaviour of the trainee.[44,45]

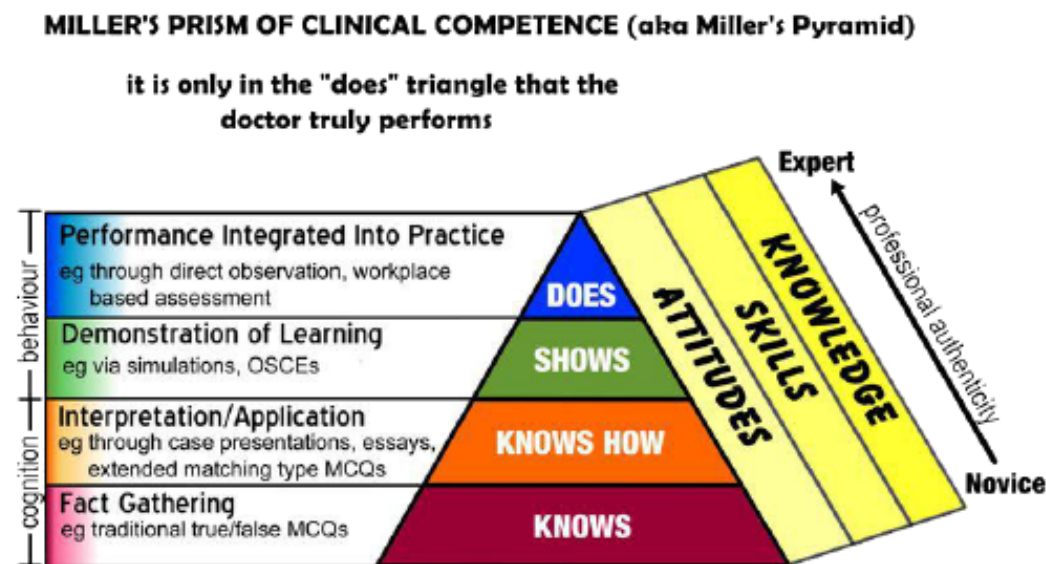


Figure 2. Miller's prism of clinical competence.[46]

In this framework, Miller distinguished between “action” and the lower levels. “Action” focuses on what occurs in practice rather than what happens in an artificial testing situation. Work based methods of assessment target this highest level of the pyramid and collect information about doctors' performance in their normal practice.[45]

It is used alongside other assessment methods to gain a complete picture of the trainee, and to ensure that all levels of Miller’s pyramid are assessed appropriately. This is done by making use of Direct Observation of Procedural Skills (DOPS), Objective Structured Clinical Examination (OSCE), Case-based Discussion (CbD) and Mini Clinical Evaluation eXercise (Mini

CEX). Collectively they improve the learning experience of the trainee, and allow the assessor to gauge the trainee's competency and growth as a clinician.

There are no formalised protocols established for the teaching of Mechanical Ventilation. However on the internet there is a wealth of information available. With the changing face of technology, and the availability of new teaching tools on a daily basis, the EC should be equipped with the ability to offer point of service information in the form of internet access, latest online journal access and copies of selected electronic books. The learning experience can be enhanced by combining internet resources and simulations (SIMS) with Virtual Reality teaching (VR) and Podcasts. This is an all in one learning experience that would encompass the use of online material, with hyperlinks to associated articles and web-pages pertinent to the education topic, combined with online discussion forums, chat rooms and assessment tools.[42,47,48] By incorporate these newer dynamic techniques and strategies and coupling them with CBTA, it would be possible to learn and teach better and more efficiently.[26]

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University of Cape Town

PART C: ARTICLE FOR SUBMISSION

Emergency Medicine Physician and Registrars knowledge of
Mechanical Ventilation in Cape Town, South Africa.

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Word Count: 2439

MeSH headings: Emergency Medicine, knowledge, mechanical ventilation, ICU, Emergency Departments.

Abstract

Objectives: To determine the knowledge of mechanical ventilation of Emergency Physicians and Registrars in Cape Town.

Methods: A questionnaire based cross-sectional study was performed using a 19-point validated questionnaire. Outcome measure was a score to determine level of knowledge. We anticipated a mean score of 75% amongst Emergency Physicians (SD = 10), and the anticipated mean score for Registrars to be 65% (SD = 10). This yielded a statistical power of 97% in order to detect a significant difference. This was based on a level of significance of 0.05

Results: The response rate was 59 out of a total of 63, (94% return rate). The mean score for the consultants was 78% (SD 14.3) and the mean score for registrars was 62.5% (SD 18.91).

Conclusions: There is a disparity in knowledge levels of Mechanical Ventilation amongst Emergency Physicians and registrars as expected. Optimal knowledge of mechanical ventilation is integral to the arsenal of every Emergency Physician. There should be a change in teaching models by embracing newer teaching methodologies, techniques and technology to enhance and consolidate the educational experience.

Introduction

Mechanical ventilation (MV) is a method of rendering respiratory support via artificial means. This can be automated (as in the use of a ventilator), or manual (as with the use of a bag-valve mask). The respiratory support that is given may be either invasive (for example placing an endotracheal tube) or non-invasive (for example with a tight-fitting face mask).[1]

There is an abundance of terminology and literature that describes and defines Non-invasive Positive Pressure Ventilation (NPPV) and the different modes.

NPPV requires that the patient have an intact sensorium, and is able to maintain and protect their airway. The main indications for NPPV in the EC are 1) acute exacerbation of COPD, and 2) acute cardiogenic pulmonary oedema. The other uses of NPPV are in a patient in hypoxemic respiratory failure, as an adjunct to improve oxygenation prior to intubation (as with delayed sequence intubation). [1,2]

Contraindications to the use of NPPV include, amongst others, the patient with an altered level of consciousness, an inability protect and clear the airway, severe head and/or facial trauma or surgery and severe upper gastrointestinal bleeding.[2]

Invasive Mechanical Ventilation can be delivered to the patient via two modes. These are: pressure regulated or volume regulated. In pressure regulated ventilation, each breath is delivered at a predetermined pressure level, thus the inspiratory volume will vary from breath to breath.[3,4]

The second mode is volume regulated ventilation; here the volume of inspired air is predetermined by the physician. Thus the preset volume will be delivered in each breath regardless of the pressures required to do so. Furthermore, each breath delivered may be mandatory (where all breaths are delivered by the ventilator at a set respiratory rate) or assisted (where patient triggered breaths are augmented by the ventilator). [4,5]

The metamorphoses of technology has made the development of new modes of ventilation possible.[5] These complex arrays of MV modes and strategies being practiced combine pressure regulated and volume regulated ventilation.[1] Essentially a Tidal Volume (TV) will be delivered so as not to exceed a pre-set pressure. So a guaranteed TV will be delivered according to the patient's respiratory effort. Many of the different modes to be found are simply a variation of each other. These include, amongst other, Pressure Regulated Volume Control (PRVC), Variable Pressure Support (VPS), Variable Pressure Control (VPC), Adaptive Support Ventilation (ASV) and Volume Ventilation Plus (VV+).[3]

Any patient requiring constant therapy and evaluation throughout their disease process may be deemed as receiving Critical Care (CC). Traditionally CC only occurred in Intensive Care Units (ICU), however the new consensus is that critical care is defined physiologically rather than geographically.[6,7] CC is no longer confined to the inner sanctum of the ICU or post-operative recovery rooms; but it may be rendered pre-hospital, in Emergency Centres (EC) and in hospital wards.

With the current epidemic of hospital overcrowding, and the over-utilisation of strained Emergency Centres (EC), there are delays in the identification and treatment of patients with emergent conditions.[8,9] This increases the likelihood of poor clinical outcomes.[10-11] The causes of overcrowding are complex and multi-factorial. The quadruple issue of: 1) hospital overcrowding, 2) hospital diversion and closure, 3) prolonged boarding in the EC and 4) the lack of infrastructure and personnel, are crippling the effective management of ECs.[12-15] At present there are no studies, neither published nor unpublished, that give an indication of the length of stay in an EC whilst awaiting a hospital bed in South Africa. Anecdotally patients may spend on average around 18 hours in the EC awaiting a bed. Thus patients admitted to hospital may have a protracted stay in the EC.[10] These aggravating factors are not unique to the South African Health System.[7-8]

The burden of disease in Cape Town is essentially made up of: violence and trauma, HIV/AIDS, infectious diseases and chronic diseases of lifestyle.[16] Approximately one third (35% males and 12% females) of admissions to EC in South Africa are due to injuries. The top three presentations are 1) 30% trauma and violence, 2) 15% respiratory disease and 3) 15% gastrointestinal complaints.[17,18] Comparatively, the figures for violence and trauma are much higher than global trends.[4,5]

The Emergency Physician (EP) is most often the first point of contact for the critically ill patient entering the hospital precinct. It is the one of the duties of the EP to optimally care for these challenging critically ill patients in the EC, because delays in these patients management can lead to acute decompensation. Thus the EP needs to be equipped with the necessary skills to identify the acutely ill or critically ill patient and to commence and facilitate the appropriate treatment pathway. Once a decision has been made to intubate and initiate Mechanical Ventilation (MV) for a patient, a cascade of events are triggered which usually culminates in the patient being admitted to the ICU or high care unit of the hospital.[1,3,14]

EPs are managing critically ill patients in the EC long after the initial resuscitation of the patient. However, due to limited ICU resources and the increasing pressure on ICU beds, critically ill patients are being intubated, ventilated, and boarded in the overcrowded EC.[1,17,18] Hence the EP initiates, maintains and occasionally weans the patient off MV in the emergency centre.[20]

Thus knowledge essential to the EP includes:

- Understanding of mechanical ventilation and its associated dangers,
- Lung protective ventilatory strategies,
- Knowledge of weaning strategies, and
- Alternatives to invasive mechanical ventilation.[5,12].

Upon intubation of the acutely ill patient, the optimal ventilatory strategy is of paramount importance. With the advent of newer ventilation modes and strategies, the choice of the mode of ventilation can be daunting.[4]

The use of MV in the emergency centre requires adequate resources in order to maintain patient safety and avoid potential risks, as these patients consume a disproportionately large amount of medical personnel, time and resources.[20]

Given the time burden and high cognitive load associated with ventilation in the EC, it is essential that EPs have appropriate knowledge and skills in this area and that education in MV is covered in Emergency Medicine (EM) training.

In South Africa doctors may work as medical officers in specialty fields before commencing their specialist training. Training and experience in mechanical ventilation prior to entering the program was considered as a variable to be evaluated. The effect of prior experience in ICU or Anaesthetics on their ability to perform this task competently was also considered.

In order to assess whether current training provides an adequate knowledge base for EM registrars and faculty, the baseline knowledge of MV of emergency medicine physicians and registrars in Cape Town was evaluated.

Method

Questionnaire

A 19 point questionnaire which had been developed by Cox in 2003 was used.[21] The questionnaire had been validated by eight intensivists in the original study. Permission was granted by the authors to use all or part of the questionnaire and to adapt it for use. Minor changes were made to the questionnaire with regards to conversion to SI units. The form, content and possible responses to the questions were not altered. The questionnaire was then evaluated by a South African Adult Intensivist based in Cape Town to determine if the questions were still appropriate and the content still current with regards to internationally accepted principles of practice.

Study population

The study was conducted on all EM registrars and EPs registered for training in Cape Town, at the University of Cape Town (UCT) and the University of Stellenbosch (SUN). The EM training programme has 42 registrars across both universities. The study surveyed all EPs working in the Western Cape public sector and all EM practitioners who have completed registrar training but have not completed the final examinations as yet. Registrars are required to complete two 3 month ICU rotations during their 4 years of training, preferably after having completed a minimum of eighteen months on the rotation.

Expected outcomes

We anticipated a mean score of 75% amongst specialist EP (SD = 10), and 65% (SD = 10) for registrars. This yielded a statistical power of 97% in order to detect a significant difference between specialist EP and EM registrars. This was based on a level of significance of 0.05.

Ethics approval

The study was approved by the University of Cape Town Human Research Ethics Committee. A cover letter explaining the process was attached to each questionnaire. Informed consent was taken from participants and there was no annotating on the questionnaire to indicate who had completed which questionnaire. Participants had to sign a register indicating that they had participated in the study (non-participants were not required to sign the register). This facilitated contacting potential participants who had not completed the questionnaire to do so at an arranged meeting. All data was stored on a password protected computer in a password protected Microsoft Excel database.

Data collection

Data was collected by means of a paper-based questionnaire at a registrar teaching session on the 24th of May 2011. Participants had 45 minutes allocated to complete the questionnaire themselves. All participants had to sign a register that was circulated to indicate that they had completed the questionnaire.

There were 40 respondents at this initial sitting. Registrars and consultants who had not completed the questionnaire were contacted and arrangements were made to meet them at a time of convenience to complete the questionnaires. There was a total response of 59 questionnaires from a possible maximum of 63. This gave a response of 94%. Of the respondents, 41 were registrars, 3 were registrars whom had completed the training programme but had not yet sat the exit exams, and 15 were consultants.

Exclusions

- Registrars and consultants from all other specialities and speciality training programmes.
- EM registrars and Emergency Physicians and practitioners not practising within Cape Town, and specialists not practicing within the public sector.

Analysis

Stata statistical software was used to analyse the data. The Shapiro-Wilk test was used to evaluate if there was a difference in scores amongst registrars and consultants.

Standard deviation demonstrates the extent of variation that exists from the mean or expected values. The number of degrees of freedom is a measure demonstrating certainty that the sample population is indeed representative of the entire population. The greater the degree of freedom, the higher is the conviction that the entire population has been accurately sampled.

TEST RESULTS

Scores

The score for the entire group was a mean of 66.9% (SD 18.5, CI 4.73). The score for consultants was Mean 78.3% (SD 14.3, CI 8.22). The scores for registrars who had completed their training time was Mean 70.1% (SD 2.8, CI NA). The score for the registrars as a group was Mean 62.5% (SD 18.9, CI 5.79).

Discussion

The anticipated mean scores for registrars was 65%, and for consultants was 75%. The actual scores attained were 62.5% and 78% respectively.

Cox et al, in the original study, showed that residents' knowledge of MV is inadequate. They went further on to make recommendations as to how to improve knowledge base and outcomes. A follow-up study by Brescia showed that residents are still inadequately trained in MV, and it also highlighted that the recommendations made by Cox et al 6 years earlier were not implemented.[22] The findings with our studies correlate well with the findings by Cox et al. Cox et al evaluated only senior residents whom had completed their ICU rotations or were rotating through ICU, whereas in this study all registrars regardless of year of training and whether or not they had completed an ICU rotation were evaluated.

Limitations

The questionnaire was based on medical vignettes only. At least a quarter of the patients presenting to EC in Cape Town are trauma patients.[5,17,18,23] An analysis was not performed on:

- the year of study and scores attained,
- prior experience and its relation to scores attained, and
- the impact of the specific ICU rotation completed to scores attained.

The results reflect the findings of the Registrars and Consultants in Cape Town, at UCT and SUN, and hence cannot be generalized to all EM training programmes in South Africa.

Conclusion

This study highlights a number of important features. It can clearly be seen that there are large deficits in EP and Registrars knowledge of MV. The primary implication for EM is that

since the outcomes of the intubated patient are directly related to MV strategies, it is of paramount importance that the EP be excellently versed in all aspects of MV. As anticipated, consultants mean scores were higher than registrars.

Recommendations

There is a need to incorporate newer dynamic techniques and strategies to teach better and more efficiently.[25] With the changing face of technology, and the availability of new teaching tools on a daily basis, the EC should be equipped with the ability to offer point of service information in the form of internet access, latest online journal access and copies of selected electronic books. The learning experience can be enhanced by combining internet resources and simulations (SIMS) with Virtual Reality teaching (VR). This is an all in one web-based learning experience that encompasses the use of online material, with hyperlinks to relevant articles and web-pages and podcasts related to the education topic, combined with online discussion forums, chat rooms and assessment tools.[22] Outcomes Based Training and Assessment should form an integral component of this symbiotic learning-teaching experience to improve knowledge base.

At least 1 ICU rotation should be completed within the first 12 months of enrolment onto the emergency medicine programme. This rotation should preferably be Intensivist-centred. Set learning objectives should be formulated in conjunction with intensivists. These learning objectives should form a core curriculum which is evidenced based. These should be taught in the form of didactic lectures and practical demonstrations, with continuous bedside teaching and evaluation of registrars' knowledge. Consultants and registrars should be encouraged to attend Continuous Medical Education activities to maintain competence on MV. Regular feedback and evaluation sessions should be scheduled between registrars and consultants. Feedback is important, and the results of the study used as a learning tool and fed back to the Consultants and Registrars as a whole.

A follow-up study should be performed within 5 years to determine if these recommendations have been implemented, and also to see if there is an improvement in knowledge with a change in teaching and education models. A further study should be conducted to determine if prior experience and exposure has an impact on scores. This should also aim to establish an optimal duration of rotation through intensive care units.

Lastly, an analysis should be performed on:

- scores per year of training to see if there is an improvement with seniority

- the questions answered incorrectly so as to attempt to determine “zones” of knowledge deficit

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Competing interests

None

Provenance and peer review

Not commissioned; externally peer reviewed.

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PART D: Appendices

Appendix 1: Permission from Drs Cox and Carson

Appendix 2: Cover Letter

Appendix 3: Questionnaire

Appendix 4: Ethics Committee approval letter

Appendix 5: Checklist for authors

University of Cape Town

Appendix 1: permission from Drs' Cox and Carson

Attached are copies with and without answers. Good luck with your study.

Shannon Carson

-----Original Message-----

From: mkalla@yahoo.com [mailto: mkalla@yahoo.com]

Sent: Thursday, February 24, 2011 2:54 PM

To: Carson, Shannon

Cc: mkalla@yahoo.com; draaparker@yahoo.co.uk

Subject: Effectiveness of medical resident education in mechanical ventilation. Permission to use questionnaire

Good day

My name is Moosa Kalla

I am a senior Emergency Medicine Registrar (resident) from South Africa.

I am currently busy with my dissertation, the topic being: Emergency Centre doctors knowledge on mechanical ventilation.

The methodology of my study is going to be questionnaire based.

I find many similarities in the study that I am proposing to do and the 1 that you have conducted already.

I am writing to you to request permission to use the questionnaire that you have formulated in part, slightly modified or completely for my study. And could you please forward me a copy of the questionnaire

I will have any alterations verified by critical care physicians, and I will as well forward you a copy of any amendments.

Thanking you

Regards

Dr Moosa Kalla

BSc (Physio), MBChB, ANE resident

Appendix 2: Cover Letter

EMERGENCY MEDICINE PHYSICIANS AND REGISTRARS KNOWLEDGE OF MECHANICAL VENTILATION IN CAPE TOWN, SOUTH AFRICA.

Thank you for your participation in the above mentioned study.

The aim of this study is to evaluate emergency medicine specialist and registrars' knowledge of mechanical ventilation. Your participation in the study is totally anonymous. There is a register which needs to be signed which will assist in getting all registrars and consultants to participate in the study.

It should take approximately 30 minutes to complete the questionnaire. Please complete all questions.

Thank you for your time and participation.

Moosa Kalla

EMERGENCY MEDICINE PHYSICIANS AND REGISTRARS KNOWLEDGE OF MECHANICAL VENTILATION

Thank you for your participation! We appreciate your time very much.

University of Cape Town

Appendix 3: Questionnaire

Clinical Scenario Questions

For each question, choose the SINGLE best answer

Case 1

A 64 year-old female with a history of COPD presents to the emergency room with increasing shortness of breath. At baseline she uses bronchodilators up to four times daily. Over the past week, her exercise tolerance has been decreasing, and she is now dyspnoeic at rest despite frequent use of her beta agonists. She reports a moderate cough with clear sputum.

On physical exam, she is in moderate respiratory distress but alert and appropriately responsive. Temperature is 38 °C, heart rate (HR) 110, respiratory rate (RR) 28, and blood pressure (BP) 110/70 mm Hg. She is using accessory muscles to breathe but can complete short sentences. Decreased breath sounds are present bilaterally and prolonged expiration is noted. Heart sounds are distant but regular and the abdomen is unremarkable.

A chest radiograph reveals hyperinflation and decreased lung markings throughout both lung fields. An arterial blood gas (ABG) performed while the patient is on 2 litres O₂ by nasal cannula reveals: pH 7.30, PaCO₂ 7.99 kPa, PaO₂ 7.73 kPa, SaO₂ 88%.

Q1 In addition to close monitoring, which ONE of the following interventions would be MOST APPROPRIATE at this time?

- a) Increased supplemental oxygen with continuous beta agonist therapy
- b) Continuous beta agonist therapy only
- c) Intubation and mechanical ventilation
- d) Non-invasive positive pressure ventilation (BiPAP)

During the course of her therapy, a decision is made to intubate the patient. After a 500mL fluid bolus, she is sedated and a 7.0 endotracheal tube is placed without difficulty. The CO₂ indicator reading is consistent with appropriate placement of the endotracheal tube. The patient is ventilated at 25 breaths per minute by Ambu-bag. Immediately after intubation however, the blood pressure is observed to be 70/40 mm Hg.

Q2 What ONE process is the MOST LIKELY cause of the hypotension?

- a) Sepsis
- b) Pneumothorax
- c) Increased intrathoracic pressure (“auto-PEEP”)
- d) Myocardial infarction

Q3 The MOST APPROPRIATE first intervention to improve the cardiovascular compromise would be to:

- a) Increase IV fluids
- b) Place a 16-gauge needle in the left anterior second intercostal space
- c) Stop bagging and allow the patient to exhale
- d) Begin dopamine at 5 mcg/kg/minute

Q4 The BP improves to 95/65 mm Hg. Which ONE of the following ventilator settings would be MOST APPROPRIATE for this patient (60 kg)?

- a) Volume assist-control with respiratory rate 22, tidal volume 400mL, PEEP 5 cm H₂O, FIO₂ 1.0
- b) Volume assist-control with respiratory rate 12, tidal volume 500mL, PEEP 5 cm H₂O, FIO₂ 0.6
- c) Volume assist-control with respiratory rate 20, tidal volume 700mL, PEEP 5 cm H₂O, FIO₂ 0.6
- d) Pressure assist-control ventilation with respiratory rate 15, inspiratory pressure of 25 cm H₂O, inspiratory to expiratory (I:E) ratio 1:1, PEEP 5 cm H₂O, FIO₂ 1.0

Q5 In volume assist-control ventilation (not pressure regulated), if the respiratory rate is set at 16 breaths per minute and tidal volume 600 mL, what ONE statement is TRUE of the tidal volume delivered if the patient's measured respiratory rate is 22 breaths per minute?

- a) 600 mL every breath
- b) 600 mL during the 16 set breaths and the rest determined by patient effort
- c) Tidal volume will be determined by patient effort each breath
- d) Tidal volume will vary depending on lung compliance

After 3 days of mechanical ventilation, the patient is awake, follows commands, and has an adequate cough reflex. She is placed on continuous positive airway pressure (CPAP) of 5 cm H₂O. After one minute she has a respiratory rate of 20 and tidal volume of 300mL.

Q6 Of the following options, which ONE would be the MOST APPROPRIATE plan for the day regarding mechanical ventilation?

- a) Sedate the patient and resume volume assist control ventilation
- b) Sedate the patient and begin pressure assist control ventilation
- c) Begin a weaning trial with pressure support ventilation or a T-piece
- d) Have the patient evaluated for tracheostomy

Case 2

A 29yo (60kg) female is found unresponsive in a city park after ingesting an unknown substance. The patient is resuscitated and intubated in the field by EMS. On arrival to the ER, the patient's temperature is 38.4 °C, HR is 110, and BP is 130/78. Thick sputum is being suctioned from the endotracheal tube. Lung exam reveals crackles in the right lower chest without wheezes. Heart sounds are normal, and urine output is adequate. A chest radiograph shows a dense infiltrate in the right lower lobe.

The patient is placed on synchronized intermittent mandatory ventilation (SIMV) with tidal volume 450 mL, set respiratory rate 16 breaths/minute, PEEP 5 cmH₂O, and FiO₂ 0.40. On these settings, the patient's respiratory rate is measured at 30 breaths per minute. An arterial blood gas reveals: pH 7.45, PaCO₂ 4.53 kPa, PaO₂ 6.66 kPa and SaO₂ 83%. The FiO₂ is increased to 1.0, and an ABG done 30 minutes later shows: pH 7.43, PaCO₂ 4.79 kPa, PaO₂ 7.33 kPa, kPa and SaO₂ 89%. The patient's measured respiratory rate is unchanged.

Q7 The PRIMARY physiologic abnormality accounting for the hypoxemia is:

- a) Excessive dead space ventilation
- b) Low cardiac output
- c) Intrapulmonary shunt
- d) Hypoventilation

Q8 Which ONE of the following is TRUE of synchronized intermittent mandatory ventilation (SIMV)?

- a) The tidal volume of patient triggered breaths above the set rate is determined by the set tidal volume
- b) The tidal volume of patient triggered breaths above the set rate is determined by patient effort
- c) The tidal volume of each breath is determined by patient effort
- d) SIMV is a form of pressure-cycled ventilation

Later that night, a nurse calls you over to examine the patient because her O₂ saturation has fallen over the past five minutes from 94% to 80% despite an increase in FiO₂ to 1.0 (100% oxygen). You notice that breath sounds are audible bilaterally but decreased symmetrically, and there is no wheezing present. Peak airway pressure has increased to 65 cm H₂O (from 40 cm H₂O) but plateau pressure is relatively unchanged at 25 cm H₂O. Measured respiratory rate is now 42, her heart rate is 110, and her BP is 150/85 mm Hg.

Q9 What ONE intervention would be MOST LIKELY to improve the physiologic process causing the patient's hypoxemia?

- a) Emergent needle decompression of presumed pneumothorax
- b) Emergent tissue plasminogen activator (tPA) followed by heparin
- c) Suctioning followed by change of the endotracheal tube if no improvement
- d) Bronchodilators followed by IV solumedrol

After you perform the proper intervention, the patient stabilizes. Gradually over the next three days her oxygenation improves. The patient is changed to pressure support ventilation with inspiratory pressure of 20 cm H₂O and PEEP of 5 cm H₂O.

Q10 Which ONE of the following is TRUE regarding the patient's respiratory status on pressure support ventilation (PSV)?

- a) Tidal volumes will be the same with each breath
- b) Minute ventilation will be constant
- c) Minute ventilation will vary according to her strength and effort
- d) Inspiratory to expiratory (I:E) ratio is set by the physician

Case 3

A 56 year-old female with diabetes mellitus is brought to the emergency room with a 3-day history of dysuria and low back pain. In the emergency room, she is obtunded and tachypnoeic. Her temperature is 38.9 °C, RR 28, HR 120, BP is 80/50, and her ideal weight is 60 kg. The patient has dry mucous membranes and brisk capillary refill. Faint bilateral inspiratory crackles are heard on lung exam, and the cardiac exam is significant only for tachycardia. Abdominal exam is unremarkable. No pedal edema is seen. The white blood cell count is 13,000 per mL and urinalysis reveals >100,000 WBCs with many bacteria. A chest radiograph demonstrates bilateral interstitial infiltrates without effusions. An ABG taken while the patient is breathing 100% oxygen by facemask reveals a pH of 7.30, PaCO₂ 3.33 kPa, PaO₂ 8.27 kPa, and SaO₂ 90%. As IV fluids and antibiotics are begun, it is felt that ventilatory support is indicated.

Q11 Which ONE of the following would be the MOST APPROPRIATE form of ventilatory support at this time?

- a) Non-invasive positive pressure ventilation (BiPAP) by face mask
- b) Intubation and volume assist-control ventilation, respiratory rate 20, tidal volume 360mL
- c) Intubation and intermittent mandatory ventilation, respiratory rate 20, tidal volume 700mL
- d) Intubation and volume assist-control ventilation, respiratory rate 20, tidal volume 700mL

On hospital day 2, she is being managed on a volume assist-control mode of ventilation. Blood pressure is 100/70 and HR is 90. While sedated, her peak airway pressures are 40 cm H₂O and plateau pressures are 24 cm H₂O. On a FiO₂ of 0.60 and PEEP of 5.0, an ABG reveals a pH 7.28, PaCO₂ 4.79 kPa, PaO₂ of 7.33 kPa, and SaO₂ 85%.

Q12 Which ONE of the following would be the MOST APPROPRIATE next measure?

- a) Increase the FiO₂ to 0.80
- b) Increase the tidal volume by 100mL from your initial setting
- c) Increase the rate by 4 breaths per minute from your initial setting
- d) Increase the PEEP to 10 cm H₂O

Q13 Which ONE of the following interventions would PROLONG the expiratory phase (“e time”) of a patient receiving volume assist-control mechanical ventilation?

- a) Increase respiratory rate
- b) Increase inspiratory flow rate
- c) Increase PEEP
- d) Increase tidal volume

Several days later in the patient’s course, she was being managed on pressure assist-control ventilation with a respiratory rate of 18, a PEEP of 12 cm H₂O, and total inspiratory pressure 30 cm H₂O. The inspiratory to expiratory (I: E) ratio is 1:1. Initially on these settings, measured tidal volumes averaged 400mL. Two days later on the same settings, the measured tidal volumes now average 500mL.

Q14 Which ONE of the following is the MOST LIKELY explanation for the change in tidal volume?

- a) Increased respiratory effort by the patient.
- b) Increased lung compliance
- c) Increased dead space ventilation
- d) Air trapping leading to increased intrinsic PEEP (“auto-PEEP”)

On Hospital Day 14, the patient is afebrile, hemodynamically stable, and has a central venous pressure (CVP) of 12. She has been managed with volume assist-control ventilation for the past 7 days and currently is receiving a tidal volume of 360 mL, respiratory rate of 24 breaths per minute, PEEP of 15 cm H₂O, and FiO₂ 0.5. An ABG at this time reveals: pH 7.35, PaCO₂ 6.66 kPa, PaO₂ 11.99 kPa, and SaO₂ 97%. Serum HCO₃ is 27 mEq/L. Peak pressure is 48 cm H₂O and plateau pressure is 38 cm H₂O.

Q15 Which ONE of the following would be the MOST APPROPRIATE intervention at this time?

- a) Decrease PEEP
- b) Begin an infusion of NaHCO_3
- c) Increase tidal volume
- d) Give IV furosemide

On hospital day 21, a tracheostomy is performed at the bedside without complication. That night, after being turned during a bath, the peak pressure alarms on the ventilator are heard and a decreased SaO_2 is noted on the monitor. On exam, the patient is in respiratory distress and is tachycardiac. The tracheostomy tube appears dislodged from its original position. Lung exam reveals limited breath sounds bilaterally without wheezes. The patients' neck appears swollen, and the skin of the neck and upper chest is crepitant to touch.

Q16 Which ONE of the following is the MOST APPROPRIATE immediate intervention?

- a) Call for a stat portable chest radiograph
- b) Place bilateral chest tubes
- c) Attempt to replace the tracheostomy tube
- d) Remove the tracheostomy tube and place an oral endotracheal tube

Case 4

A 35yo female (60kg) with asthma is intubated on arrival to the ER for respiratory distress. The ventilator mode is volume assist-control; settings are FiO₂ 0.6 (60% oxygen), tidal volume 500mL, PEEP 5 cm H₂O, set respiratory rate of 22 breaths/minute, inspiratory flow of 80L/min. The patient is heavily sedated and not breathing over the set rate. Fifteen minutes after intubation an ABG shows: pH 7.22, PaCO₂ 7.99 kPa, PaO₂ 11.33 kPa, and SaO₂ 95%. Peak inspiratory pressure is 70 cm H₂O and plateau pressure is 40 cm H₂O. Her blood pressure is 85/60 and decreasing. The heart rate has increased to 120 (from 95 earlier).

Q17 What SINGLE intervention would be MOST APPROPRIATE right now?

- a) Decrease respiratory rate to 12 breaths per minute
- b) Increase PEEP to 15 cm H₂O
- c) Increase tidal volume to 600mL
- d) Decrease FiO₂ to 0.3 (30%)

Q18 How would you quantify the amount of “auto-PEEP” present in a patient (who is sedated and paralyzed)?

- a) Measure airway pressure during a 1.0 second pause at the end of inspiration (and subtract set PEEP)
- b) Measure airway pressure during a 1.0 second pause at the end of expiration (and subtract set PEEP)
- c) Subtract the plateau pressure from the peak inspiratory pressure
- d) Multiply flow rate times the tidal volume

On the morning of the second day of mechanical ventilation while heavily sedated, the patient's SaO₂ decreases suddenly from 96% to 84% and her BP falls from 118/76 to 90/55. Peak airway pressure has increased from 40 cmH₂O to 75 cm H₂O and the plateau pressure has increased from 28cm H₂O to 50 cm H₂O. The patient remains sedated. On lung exam wheezes are present. Good air movement is present on the left side though somewhat decreased air movement is noted on the right. Heart sounds are distant and regular.

Q19 Which ONE of the following is the MOST LIKELY explanation for this change in airway pressures?

- a) Occlusion of the endotracheal tube
- b) Increased bronchospasm
- c) Patient-ventilator asynchrony
- d) Tension Pneumothorax

University of Cape Town

Appendix 4: Ethics Committee Approval Letter



UNIVERSITY OF CAPE TOWN

Faculty of Health Sciences
Human Research Ethics Committee
Room E52-24 Grootte Schuur Hospital Old Main Building
Observatory 7925
Telephone [021] 406 6626 • Facsimile [021] 406 6411
e-mail: shuretta.thomas@uct.ac.za

12 May 2011

Sent via Internal mail & Email

HREC REF: 219/2011

Dr M Kalla,
Department of Surgery
Division of Emergency Medicine

Dear Dr Kalla,

PROJECT TITLE: EMERGENCY MEDICINE PHYSICIANS AND REGISTRARS KNOWLEDGE OF MECHANICAL VENTILATION IN CAPE TOWN, SOUTH AFRICA.

Thank you for submitting your new study to the Faculty of Health Sciences Human Research Ethics Committee

It is a pleasure to inform you that the Ethics Committee has formally approved the above-mentioned study.

Approval is granted until 12 May 2012

Please submit an annual progress report (FHS016) if the research continues beyond the expiry date. Please submit a brief summary of findings if you complete the study within the approval period so that we can close our file.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please quote the HREC, REF in all your correspondence.

Yours sincerely

A/PROF MARC BLOCKMAN

CHAIRPERSON, FHS HUMAN ETHICS

Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938

This serves to confirm that the University of Cape Town Human Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Convention on Harmonisation Good Clinical Practice (ICH GCP) and Declaration of Helsinki guidelines.

The Human Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

Appendix 5: Instructions for Authors

Emergency Medicine Journal Manuscript Format

Manuscript format

Cover letter

Title page

Manuscript format

Statistics

Style

Figures/illustrations

Tables

References

Supplementary files

All material submitted is assumed to be submitted exclusively to the journal unless the contrary is stated. Submissions may be returned to the author for amendment if presented in the incorrect format. It should be in both the manuscript and the details page during submission.

Please note that only the article text (from first word of main text to the last word in reference list) will be used to typeset your article.

All other data (known as the metadata), such as article title, author names and addresses, abstract, funding (etc) statements will be taken from the fields you have filled in at submission, so you must ensure that these are up to date and accurate.

Cover letter

Your cover letter should inform the Editor of any special considerations regarding your submission, including but not limited to:

1. Details of related papers published or submitted for publication.

Copies of related papers should be submitted as “Supplementary files not for review” to help the Editor decide how to handle the matter.

2. Details of previous reviews of the submitted article.

The previous Editor's and reviewers' comments should be submitted as Supplementary material along with your responses to those comments. Editors encourage authors to submit these previous communications - doing so may expedite the review process.

3. Indication as to whether any of your articles (for example, appendices, large tables) could be published as Web only files rather than in the print version of the article. Please label any files for online publication only with this designation.

Title page

The title page **must** contain the following information:

1. Title of the article.
2. Full name, postal address, e-mail, telephone and fax numbers of the corresponding author.
3. Full names, departments, institutions, city and country of all co-authors.
4. Up to five keywords or phrases suitable for use in an index (it is recommended to use MeSH terms).
5. Word count - excluding title page, abstract, references, figures and tables.

Acceptance

Please note: If any of this information is repeated in the final Word document it will be removed by the typesetters and replaced with the information from the submission system. Therefore please check the metadata on ScholarOne Manuscripts carefully and make any changes before submitting the final version of your Word document.

List of the information taken from submission system only:

- Article type
- Title
- Author names
- Author affiliations, and corresponding author's full details
- Abstract (where applicable)
- Keywords
- Study approval
- Patient consent
- Funding statement
- Competing interests

- Contributor statement
- Trial Registration number (for clinical trials)

Manuscript format

Please note, this instruction is for submission only.

The manuscript must be submitted in Word. PDF format is not accepted.

The manuscript must be presented in the following order:

1. **Title page.**
2. **Abstract** (or summary for case reports) (note: references not allowed in abstracts or summaries).
3. **Main text** (provide appropriate headings and subheadings as in the journal. We use the following hierarchy: **BOLD CAPS**, **bold lower case**, Plain text, *Italics*).
4. **Tables** should be in the same format as your article (ie Word) and not another format embedded into the document. They should be placed where the table is cited and they must be cited in the main text in numerical order.
5. **Acknowledgments, Competing interests, Funding.**
6. **Reference list.**

Appendices (these should be Web only files to save space in the print journal; if so, please ensure you upload appendices as Web Only files and ensure they are cited in the main text as such.)

Images must be uploaded as separate files (view further details in Figures/illustrations) All images must be cited within the main text in numerical order.

Do not use the automatic formatting features of your word processor such as endnotes, footnotes, headers, footers, boxes etc. Please remove any hidden text.

Statistics

Statistical analyses must explain the methods used.

Guidelines on presenting statistics.

Guidelines on RCTs: CONSORT, QUORUM, MOOSE, STARD, and Economic submissions.

Style

Abbreviations and symbols must be standard and SI units used throughout except for blood pressure values which are reported in mm Hg.

Whenever possible, drugs should be given their approved generic name. Where a proprietary (brand) name is used, it should begin with a capital letter. Acronyms should be used sparingly and fully explained when first used.

View more detailed style guidelines.

Figures/illustrations

Colour images and charges

If you wish to publish colour figures in print you will be charged a fee that will cover the cost of printing. The journal charges authors for the cost of reproducing colour images on all unsolicited articles, see the journal web pages for cost information. Alternatively, authors are encouraged to supply colour illustrations for online colour publication and black and white publication in the print. This is offered at no charge.

File type

Ideally, submit your figures in TIFF or EPS format. We can also accept figure files of the following types: BMP, EPI, GIF, JPEG, PDF, PNG, PNG8, PNG24, PNG32, PS, PSD, SVG, WMF.

Resolution requirements apply (9cm across for single column, 18cm for double column):

1. For B/W, the format should be either TIFF or EPS. The resolution should be in 300 DPI.
2. For 4-colour, the format should be either tiff or eps in CMYK. The resolution should be 300 DPI.
3. For line-art, vector format is preferable. Otherwise, the resolution should be 1200 DPI.

During submission, when you upload the figure files label them with the correct **File Designation**: for example Mono Image, for black and white figures, and Colour Image for colour figures.

Histograms should be presented in a simple, two-dimensional format, with no background grid.

Figures are checked using automated quality control and if they are below standard you will be alerted and provided with suggestions in order to improve the quality.

All images should be mentioned in the text in **numerical order** and figure legends should be listed at the end of the manuscript.

Please ensure that any specific patient/hospital details are removed or blacked out.

NOTE: we do NOT accept figures which use a black bar to obscure a patient's identity.

Online only material

Additional figures and tables, methodology, references, raw data, etc may be published online only to link with the printed article. If your paper exceeds the word count you should consider if any of the article could be published online only as a "data supplement". These files will not be copyedited or typeset.

All data supplement files should be uploaded using the File Designation: "Web only files".

Please ensure any data supplement files are cited within the text of the article.

Multimedia files

You may submit video and other files to enhance your article (video files should be supplied as .avi, .wmv, .mov .mp4 or .H264). When submitting video files, ensure you upload them using the File Designation "Video Files".

Using material already published elsewhere

If you are using any figures, tables or videos that have already been published elsewhere you must obtain permission from the rights-holder (this is usually the publisher and not the author) to use them and add any required permission statements to the legends.

Tables

Tables should be submitted in the same format as your article (Word) and not another format embedded into the document. They should appear where the table should be cited, cited in the main text and in numerical order. Please note: we **cannot** accept tables as Excel files within the manuscript.

If your table(s) is/are in Excel, copy and paste them into the manuscript file.

Tables should be self-explanatory and the data they contain must not be duplicated in the text or figures - we will request that any tables that are longer/larger than 2 pages be uploaded as web only data.

References

Authors are responsible for the accuracy of cited references: these should be checked against the original documents before the paper is submitted. It is vital that the references are styled correctly so that they may be hyperlinked.

Citing in the text

References must be numbered sequentially as they appear in the text. References cited in figures or tables (or in their legends and footnotes) should be numbered according to the place in the text where that table or figure is first cited. Reference numbers in the text must be given in square brackets immediately after punctuation (with no word spacing)—for example, [6] not [6].

Where more than one reference is cited, separate by a comma—for example, [1, 4, 39]. For sequences of consecutive numbers, give the first and last number of the sequence separated by a hyphen—for example, [22-25]. References provided in this format are translated during the production process to superscript type, which act as hyperlinks from the text to the quoted references in electronic forms of the article.

Please note, if your references are not cited in order your article will be returned to you before acceptance for correct ordering.

Preparing the reference list

References must be double spaced (numbered consecutively in the order in which they are mentioned in the text) in the [slightly modified] Vancouver style (see example below). Only papers published or in press should be included in the reference list. (Personal communications or unpublished data must be cited in parentheses in the text with the name(s) of the source(s) and the year. Authors should get permission from the source to cite unpublished data.)

References must follow the [slightly modified] Vancouver style:

12 Surname AB, Surname CD. Article title. Journal abbreviation Year;**Vol**:Start page–End page.

Use one space only between words up to the year and then no spaces. The journal title should be in italic and abbreviated according to the style of Medline. If the journal is not listed in Medline then it should be written out in full.

Check journal abbreviations using PubMed.

List the names and initials of all authors if there are 3 or fewer; otherwise list the first 3 and add et al. (The exception is the Journal of Medical Genetics, which lists all authors.)

Example references:

Journal article

13 Koziol-Mclain J, Brand D, Morgan D, et al. Measuring injury risk factors: question reliability in a statewide sample. *Inj Prev* 2000;**6**:148–50.

Chapter in book

14 Nagin D. General deterrence: a review of the empirical evidence. In: Blumstein A, Cohen J, Nagin D, eds. Deterrence and Incapacitation: Estimating the Effects of Criminal Sanctions on Crime Rates. Washington, DC: National Academy of Sciences 1978:95–139.

Book

15 Howland J. Preventing Automobile Injury: New Findings From Evaluative Research. Dover, MA: Auburn House Publishing Company 1988:163–96.

Abstract/supplement

16 Roxburgh J, Cooke RA, Deverall P, et al. Haemodynamic function of the carbomedics bileaflet prosthesis [abstract]. Br Heart J 1995;73(Suppl 2):P37.

Electronic citations

Websites are referenced with their URL and access date, and as much other information as is available. Access date is important as websites can be updated and URLs change. The "date accessed" can be later than the acceptance date of the paper, and it can be just the month accessed. See the 9th edition of the AMA Manual of Style for further examples.

Electronic journal articles

Morse SS. Factors in the emergency of infectious diseases. Emerg Infect Dis 1995 Jan-Mar;1(1). www.cdc.gov/nciod/EID/vol1no1/morse.htm (accessed 5 Jun 1998).

Electronic letters

Bloggs J. Title of letter. Journal name Online [eLetter] Date of publication. url

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