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Mechanical Ventilation in the Intensive Care Unit: A Prospective Study of Indications and Factors that Affect Outcome in a Tertiary Hospital in Nigeria

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Abstract

The need for ventilatory support is one of the commonest indications for admission into the intensive care unit (ICU). Despite the usefulness of mechanical ventilation, its damaging effect on the lungs has also been widely recognized.

The study was a prospective, case-controlled survey of all mechanically ventilated patients admitted in our ICU from November 2013 to April 2014. For every ventilated patient, a non-ventilated similar patient served as a control.

A total of 128 patients were admitted into the ICU over the six month period and 44 patients constituting 34.4% were mechanically ventilated. The average duration of mechanical ventilation was 12.30 ± 10.10 days. Duration of mechanical ventilation, use of arterial blood gas measurement and ionotropic support had significant effect on weaning from ventilation with p values of 0.005, 0.05 and <0.001 respectively. Mechanically ventilated patients had >4 times chance of death than non-ventilated patients.

Mechanical ventilation though a useful therapeutic intervention in the ICU is associated with increased mortality. Duration of ventilation, use of arterial blood gas (ABG) and need for ionotropic support influenced successful weaning off ventilator. It may be expedient therefore to weigh the risk: benefit assessment of mechanical ventilation before commencement in the ICU.

Introduction

The need for ventilatory support is one of the commonest indications for admission to the intensive care unit (ICU) [1]. The intensive care unit as we know it now came to be with the introduction of mechanical ventilation into clinical practice in the 1940s [2]. Despite the usefulness of mechanical ventilation, its damaging effect on the lungs has also been widely recognized [3]. Therefore the decision to mechanically ventilate a patient must take into account the primary indication for the ventilatory support and its reversibility. In addition, the goal of ventilation and thus its appropriate mode must be set for each patient to increase benefit and reduce untoward effect [3].

The indications for mechanical ventilation are varied and have traditionally been grouped into hypoxic and ventilatory respiratory failures. Some conditions that predispose to respiratory failure include respiratory distress, airway obstruction, reduced or poor respiratory drive, abnormal chest wall and respiratory muscle fatigue. It must be noted however that the primary indication for ventilatory support must be reversible to allow for early weaning off the ventilator.

The outcome of mechanical ventilation has been studied previously. Esteban and colleagues4 reported the characteristics and outcomes of adult patients who were mechanically ventilated. They observed that 33% of patients admitted to the ICU were mechanically ventilated and "survival depended on both factors present at the start of mechanical ventilation and patient management in the intensive care unit" [4]. From the above study, it was concluded that outcome of ventilated patients in the ICU does not depend on ventilatory support only but on other factors such as patients clinical status and other interventions in the unit.

Studies on outcome of mechanical ventilation in the ICU are limited most of the time by its retrospective nature and such studies are rare in the Sub-Saharan Africa. We conducted a prospective study on the indications and outcome of mechanical ventilation in our ICU with a view to determining factors associated with outcome.

Methodology

The study was carried out in the Intensive Care Unit of the University of Benin Teaching Hospital, Benin (UBTH.), Edo state, Nigeria. It is a level III, multidisciplinary unit catering for medical, surgical and paediatric patients from across the neighbouring states of Delta, Ondo, Ekiti and Kogi.

The study was a prospective, case controlled survey of all mechanically ventilated patients admitted to our ICU from November 2013 to April 2014. For every ventilated patient, a similar non-ventilated patient served as a control. Data obtained included the socio-demographical characteristics of the patients, indications for mechanical ventilation, duration of ventilation and weaning off ventilator. Other data obtained were interventions employed in the ICU like blood transfusions and ionotropic therapy including their association with weaning off the ventilator.

Data collected were entered into a proforma and analyzed using SPSS version 16.0. Parametric data were analyzed with student's t-test

and categorical data were analyzed with chi-square and Fischers' exact test. The odd ratio (OR) was calculated with a 95% confidence interval. P value <0.05 was set for statistical significance.

Results

A total of 128 patients were admitted to the ICU over the six month period and 44 patients constituting 34.4% were mechanically ventilated. The mean age of patients ventilated during this period was 37.7 ± 21.10 years with a male to female ratio of 1:1.2 (Table 1).

Age (years)		Frequency	Percentage
	10-Jan	4	9.1
	20-Nov	2	4.5
	21-30	16	36.4
	31-40	8	18.2
	41-50	2	4.5
	51-60	4	9.1
	>60	8	18.2
Total		44	100
Sex			
	Male	20	45.5
	Female	24	54.5

Table 1: Socio-demographics.

Respiratory distress and airway protection were the major indications for mechanical ventilation in this study representing 38.6% and 27.3% respectively. Other indications included deteriorating Glasgow coma score (GCS) and hyperventilation, 20.5% and 13.6% respectively (Table 2).

Indications	Frequency	Percentage
Respiratory distress	17	38.6
Airway protection	12	27.3
Hyperventilation	6	13.6
Deteriorating GCS	9	20.5
Total	44	100

Table 2: Indications for mechanical ventilation.

Patients were ventilated for variable number of days ranging from 1-36 days. The mean duration of ventilation was 12.30 ± 10.10 days with most patients being ventilated for 1-7 days (38.6%) (Table 3).

The duration of mechanical ventilation had a significant effect on weaning (p=0.005).

Thirty patients representing 68.2% were successfully weaned off the ventilator while the rest of the patients were ventilator-dependent for the period of the study (Figure 1 and Table 4).

Duration (days)	Frequency	Percentage
7-Jan	17	38.6
14-Aug	14	31.8
15-21	5	11.4
22-29	2	4.5
≥ 30	6	13.6
Total	44	100
Mean=12.30 ± 10.10		

Table 3: Duration of ventilation.

Figure 1: Weaning from ventilation, (Blue=Yes, Red=No).

Duration of ventilation	Successful weaning	Total
<7days (17)	Yes (30)	47
>7days (27)	N0 (14)	41
Total (44)	44	88

Table 4: Duration of ventilation *vs.* Successful weaning.

Figure 2 shows that synchronized intermittent mandatory ventilation (SIMV) was the more preferred mode of ventilation in the ICU (52.3%).

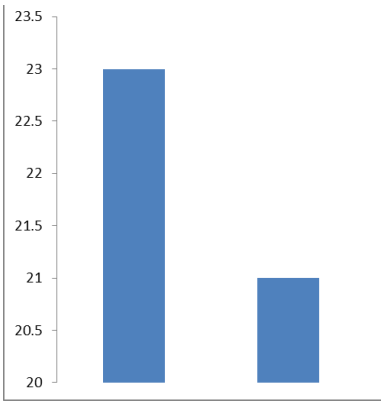

Figure 2: Mode of ventilation, (SIMV *vs.* A/C).

Assist control mode (A/C) was employed in 47.7% of patients in the units. The mode of ventilation of patients in the ICU did not have any effect on successful weaning or outcome, (p value=0.126, 0.280).

Most of the patients in the ICU were on one form of interventions or the other ranging from renal replacement therapy and ionotropic support. There was also an additional requirement for blood transfusion for others. The need for ionotropic support had a significant impact on successful weaning, with those needing ionotropic support being about 5 times less likely to be weaned off ventilator compared with those not on ionotropes (p<0.001, OR=5.1099, 95% CI=2.0639 to 12.6512).

Arterial blood gas measurement was done for 21 patients among those who were ventilated comprising of 47.7%. However, ABG sampling did not have any significant impact on success of weaning or the patients' outcome (p value=0.132). Of the total number of patients who had endotrachael intubation, only 25% had tracheostomy (11 patients). Tracheostomy (TT) had a significant effect on successful weaning as patients on TT had >6 times chance of being successfully weaned off ventilator (p<0.0001, OR=6.4286, 95% CI=2.532 to 16. 3213).

Patients who were mechanically ventilated in the ICU had >4 times risk of mortality compared with non-ventilated patients. P value 0.002, OR=4.08, 95% CI=1.6234 to 10.254. The overall mortality of patients admitted in the ICU during this 6 month period was 63.6%.

Discussion

Despite the fact that mechanical ventilation is one of the commonest indications for ICU admission, less than half (34.4%) of our patients in this study received ventilatory support. A similar multi-centre study done in the Scandinavian region reported a 47% rate for ventilating patients which is higher than in our study [5]. Our rate of 34.4% is also far lower than that reported by Kubler et al. [6] in a multi-centre prevalence study in Poland where >70% of their patients were mechanically ventilated. This low ventilatory rate in our ICU could be due to inadequate availability of ventilators per time in the unit. In addition, most of the ventilators are not versatile with any provision for paediatric patients who might have needed ventilatory support. The provision of more ventilators with capacity for ventilating all age groups of patients is highly advocated.

Indications for mechanical ventilation in the Intensive Care Unit (ICU) are varied. In our study, we observed that respiratory distress and airway protection were the major indications for mechanical ventilation. It is common practice to institute mechanical ventilation when a patient cannot maintain an airway or maintain adequate oxygenation or ventilation. The following parameters qualify for ventilatory assistance, respiratory rate (RR) >30/min, inability to maintain arterial O_2 saturation >90% with fractional inspired O_2 (FiO_2)>0.60, and $PaCO_2$>50 mmHg with pH<7.25 [7]. Early institution of mechanical ventilation in patients in respiratory distress will prevent morbidity and mortality. The saying "delay is dangerous" is sacrosanct in this regard.

Weaning off mechanical ventilation is the process of discontinuing a patient from ventilatory support. The decision to wean a patient off the ventilator is influenced by the clinical judgment of the attending clinician [8]. In this study, 68.2% of our patients were successfully weaned off ventilator. Chao and Scheinhorn reported that up to 20% of mechanically ventilated patients in the ICU exhibited difficulty with weaning off the ventilator repeatedly [9]. Our observation revealed even a higher failure rate of weaning. This is associated with a longer duration of ventilation with its associated sequaele. There is however some factors that determining successful weaning. We found out that the duration of mechanical ventilation had a significant effect on weaning. The longer the duration of ventilating a patient in the ICU, the less likely the weaning off process. This finding should however be interpreted with caution. This is because; it is not clear whether duration of ventilation per se led to difficulty with weaning or failure of judgment to wean led to longer duration of ventilation. Blackwood and colleague had concluded earlier that implementation of standardized weaning protocol in the ICU resulted in reduction of duration of mechanical ventilation [10]. It is expedient therefore that implementation of protocol for weaning ventilated patients off the ventilator should be complied with at all times.

Furthermore, the need for ionotropic support among ventilated patients was associated with a reduced likelihood of successful weaning off ventilator. Sudarsanam and co-workers [11] reported that one of the predictors of mortality in mechanically ventilated patients was the use of ionotropes. The reason for this finding may be due to the interplay which exists between the cardiovascular and respiratory systems. Adequate gas exchange and ventilation requires an optimal cardiovascular system. When the heart becomes dysfunctional thus requiring ionotropic support, spontaneous ventilation becomes compromised and inadequate. It can be extrapolated therefore that early successful withdrawal of ionotropic support following improved cardiac function will have attendant positive effects and related to successful weaning off ventilatory support and eventual outcome.

Patients were commenced on mechanical ventilation using either synchronized intermittent mandatory ventilation (SIMV) or assist control ventilation (A/C) although a slightly higher numbers of our patients were placed on the SIMV mode of ventilation, this did not affect weaning or eventual outcome. In SIMV, ventilator breaths are synchronized with patient inspiratory effort and has been described as the most effective and efficient mode of ventilation especially in the ICU [12]. On the other hand, CMV has been associated with profound diaphragm muscle dysfunction and atrophy and thus it is no longer the preferred mode of mechanical ventilation [13]. Patients requiring mechanical ventilation in the ICU are often commenced on SIMV except in cases of neuromuscular diseases and post cardiac arrest state. This will encourage use of patients' respiratory muscles and facilitate early weaning.

Only 25% of our ventilated patients had open tracheostomy after variable duration of endotracheal intubation. Previously, it was suggested that after one week of intubation, if extubation does not appear likely within a week, tracheostomy should be performed [14]. The TracMan trial [15] classified tracheostomy into early tracheostomy, within four days and late tracheostomy, after 10 days of intubation and found no difference in the primary outcome (30-day mortality) or other secondary outcomes. Tracheostomy allows for easier tracheo-bronchial toileting and early weaning of patients on mechanical ventilators. Refusal of patients' relative to give consent and the reluctance of some clinicians regarding tracheostomy may account for the low rate of tracheostomy in this study. Education of clinicians and patients' relatives on the advantages of tracheostomy especially in patients needing prolonged airway protection and/or mechanical ventilator is hereby advocated. Although percutaneous tracheostomy has been found to be better than open tracheostomy [16] lack of equipment and trained personnel makes this difficult in our center.

Lastly, this study revealed that although mechanical ventilation is a useful intervention in the ICU, it increased the risk of mortality. Patients on mechanical ventilator had more than four times risk of mortality compared to non-ventilated patients in the ICU. As a result of this finding, the indication for ventilation and its goal must be established before instituting ventilatory support. Also, the risk: benefit assessment of mechanical ventilation must be performed for all patients requiring ventilator assistance.

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