Analysis of outcomes of critically ill children mechanically ventilated in a Nigerian Intensive Care Unit (ICU)

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Abstract

Background: The number of critically ill paediatric patients requiring ICU admission with mechanical ventilation is increasing. The aim of the study was to evaluate the outcomes of critically ill paediatric patients requiring mechanical ventilation in an Intensive Care Unit (ICU).
Methodology: This was a prospective study of all critically ill paediatric patients managed in ICU during the study period. The demographics, indications for admission, diagnosis, type of airway/ventilatory supports, ICU complications, and outcome were reviewed.
Results: There were eighteen patients with mean age of 8.4±0.54 years. Five (27.8%) had traumatic brain injury and the indication for admission was respiratory failure in 6(33.3%). The median(range) days spent on endotracheal intubation, mechanical ventilation and ICU stay was 3(1-12), 3(1-6) and 8(1-14) respectively. Fourteen (77.8%) patients had a total of 30 complications. The ten patients (55.5%) who died were mechanically ventilated while of the eight patients that survived, six (33.3%) and one (11.1%) patient each had mechanical ventilation, oxygen insufflation and endotracheal intubation only respectively. Mortality following complication was most significant for pulmonary oedema 0(0%) (P=0.001).
Conclusion: The study shows a high rate of morbidity and mortality amongst ventilated paediatric patients especially among those with traumatic brain injury.

Analyse des résultats des enfants gravement malades ventilés mécaniquement dans une unité de soins intensifs (USI) nigériane

Résumé
Contexte de l'étude: Le nombre de patients pédiatriques gravement malades nécessitant une admission en soins intensifs avec ventilation mécanique augmente. Le but de l'étude était d'évaluer les résultats de patients pédiatriques gravement malades nécessitant une ventilation mécanique dans une unité de soins intensifs (USI).
Méthode de l'étude: Il s'agissait d'une étude prospective portant sur tous les patients pédiatriques gravement malades pris en charge en soins intensifs pendant la période d'étude. Les données démographiques, les indications d'admission, le diagnostic, le type d'assistance respiratoire/ventilatoire, les complications en soins intensifs et les résultats ont été examinés.
Résultat de l'étude: Il s'agissait de dix-huit patients d'âge moyen de 8,4 ± 0,54 ans. Cinq (27,8 %) avaient un traumatisme crânien et l'indication d'admission était une insuffisance respiratoire chez 6 (33,3 %). La durée médiane (intervalle) des jours consacrés à l'intubation endotrachéale, à la ventilation mécanique et au séjour en soins intensifs était respectivement de 3 (1-12), 3 (1-6) et 8 (1-14). Quatorze (77,8 %) patients ont présenté un total de 30 complications. Les dix patients (55,5 %) décédés étaient sous ventilation mécanique tandis que parmi les huit patients qui ont survécu, six (33,3 %) et un (11,1 %) patients avaient chacun respectivement une ventilation mécanique, une insufflation d'oxygène et une intubation endotrachéale. La mortalité suite à une complication était la plus significative pour l'œdème pulmonaire 0 (0 %) (P = 0,001).
Conclusion: L'étude montre un taux élevé de morbidité et de mortalité chez les patients pédiatriques ventilés, en particulier chez ceux présentant un traumatisme crânien.

INTRODUCTION

Mechanical ventilation is a method of artificially assisting or replacing spontaneous breathing and this respiratory and airway support forms an important part of management of the critically ill post-operative patient. Although previously believed to be expensive and labour intensive, recent advances and newer modes have made it easy and simple to use as well as applicable to paediatric patients (1).Thus the percentage of children receiving mechanical ventilation in the Intensive Care Unit (ICU) is gradually increasing coupled with advances in surgery and anaesthesia which has allowed adequate perioperative care for paediatric patients coming for complex and delicate procedures (2-4). Despite this increase in number of children undergoing ICU care and mechanical ventilation, there is a scarcity of ventilators and manpower especially in developing countries (5). Mechanical ventilation prevents respiratory failure while the patient recovers from the primary pathology which may or may not be complicated by hypoxia and haemodynamic instability (6-8). Intubation and commencement of mechanical ventilation carries its attendant risk with associated morbidity and mortality (9).

In previous studies done in our centre, the outcome of admissions into the Intensive Care Unit regarding paediatric, obstetric, and neurosurgical patients was previously described however the outcomes in intubated and ventilated pediatric patients is yet to be fully described (10-13). There are anatomical and physiological differences in the paediatric airway compared to the adult airway. This peculiarities are well known to increase the incidence of airway related complications both in the preoperative setting as well as the ICU (14). Endotracheal intubation in the ICU is associated with a high incidence of complications, ranging from 28-54% (15) in adults and as high as 61% in the paediatric patients (16,17). The aim of this study therefore was to determine the characteristics and outcomes of mechanically ventilated paediatric patients in our ICU. We also sought to identify complications associated with mechanical ventilation in paediatric patients and the association of these complications with clinical outcomes.

MATERIALS AND METHODS

Study Design

This was a retrospective observational study conducted in a 4-bedded ICU between 1st August 2018 and 31st July2019. A structured questionnaire was filled for each child (medical and surgical) admitted into the ICU and requiring endotracheal intubation for airway management and or respiratory support.

Study Site

This study was carried out at the ICU of the University of Ilorin Teaching Hospital Ilorin , Kwara State Nigeria and this ICU has three functional ventilators each connected to piped gas supply. The ventilators can deliver several modes including Synchronised Intermittent Mandatory Ventilation (SIMV), Intermittent Positive Pressure Ventilation (IPPV), Continous Positive Airway Pressure (CPAP), and Bilevel Positive Airway Pressure (BIPAP). Admission into the ICU was based on the decision of the attending intensivist and not influenced by the researcher. Inclusion criteria were all paediatric patients requiring endotracheal intubation, noninvasive or invasive mechanical ventilation. The ICU is an open one hence all patients were co-managed by the attending anaesthetist and the primary managing physician. Whenever the need arose, opinion of other clinical subspecialties was sort in the management of patients. The mode of ventilation employed was based on patient's clinical state and was determined primarily by the attending anaesthetist in accordance with international guidelines. As at the time of this study, the ICU had no protocol for initiation of or weaning from mechanical ventilation and it was left at the discretion of the attending anaesthetist. Data collected included demographics, indications for admission, working diagnosis, managing unit, type of airway/ventilatory supports, complications developed while in ICU, number of days on Endotracheal tube (ETT), Mechanical Ventilation (MV), duration of ICU admission, frequency of intubations, and outcome.

Ethical Consideration

Ethical approval was **o**btained from the institution Ethical Review Committee of the University of Ilorin Teaching Hospital who approved the release of hospital records of the patients used in this study.

Data Analysis.

Data was analyzed using the Statistical Package for Social Sciences SPSS software version 20.0 (SPSS Software IBM Corp., Armonk, NY, USA). Nominal data were presented as percentages and proportions and analyzed using Chi square test or Fischer's exact

test as appropriate. Ordinal variables were presented in median and range. Logistic regression analysis was used to identify factors affecting outcome. The level of significance was set at $P<0.05$.

RESULTS

A total of 18 children were admitted into the ICU during the period under review comprising 8 (44.4%) females and 10(55.6%) males. The mean age of patients was 8.4±0.54 years, range 1-16years. The diagnosis on admission included traumatic brain injury 5(27.8%), airway obstruction 3(16.7%), peritonitis 4(22.2%), aspiration pneumonitis 2 (11.1%), brain lesion 1(5.6) and burns 1(5.6%) as shown in Table 1. The commonest indication for endotracheal intubation was respiratory failure in 6(33.3%) of patients. Other indications are shown in table 1. The commonest airway/respiratory support provided was endotracheal intubation/mechanical ventilation in 16(88.8%) patients as shown in table 1 while one patient (5.6%) each had oxygen insufflation and only endotracheal intubation without ventilation. The median (range) days spent on endotracheal intubation was 3(1-12), while the median (range) days spent on mechanical ventilation was 3(1-6) and the median (range) duration of ICU stay was 8(1-14). A total of 30 complications were recorded including tubal blockage in 14(77.8%), pulmonary oedema 7(38.9%), Hypoxia 4(22.2%), Hypotension 3(16.7%) and aspiration pneumonitis 2(11.1%) of patients as shown in table 2. The complications were recorded in 14 patients giving an overall complication rate of 77.8% with about ten patients having more than one complication. Of the fourteen (14) patients that had tubal blockade, seven (7) each had complete and partial blockade. Also, of the fourteen patients, 6 required re-intubation, 1 required tracheostomy and 7 required serial suctioning. The mean number of times of endotracheal intubation was 5.5 with a median (range) of 2(1-14) attempts. Two patients had their endotracheal tubes changed once, four patients had their endotracheal tube changed twice while one patient each had their endotracheal tubes changed twelve (12) and 14 (fourteen) times. The details of the endotracheal intubation frequency are on table 3. A total of 10 patients died giving an overall mortality rate of 55.5%. The type of airway/respiratory support the patients received had no significant influence on the eventual patient outcome (P=0.086). The ten patients (55.5%) who died were mechanically ventilated while of the eight patients that survived, six (33.3%) patients and one (11.1%) patient each had mechanical ventilation, oxygen insufflation and endotracheal intubation only respectively as shown in table 1. Mortality was higher in patients who were admitted due to traumatic brain injury occurring in four (4) patients representing 80% of patients with traumatic brain injury p=0.01 as shown in table 4. Mortality following each complication was 7 (50%) for tube blockage (P=0.969), pulmonary oedema 7(100%) (P=0.001), aspiration pneumonia 1(50%) (P=0.976), hypotension 1 (33.3%) (P=0.468), and hypoxia 2 (50%) (P=0.969). This is shown in table 2 below.

DISCUSSION

There is still a paucity of data on paediatric mechanical ventilation in the sub region owing to several factors including lack of available manpower and training, scarcity of paediatric friendly ventilators and availability of oxygen. Despite all these, the study still showed the increasing trend towards ICU admission in paediatric patients as also noted by Abiodun *et al* (18) thus making a case for a strictly paediatric ICU. There were slightly more male patients in our study compared to females and this appears to be a general trend as seen by Mehretie *et al* (19), Bacha *et al* (20) and Zhang *et al* (21). The mean age for the subjects in this study was slightly higher than that of Mukhtar *et al* (22) and Mehretie *et al* (19). This age difference between the results from different researchers may result from demographic differences and also from differential burden of particular diseases in specific geographical areas. This is reflected in the finding that trauma related cases had the highest number of admitting diagnosis followed by respiratory related problems. This agrees with the findings of Mukhtar *et al* (22) and Hague *et al* (23) but not with Abebe *et al* (24) while Bacha *et al* (20) found more of respiratory related illnesses followed by neurological cases. It is not surprising to see trauma/neurological illness and respiratory being high on top of the list as these studies were done in developing countries where there is a high rate of domestic and motor vehicular accidents caused by bad roads, environmental and human factors coupled with poor prehospital care. Also, the peculiar nature of the paediatric airway predisposes them to foreign body aspiration and other airway related problems including infections of various aetiologies.

The commonest indication for ICU admission in this study was respiratory failure (33%) and decreasing level of consciousness

(33%) which agrees with the findings of Mehretie *et a* (19) although with higher values. Common indications for mechanical ventilation include respiratory failure of various aetiologies, decreasing level of consciousness and as part of post cardiac arrest care etc. (25,26).

The percentage of children who were intubated and mechanically ventilated in this study were about 89% which is very high when compared to other studies 10% (247), 32.8% (28), 37% (24), 41% (20) all done in Africa and 34.6% (29) and 50.7% (22) in Europe and Asia respectively. The reason for this could be due to the different states of the patient at admission. In addition to intubation and mechanical ventilation, there are other means of providing oxygen therapy in the ICU and the choice of each is dependent on several factors, including the type of ICU ventilator and modes available, skill and preference of the physician, pathology of the patient and degree of respiratory support required.

As the degree of dependence of the respiratory system to the external support increases, the choice of oxygen supplementation moves from non-invasive to invasive (26,30). Nasal cannula allows oxygen therapy while allowing patient's use of mouth to talk and eat and is not claustrophobic. The facemask which though can deliver higher and variable fiO_2 than the nasal cannula, is claustrophobic and does not have these advantages of nasal cannula (29). A reservoir bag allows administration of more than 90% oxygen by reducing the amount of entrained air, CPAP and BiPAP also allows positive pressure to be delivered to the airway during respiratory support while ventilators connected to a patient, either via tracheostomy or endotracheal tube allows more controlled oxygen therapy with endotracheal tubes having the advantage of protecting the airway from aspiration (29). Studies show that the commonest mode of ventilation was SIMV while CPAP was the commonest weaning mode employed (19-21). This could be because SIMV breaths are synchronized with the patient's respiratory effort thus is easily tolerable and doesn't require heavy sedation and paralysis. In fact, it has been shown to allow the patient to "exercise" their respiratory muscles while on the ventilator by allowing spontaneous breaths and less ventilator support thus aiding weaning (25). The median (range) number of intubation attempts in our study 2(1-14) showed that some patients were intubated more than 10 times over their duration of stay in the ICU. This figure could not be compared to other studies cited in this article. Despite it looking rather high, the reason was because the narrowed airway of the paediatric patient predisposes to tubal blockade easily necessitating extubation and re-intubation. Also, there is no policy in our centre on when tracheostomy is indicated and the Ear Nose and Throat (ENT) surgeons in our centre have a policy of avoiding tracheostomy in paediatric patients at all cost except when it's no longer feasible due to morbidity associated with paediatric tracheostomy especially difficult decannulation (31). In addition, non-availability of appropriately sized tubes sometimes in our centre results in intubation with inappropriate sized tubes thus predisposing to blockade. The commonest complication in our study was tubal blockade. Other studies noted other complications like Acute Respiratory Distress Syndrome (ARDS) (19), Multi Organ Dysfunction Syndrome (MODS) (20), lobar atelectasis (22). Other complications include pulmonary oedema, aspiration pneumonitis, hypotension and hypoxia. The overall complication rate in our study (77%) is higher compared to Mukhtar *et al* (22) (9.4%), Bacha *et al* (20) (27.3%). This could be due to patient and logistic factors. From our study, pulmonary oedema carried the greatest association with mortality ($p<0.0001$). Other predictors of mortality in the paediatric ICU patient include Malnutrition (19), MODS and comorbidities (20), prolonged duration of mechanical ventilation >10days and cardiogenic shock (21), while Zhang *et al* (20) found that tracheostomy was associated with improved survival in ventilated patients. The median days spent on mechanical ventilation was 3(1-6) when compared to 4.4(1-90) days seen by Bacha *et al* (20). Prolonged duration on mechanical ventilation was found to be associated with increased mortality (20,22) possibly due to increased likelihood to develop complications of mechanical ventilation. Also, the median duration of ICU stay was 8(1-14) while Mehretie *et al* (19) found that duration of ICU stay of 8 or more days was associated with improved survival this may be because their study showed a lot of mortality within 24 hours of admission. We have several challenges in our patient care pathway such as a dearth of specialized manpower, logistic challenges, delayed presentation by patients for care etc. To improve the outcome of ICU admission in children in our environment, effective, organized, protocol driven management incorporating a wholistic

multidisciplinary team approach is needed to ensure good outcome. In addition, proper use of tracheostomy is advocated and when this is properly in place, our complications and mortality rate will also decrease.

CONCLUSION

Traumatic brain injury is the commonest indication for ICU admission in our environment. The mortality rate is high in children admitted into ICU who develop pulmonary oedema following mechanical ventilation. Proper attention to details, protocol-based care based on best available international best practices as well a team approach will be needed to ensure good outcome.

Limitations: The limitations of this study were a small sample size, lack of use of Arterial Blood Gases (ABG) among our patients to evaluate effectiveness of our MV. In addition, non-availability of a dedicated ICU laboratory is a major constraint faced in the management of these patients. Also Acute Physiological and Chronic Health Evaluation (APACHE) and risk scoring was not done for our patients to determine the degree of severity of the illness.

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Table 1: showing the diagnosis at ICU admission, indications for admission and types of airway support offered and their respective outcomes.

		Frequency	Percentage %
Diagnosis	Traumatic Brain Injury	5	27.8
	Peritonitis/Intestinal Obstruction/Enterocutaneous Fistula	4	22.2
	Airway Obstruction/Foreign Body Aspiration	3	16.7
	Aspiration Pneumonitis/Embolism/Pulmonary Oedema	2	11.1
	Brain Lesion/Tumour	1	5.6
	Burns	1	5.6
	Others	2	11.1
	Total	18	100.0
Indications for admission	Respiratory failure	6	33.3
	Decreasing level of consciousness	6	33.3
	Perioperative complication	5	27.7
	Post cardiac arrest	1	5.7
	Total	18	100
Type of Airway support offered (mortality)	Endotracheal intubation + Mechanical ventilation	16(10)	88.8(100)
	Endotracheal intubation	1(0)	5.6(0)
	Oxygen insufflations	1(0)	5.6(0)
	Total	18(10)	100(100)

Table 2: showing complication rate

Complications	Number (percentage)
Tubal blockade	14(77.8%)
Pulmonary oedema	7(38.9%)
Hypoxia	4(22.2%)
Hypotension	3(16.7%)
Aspiration pneumonitis	2(11.1%)

Table 3: showing the number of times intubation was done.

Number of times intubation was done.	Number of patients
1	2
2	4
3	2
4	2
6	1
7	1
8	2
10	2
12	1
14	1
Total	18

Mean intubation times 5.5, median (range) intubation attempt 2(1-14)

Table 4: showing the outcomes and their respective diagnosis.

Diagnosis	Outcomes		Total	P value
	Survived	Died		
Airway obstruction/FBA	1	2	3	0.67
Pneumonitis/embolism/pulmonary oedema	1	1	2	1.0
Brain lesion/tumour	1	0	1	0.42
Others	1	1	2	1.0
Peritonitis/intestinal obstruction/enterocutaneous fistula/sepsis	3	1	4	0.047
Severe burns/electric shock	0	1	1	0.42
TBI	1	4	5	0.01
Total	**8**	**10**	**18**	

FBA-Foreign body aspiration TBI –Traumatic brain injury

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