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Outcome of mechanical ventilator use and associated factors at Saint Paul's Hospital Millennium Medical College Medical Intensive Care Unit

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Abstract

Background: Mechanical ventilation is among the most commonly used therapeutic option in Intensive Care Units (ICU) as bridge therapy to give time until the underlying medical condition is treated. However, its outcome has not been extensively studied in Ethiopia.

Methods: Retrospective cross-sectional study was conducted to assess the outcome and associated factors of mechanical ventilator use among patients admitted at St. Paul's hospital millennium medical college medical intensive care unit (ICU) from June 2013 to June 2018. Pre-tested check list was used to collect data from patients' charts. Descriptive and logistic regression analysis was performed to describe and assess association between dependent and explanatory variables with a statistically significant association at $P < 0.05$.

Results: Only six hundred one (43.1%) of the 1395 admitted patients were intubated and mechanically ventilated. Two hundred forty-seven (41.1%) of ventilated patients' record was analyzed, of which one hundred forty-nine (60.3%) were women and mean age of 36.96 years. The overall mortality was 57.1% among mechanically ventilated patients. Forty-six percent of mechanically ventilated patients developed ventilator associated pneumonia. While fourteen percent of patients were having prolonged mechanical ventilation, tracheostomy use was only 2.4%.

Conclusion: The overall mechanical ventilator use related mortality was high. Patients who had co-morbidities, requiring dialysis, and duration of ventilation were significantly associated with mechanical ventilator use related mortality. Measures should be taken in high risk patients to decrease ventilator use related mortality and tracheostomy practice should be improved according to the indications.

Keywords: Ethiopia, Mechanical ventilator, Outcome, Pneumonia, Tracheotomy

Background

Mechanical ventilation is instrumental in the rescue and maintenance of the patient with failing cardio-respiratory function till underlying condition is treated.[1] Soon after, the modern concept of intensive care unit (ICU) has been innovated by an anesthetist in Denmark over half a century ago during the polio pandemic; The use of positive pressure ventilation outside the operating room was famously precipitated by an epidemic of poliomyelitis in Copenhagen in 1951.[2] Since then, systematically applying positive-pressure ventilation for patients dying of poliomyelitis produced dramatic and immediate improvements in survival leading to the global adoption of positive-pressure ventilation to manage acute respiratory failure and revolutionizing clinical medicine.[3]

As it was studied in different countries, the indications for mechanical ventilation are acute respiratory failure, coma, acute exacerbation of chronic obstructive pulmonary disease, and neuromuscular disorders, respectively based on prevalence. [4] Currently, a new form of non-invasive support based on the continuous nasal delivery of a high flow of heated and humidified gas offers an attractive alternative. In randomized trial in hypoxemic patients mostly with pneumonia, oxygen delivered by high-flow nasal cannula (HFNC) reduced mortality compared with noninvasive ventilation or conventional oxygen therapy in the whole cohort, and reduced the need for intubation in the subgroup of patients with a ratio of arterial oxygen partial pressure to fractional inspired oxygen (PaO2/FiO2) less than 200 mmHg. [2, 5]

Mechanical ventilation use is common and accounts for a disproportionate amount of resource use, particularly in urban hospitals and in elderly patients. Mortality for mechanically ventilated patients is high in developing countries. Quality improvement and cost reduction strategies targeted at these patients are warranted. [6]

Mechanical ventilation is an important organ support therapy given to the critically ill patient. The goal of ventilation therapy is to lessen the work of respiration and improve pulmonary gas exchange and thereby maintain or restore an adequate oxygen supply to the tissues. Mechanical ventilation can cause substantial and often lifelong cognitive, physical and behavioral impairments that require long-term access to healthcare services if inappropriately used. However, predicting the healthcare service utilization and mortality rate associated with Invasive mechanical ventilation (IMV) is difficult because of its widely varying rate and extent of recovery especially in developing country. [7]

New modes of mechanical ventilation are often introduced recently including home mechanical ventilators especially noninvasive. Yet each new mode involves nothing more than a modification of the manner in which positive pressure is delivered to the airway and of the interplay between mechanical assistance and the patient's respiratory effort. The purpose of a new mode of ventilation may be to enhance respiratory-muscle rest, prevent deconditioning, improve gas exchange, prevent lung damage, enhance the coordination between ventilatory assistance and the patient's respiratory efforts, and foster lung healing. This is at expense of extra resource demand and need of different field of trained health professionals. [8] Mechanical ventilation can have life-threatening complications; it should be discontinued at the earliest possible time. Weaning is one of the most challenging problems in intensive care and it accounts for a considerable proportion of the workload of staff in an ICU and use of both invasive and noninvasive assessment tools for possible weaning predictors. Even though these tools are not available in most developing countries, they have significantly reduced related complications including mortality by avoiding use of only expert opinion. [9]

Major advances have been made in our understanding of the pathophysiologic abnormalities present at different stages of acute respiratory distress syndrome (ARDS) which is common cause of respiratory failure and indication for intubation so far. [10] There is evidence for the benefits of using high Positive end expiratory pressure (PEEP) but also understand that it needs to be based on a more individualized response. Spontaneous breathing may need to be avoided at an early and severe stage, while it may be favored cautiously in milder and later stages of Acute respiratory Distress Syndrome (ARDS) . New monitoring tools, including esophageal pressure measurements may considerably help in this regard. [11] The significance of this study is understanding the outcomes of mechanical ventilator use and associated factors will help critical care physicians and managers better understand and improve mechanical ventilator use.

Methods

Study design and setting

Cross-sectional design was conducted from June 2013 to June 2018to assess outcome and its associated factors among admitted patients in medical intensive care unit using mechanical ventilator at Saint Paul's Hospital Millennium Medical College (SPMMC), Addis Ababa, Ethiopia.

Sample size determination

All patients admitted to medical ICU were study population. Using single proportion formula, prevalence of mechanical ventilator outcome in central Africa was 77% and 5% margin of error was used with 95% confidence interval; the total sample size included in the study was 247.

Inclusion and exclusion criteria

Inclusion criteria

All adult patients who were admitted in the medical ICU for the past five years and whose age is greater than 18.

Exclusion criteria

Patients who stay for less than 6 hours after intubation, patients with incomplete chart record, patients who were ventilated for surgical or gynecologic/obstetric indications or for post anesthetic complications

Data entry and analysis

The collected data were coded and entered in to the computer, using Epi-info and SPSS version 20 statistical package; univariate, bivariate and multivariable analysis were done for association. The result was described using frequency tables in numbers, percentage, and summarized using tabular presentation. Odds ratio (OR) and confidence interval (CI) were used to assess the presence and degree of association between dependent and independent variables. P-value of < 0.05 were set for the significance of associations.

Ethical clearance

Ethical clearance for the study was obtained from the Institutional Review Board (IRB) of SPMMC.

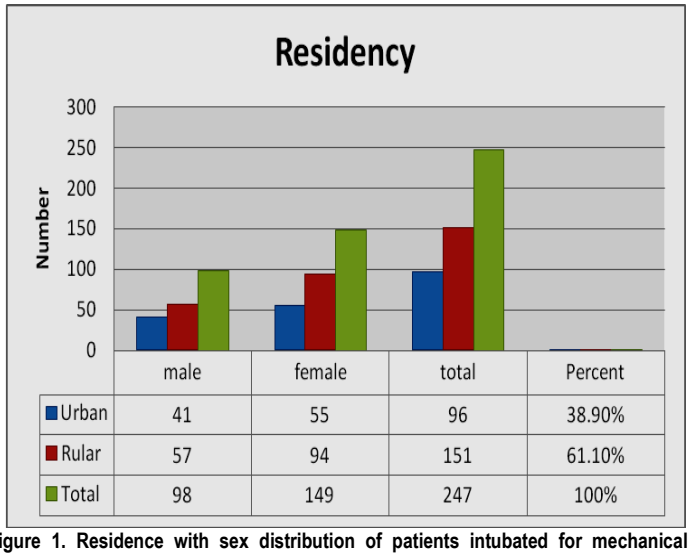
Results

Characteristics of the study participants

A total of one thousand three hundred ninety-five patients were admitted to SPHMMC medical intensive care unit from June 20, 2013 to June 20, 2018; of which six hundred one (43.1%) patients were intubated for mechanical ventilation. Of patients who require mechanical ventilation, two hundred twenty-three (37.1%) patients were admitted for mechanical ventilation from surgical and gynecology/obstetric departments for main post-surgical and anesthesia indications. Among mechanically ventilated patients; forty-one percent (41.1%) of study participants fulfill the inclusion criteria and entered for analysis.

Demographic characteristics

Of the total 247 case notes of patients available for review, one hundred forty-nine patients (60.3%) were women making the female to male ratio 1.5 to 1. The Patients age were ranged from 18 to 95 with mean age of 36.96 years (±16.945). Majority of patients were from 25-54 years accounting 62%. Majority are from rural residence (61%) (Figure1).



	male	female	total	Percent
Urban	41	55	96	38.90%
Rular	57	94	151	61.10%
Total	98	149	247	100%

Figure 1. Residence with sex distribution of patients intubated for mechanical ventilation at SPHMMC medical ICU; Addis Ababa, Ethiopia from June 20, 2013 to June 20, 2018

Characteristics of patients during the whole ventilation period

Co-morbidities were identified in 65.2% of patients intubated for mechanical ventilation; of which acute renal failure accounts 28.3%. Among patients who had either acute or chronic renal failure as comorbidity; 63.0 % of them require dialysis (Figure 2).

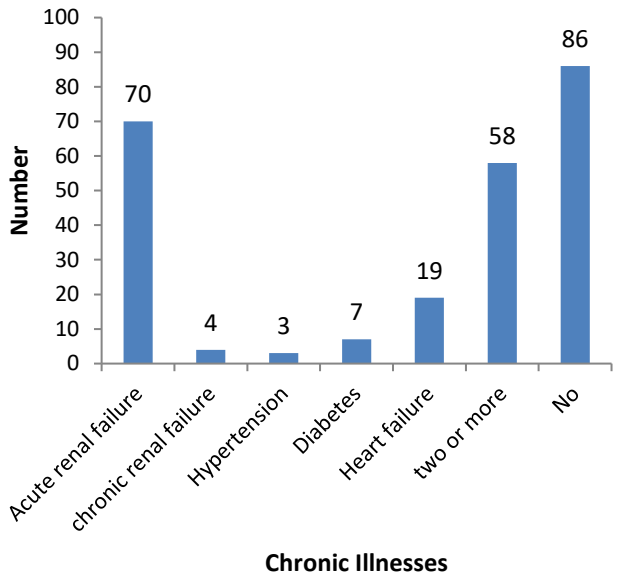


Figure 2. Chronic illnesses from patients intubated for mechanical ventilation at SPHMMC medical ICU, Addis Ababa, Ethiopia from June 20, 2013 to June 20, 2018

Ventilator associated pneumonia were diagnosed as commonest complication of mechanically ventilated patients seen in 46% of medical patients followed by barotrauma (3.0%). Most of the patients (91.5%) were put on assist control (AC) as initial mode of ventilation while the remaining 8.5% of patients were started mechanical ventilation with SIMV mode. SIMV use as initial mode was significantly decreased since last three years as initial mode of mechanical ventilation.

Type I respiratory failure was the commonest indication for mechanical ventilation seen in 97.2% of patients (Pneumonia (48.4%), ARDS (32.1%) and Septic shock (16.7%)) and the remaining 2.8% were Type II respiratory failure.

From all medical patients intubated for mechanical ventilation, 73.3% of patients had at least one electrolyte abnormality during the whole course of ventilation. Hypokalemia was frequently identified electrolyte abnormality (28.2%). One hundred ninety-eight (80.2%) patients developed at least mild anemia during the course of ventilation.

Vital sign at base line

Most patients were tachycardia and tachypneic at the start of mechanical ventilation.

Outcome and other related conditions

From the total 247 participants, one hundred forty-one (57.1%) died during mechanical ventilation period and others were transferred to wards and discharged home except one patient died after transfer to wards with the diagnosis of massive pulmonary thromboembolism (Table 1). Shock with multi-organ failure was the most common cause of death accounting 44%. Tracheostomy use was only in 6(2.4%) of patients even though 14.2% of patients were having prolonged mechanical ventilation. The mean duration of ventilation by mechanical ventilator was 8.04 days with maximum of 38 days. Forty percent of the patients need at least one week to be off mechanical ventilator use. Most patients' presentation (92%) was within one week of start of illness. Majority of admitted patients stayed in the hospital for less than one week before mechanical ventilation. One hundred sixty-six (67.2%) of patients' albumin level was below lower normal range with mean of 2.88 (Table 1).

Table 1. Summary of mechanical ventilation related conditions from patients intubated for mechanical ventilation at SPHMMC medical ICU, Addis Ababa, Ethiopia from June 20, 2013 to June 20, 2018.

Variable	Category	Frequency (Percent)
Outcome	Extubated	106 (42.9)
	Death	141 (57.1)
Cause of death	Shock with multiorgan failure	62 (44.0)
	Respiratory failure	57 (40.4)
	Sudden death	22 (15.6)
Duration of mechanical ventilation	1-2 days	50 (20.2)
	3-7 days	98 (39.7)
	>7 days	99 (40.1)
Hospital stay before intubation	7 or less days	197 (79.8)
	More than 7 days	50 (20.2)
Duration of illness before intubation	<8 days	194 (78.5)
	8-14 days	34 (13.8)
	15-21 days	10 (4.0)
	>21 days	9 (3.6)
Complication of mechanical ventilation	Baro trauma	8 (3.2)
	VAP	113 (45.7)
	NO	126 (51.1)

Bi-variate and multivariable logistic regression analysis result

Binary logistic regression analysis was done to identify factors associated with mechanical ventilator use related mortality for each independent variable.

From patients' sociodemographic characteristics and baseline vital signs, age of the patient, place where they come and their base line blood pressure level were significantly associated with mortality. Those patients who came from outside Addis Ababa were 1.4 times higher mortality than those from Addis Ababa (COR =1.44, 95% CI: 1.04-1.99)). Patients who had comorbidities, those who require dialysis and patients who develop type I respiratory failure were significantly associated with mechanical ventilator use related mortality. Patients who had at least one comorbidity were ten times higher chance of death than those who did not have (COR = 10.43, 95% CI: 1.45-75.10) (Table 2).

Table 2. Binary logistic regression analysis for patient related variables with outcome of mechanical ventilation at SPHMMC medical ICU; Addis Ababa, Ethiopia from June 20, 2013 to June 20, 2018.

Variables	Category	COR (95% CI)
Hemoglobin	>13.5	1.00
	<7	1.25 (0.59-2.67)
	7.1-10	0.94 (0.62-1.42)
	10.1-13.5	1.286 (0.83-2.00)
Electrolyte	Potassium disorders	0.97 (0.61-1.55)
	Sodium disorders	0.78 (0.29-2.09)
	Two or more abnormality	1.42 (0.92-2.15)
	No electrolyte abnormality	1.00
Indication	Type Respiratory failure 2	1.00
	Type Respiratory failure1	1.34 (1.04-1.72)
Comorbidity	No	1.00
	Yes	10.43 (1.45-75.10)
Dialysis	Yes	1.54 (1.16-2.05)
	No	1.00
Albumin	Low	1.26 (0.93-1.71)
	Normal	1.00

COR: Crude odds ratio; CI: confidence interval

The first 48 hours of ventilation time were significantly associated with mortality. In duration of illness before start of mechanical ventilation were also having similar association. The prevalence of prolonged mechanical ventilator was very high and those patients had 1.4 times chance of death (Table 3).

Table 3. Binary logistic regression analysis for mechanical ventilator related variables with outcome of mechanical ventilation at of SPHMMC medical ICU, Addis Ababa, Ethiopia from June 20, 2013 to June 20, 2018

Variables	Category	OR (95% CI)
Duration of ventilation	3-7 days	1.00
	<=2 days	**6.62 (2.19-20.04)**
	More than 7 days	1.39 (0.67-2.91)
Hospital stay before intubation	<7days	1.00
	>7days	1.13 (0.65-1.98)
Duration of illness before intubation	<7days	1.00
	7-14days	1.48 (0.85-2.57)
	15-21days	**2.08 (1.07-4.03)**
	>21days	1.44 (0.79-2.63)
	No	1.00
Complication	Baro trauma	7.00 (0.86-56.90)
	VAP	1.17 (0.810-1.70)
Initial Mode of ventilation	SIMV	1.00
	AC	**3.44 (1.12-10.62)**
Tracheostomy use	No	1.00
	Yes	2.00 (0.37-10.92)

COR: Crude odds ratio; CI: confidence interval

All variables that had association in Univariate analysis were entered into multivariate analysis. Mode and duration of ventilation, requiring dialysis and having co-morbidities were significantly associated with mechanical ventilator related mortality (Table 4). For instance, those patients who require dialysis during the course of mechanical ventilator had 2.3 times chance of failure from extubation than those who did not require dialysis (AOR = 2.31, 95% CI: 1.21-4.41).

Table 4. Result of multivariate logistic regression analysis for patients intubated for mechanical ventilation at SPHMMC medical ICU; Addis Ababa, Ethiopia from June 20, 2013 to June 20, 2018

Variables	Category	AOR (95% CI)
Requiring Dialysis	Yes	2.31 (1.21-4.41)
	No	1.00
Having Comorbidity	Yes	2.01 (1.27-14.37)
	No	1.00
Initial mode of ventilation	AC	3.83 (1.08-13.53)
	SIMV	1.00
Duration of ventilation	3-7 days	1.00
	<=2 days	4.56 (2.21-9.37)
	More than 7 days	1.09 (0.73-1.63)

AOR: Adjusted odds ratio; CI: confidence interval

Discussion

Prevalence of mechanical ventilation among ICU admitted patients were 43.1% which was similar with a study done in Sirilanka (43%), South India (41%), but higher compared to a study done from central Africa which was 23.4%. [12,13,19] The overall mortality rate from patients requiring invasive ventilation support was 57.1%. This rate is similar to that reported in Sirilanka (58%) but lower than a study from central Africa 77%, Nigeria 83.3%, south India 71.5%. [12,13,19] On the other hand, it is significantly higher than even from over all ICU mortality report from US (12.4%) from 2012 report while assessing trends of ICU outcome and southern Brazil mechanical ventilator outcome which was 51% mortality rate.[15, 20] This might be due to difference in study period and population; decrease ICU volume proportion to general ward 25% VS 6.1% in USA and ours respectively which affect outcome negatively.[14] In addition; difference in resource allocation to intensive care and variation in character of ICU admitted patients might contribute for the difference. [20]

The most common indication for mechanical ventilation in this study was type I respiratory failure accounting 97.2% of causes of invasive ventilation. This indication for invasive ventilation is higher than other studies showing 66% which may be due to use of noninvasive ventilation in other areas. In addition, AC as initial mode of ventilation was used in 91.5% which is significantly higher compared to others reported in west China (50%), multi survey (55%) in multi hospital study. [5, 21] However, there was no mortality benefit between each mode of ventilation in other studies rather effectively improve oxygenation, incidence of delirium and patient-ventilator asynchrony, dosages of analgesics and sedatives, and duration of mechanical ventilation and hospital stay by using SIMV. The difference in association may be due to difference in objective of study like in west China it was to assess the mortality benefit in each mode of

ventilation. Secondly; individuals were assigned as 1:1 ratio but in this study 91.5% of patients were on AC mode. The mortality rate for ventilation were inversely associated with duration of ventilation which is more in less than 48hours which is similar with the study in central Africa that was seen in the first 24 hours. [12] This is the time by which patient ventilator asynchrony is common and related complication have been seen.

The prevalence of tracheostomy use were 2.4% even though 14.2% of the patients were having prolonged ventilation which indicates our patients took longer time before extubation and had low threshold to use tracheostomy compared to multicenter hospital studies in which tracheostomy use was 24% and in Italian study (10%) and it showed significant reduction of ICU use by transferring to step-down as well as change to noninvasive ventilation reduce mechanical ventilator occupancy .[4,22] This is directly showing the facility we use in our setup which add up further incapability to use appropriately available ICU bed and mechanical ventilator.

Ventilator associated pneumonia were significantly associated with prolonged mechanical ventilation and diagnosed in 45.7% of mechanically ventilated patients which is higher than the study done in France with a maximum of 28%, republic of Korea 27%; from American medical association report 24%.[23,24,25] This may be due absent in gold standard diagnostic criteria for mechanical ventilation associated pneumonia and inversely association with hospital volume which is true in our hospital, and secondly it may be due to absent infection prevention protocol in our ICU.[15,18]

Among 247 patients, 73.4% had at least one electrolyte abnormality which is higher than a study done Al-Azhar University showing 28% seen at day one of ventilation which may underestimate the overall result. Near to twenty-eight and thirty percent of patients had acute renal failure and chronic renal failure, respectively as co-morbidity among mechanical ventilated patients at start or during the course mechanical ventilation. Nineteen percent of ventilated patient and 60% of patients with renal failure were requiring hemodialysis which is significantly associated with mortality. The current result is similar with Brazilian study which had renal failure in 69.5% of patients, and 31.9% of patients were undergone hemodialysis and were directly associated with mortality. [28] Hemodialysis were seen 9% from ATS report and 11.3% from Canadian report with statistically significant association with mortality. [17, 29] The Chinese study showed the same association of dialysis need .[7]

Co-morbidity was found among 65.2% of the study population which was directly associated with mechanical ventilator related mortality. This result is lower than single center experience from central India showing prevalence of co-morbidities to be 76.7% with significant relation with mortality. [16] Other study from Spain has also shown that comorbidity increased mortality rate in ventilated patient. [30]

The current study showed that patients with low hemoglobin level had 1.4 times more chance to fail from extubation than patients with normal hemoglobin level even though not statistically significant with mechanical ventilator use related mortality. Albumin level was also not significantly associated with mechanical ventilator use related mortality. However, both low hemoglobin and albumin level were associated with prolonged mechanical ventilator use. This result is against other studies suggesting that low hemoglobin and albumin level had statistically significant association with mortality as reported in retrospective study in Taiwan.[31,32] The difference might be due to target population variability both clinically as well as age distribution.

Conclusions

The prevalence of mechanical ventilator use among medical ICU admitted patients was high. Ventilation in the first 48 hours; requiring hemodialysis; presence of comorbidity was significantly associated with mortality. Even though the prevalence of prolonged mechanical ventilation was higher, tracheostomy use was very low. The prevalence of ventilator associated pneumonia was very high during the course of mechanical ventilation. But there are some limitations like exclusion of surgical patients and retrospective data. Possible measures should be taken in high risk patients to decrease ventilator use related mortality. Tracheostomy practice should be improved according to the indication. Further study should be needed.

Abbreviations

MICU: Medical intensive care unit

IMV: Invasive mechanical ventilation

ICU: Intensive care unit

ETT: endotracheal tube

CPAP: Continuous positive air way pressure

MV: mechanical ventilation

VAP: Ventilator associated pneumonia

SPHMMC: Saint Paul Hospital Millennium Medical College

Declarations

Consent for publication

Further, informed consent for publication was also obtained from each study participant under the consent form by mentioning for all of them that the data will be published in international journals. So, this is to confirm that informed consent for publication was obtained from all the study participants. The collected data is kept confidential under the primary investigator and co-investigator.

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Authors' contributions

WH conceptualized the research problem, designed the study, conducted field work, collected data, and drafted the manuscript, data analysis and preparation of the manuscript for publication. TB was involved in preparing the research proposal, revision of the manuscript. Both authors of the manuscript have read and agreed to its content.

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Competing interest

All authors read and approved the final manuscript. The authors declare that they have no competing interests.

Availability of Data and Materials

The datasets used and/or analyzed in the current study or data collection tool are available from the corresponding author on reasonable request.

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