A STUDY ON

THE PRACTICE OF MECHANICAL VENTILATION
IN KENYATTA NATIONAL HOSPITAL
INTENSIVE CARE UNIT

DISSERTATION IN PART FULFILLMENT FOR THE AWARD OF MASTER OF MEDICINE DEGREE IN ANAESTHESIOLOGY OF THE UNIVERSITY OF NAIROBI

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DECLARATION

I declare that this dissertation is my original work and that it has not been presented elsewhere for the award of a degree in any University.

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ACKNOWLEDGEMENT

My sincere gratitude is extended to all those who have made a contribution of one kind or another in my effort to complete this work. Of special mention is Professor Ngumi my supervisor, DR Chokwe and KNH Research and Ethical Committee. These people have given a meticulous academic critique to this work sending me back and forth a number of times before I could satisfy them. Their critical input has made this material a pleasant academic as well as a practical resource to interact with.

I'm indeed indebted to all my lecturers and consultants who so generously shared invaluable information from their lived experiences and my fellow senior house officers for their unflinching support.

At the risk of leaving out many others who were equally important contributors to the success of this write-up, I wish to thank my family for the patience they had to endure. At numerous occasions, I made them miserable by declining to give them my attention, audience or company when they needed it most.

To everybody else, I remain enormously indebted and give glory to God for this far He has brought us.

April, 2007

DR Njoroge P N
DEDICATION

1. To my parents for their encouragement and for teaching me the value of hard work.

2. To my wife and children in appreciation of their support, inspiration and their patience during my long hours away from home.
LIST OF ABBREVIATIONS

KNH_____ Kenyatta National Hospital
ICU_______ Intensive Care Unit
Kpa _____ Kilopascal
ML _______ Milliliters
MM _______ Millimeters
CM _______ Centimeters
Spp ______ Species
PaO₂ ______ Arterial Partial Pressure of Oxygen
PaCo₂_____ Arterial partial pressure of carbon dioxide
GNEB _____ Gram Negative Enterobactericeae
IPPV _____ Intermittent Positive Pressure Ventilation
CMV _____ Continuous Mandatory Ventilation
PSV ______ Pressure Support Ventilation
ARDS ____ Adult Respiratory Distress Syndrome
COPD ___ Chronic Obstructive Airway Disease
SIMV _____ Synchronised Intermittent Mandatory Ventilation
CPAP _____ Continuous Positive Airway Pressure
PEEP _____ Positive End Expiratory Pressure
BIPAP™ __ Biphasic Positive Airway Pressure
IRV ______ Inverse Ratio Ventilation
NIV ______ Non Invasive Ventilation
Kg _______ Kilogram
IMV ______ Intermittent Mandatory Ventilation
A/C _______ Assist Control
PPS ______ Proportional Pressure Support
ATC ______ Automatic Tube Compensation
MRSA _____ Methicillin Resistant Staphylococcus Aureus
F10₂ ______ Fractional Concentration of Inspired Oxygen.
SPSS _____ Statistical Programme for Social Scientists

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This was a descriptive longitudinal study that was carried out in Kenyatta National Hospital intensive care unit between January and March 2007. The main objective of the study was to describe the pattern of ventilatory support to patients admitted in the ICU. Other objectives included the determination of diagnoses of mechanically ventilated patients, the duration of ventilatory support, the weaning outcomes and microorganisms isolated from tracheal aspirates.

The information obtained from the patients was filled in structured questionnaires by the principle investigator. Data analysis was done using the SPSS programme and standard statistical tests applied.

The study revealed that most of the patients were males (64.1%) with male to female ratio of 1.8:1. Head injuries accounted for almost a third (29.7%) of all patients admitted for mechanical ventilatory support. 27.2% of the patients were referred from the District hospitals. Mechanical ventilatory support was delivered through translaryngeal intubation in 80.5% of the patients. Half of the patients (50.6%) were successfully weaned from ventilatory support while 4.4% became ventilator dependent. Pseudomonas aeruginosa was the commonest microorganism isolated from tracheal aspirates and accounted for 19.8% of all tracheal aspirates that were done. The commonest complication was tube blockage/displacement (28.8%) while critical incidents were reported in almost a third of the patients (31.1%).

The study recommended that better utilization of Acute and Emergency department, intensive care rooms in medical and surgical wards and post anaesthetic care unit would reduce the number of referrals to the ICU. Clearly elaborated admission criteria for admission of patients for mechanical ventilation should be availed and a weaning protocol should be prepared and availed to all critical care teams.
INTRODUCTION AND LITERATURE REVIEW

The Drinker and Shaw tank type of ventilator of 1929 was one of the negative pressure machines widely used for mechanical ventilation. Better known as iron lung, this metal cylinder completely encased the patient up to the neck. A vacuum pump created a negative pressure in the chamber, which resulted in expansion of the patient's chest. This change in chest geometry reduced the intra-pulmonary pressure and allowed ambient air to flow into the patient lungs. When vacuum was terminated, the negative pressure applied returned to zero and elastic recoil of the lungs and chest permitted passive expiration.

Negative pressure ventilation today is used in only few situations. The cuirass or the shell unit allows negative pressure to be applied only on a patient's chest using a form fitted shell and a soft bladder. It is a suitable option for patients with neuromuscular disorder especially those with a residual neuromuscular function, because it does not require a tracheostomy with its inherent problems. Military concepts of delivering oxygen and gas volume to fighter pilots during World War 2 at high altitudes were incorporated in the design of modern positive pressure ventilators. Development of safe endotracheal tubes with a high volume and low pressure cuffs replaced the iron lung.

Intensive use of positive pressure mechanical ventilation gained momentum during the polio epidemic in Scandinavia and United States in the early 1950s. In Copenhagen, the patient with polio and respiratory paralysis who was supported manually by forcing 50% oxygen through a tracheostomy had a reduced mortality rate. However this heroic intervention required the continuous activity of 1400 medical students recruited from Universities. The overwhelming manpower needed coupled with a decrease in mortality rate from 80% to 20% led to the adaptation of the positive pressure machines used in the operating room for use in the ICU.
Mechanical ventilation refers to the delivery of full or partial ventilatory support by a volume cycled mechanical ventilator or by pressure support. It also includes the maintenance of a positive airway pressure at the end of expiration. Partial ventilatory support which can be delivered as non-invasive positive pressure ventilation is often sufficient in selected circumstances; such as cardiogenic pulmonary edema or hypercapneic respiratory failure due to chronic obstructive pulmonary disease (COPD). In most cases, full ventilatory support is provided via artificial airway such as an endotracheal tube or a tracheotomy tube.

The indications for mechanical ventilation include;

1. Respiratory failure
2. Comatose patients from several causes including head injury, drug overdose
3. Control of intracranial pressure
4. Reduction of metabolic demands
5. Post operative ventilation
6. Inter or intra-hospital transfer of critically ill patients.

The goals of mechanical ventilation are to;

1. Reverse hypoxemia
2. Relieve muscle fatigue
3. Reduce metabolic cost of breathing
4. Reverse atelectasis
5. Improve lung compliance

In acute respiratory distress syndrome (ARDS) and acute lung injury, invasive ventilation modes and strategies have been developed to protect the delicate lung tissue and these have been shown to decrease mortality.
Apart from ventilatory support in the critically ill patients in an intensive care unit, mechanical ventilatory support can also be provided in the following areas:

1. Home; usually intermittently especially at night and non-invasively
2. Hospital wards; via non invasive routes if appropriate facilities and staff are available
3. Hospital theatres during anaesthesia and immediate post operative period

Mechanical ventilation improves gaseous exchange and decreases the work of breathing. The application of positive pressure to the respiratory system improves ventilation – perfusion matching and decreases inter-pulmonary shunting, both of which relieve hypoxemia and diminish hypercapnia. Alterations in lung mechanics, such as increased airway resistance and decreased lung compliance result in increased work of breathing for the ventilatory muscles particularly the diaphragm. Anaerobic metabolism may occur resulting in lactic acidosis. The initiation of mechanical ventilation without muscular paralysis ameliorates the work to a considerable but incomplete extent resulting in a fall in plasma lactate levels and improvement in gaseous exchange.

Ventilatory muscles continue to perform some work, although the magnitude of this work tends not to be fatiguing when at least 80% of minute ventilation is provided by the machine. By alleviating the work of breathing mechanical ventilation decreases the diaphragm’s demand for excessive blood flow and creates an opportunity for reversing the circumstances producing diaphragmatic fatigue and potentially life threatening hypercapnia.

The decision to initiate mechanical ventilation entails a significant commitment of hospital resources and a set of unique and potentially serious complications. The main indication is acute respiratory failure as reflected by inability to oxygenate the arterial blood adequately and loss of the capacity to sustain adequate alveolar ventilation. Clinically, this is manifested by the presence of
rapid shallow breathing \textsuperscript{11}, \textsuperscript{25}, \textsuperscript{33}. The objectives of mechanical ventilation are both physiologic and clinical and the decision to initiate must take clinical circumstances into account as well as physiological derangements. In general it is important to consider mechanical ventilation early in a patient’s course of illness, but the method chosen may depend upon the disease process. As an example a patient with severe chronic obstructive pulmonary disease and carbon dioxide retention may have acute on chronic hypercapnia and should be considered for non-invasive positive pressure ventilation if emergency intubation is not warranted \textsuperscript{14}, \textsuperscript{21}, \textsuperscript{23}.

**NON INVASIVE VENTILATION (NIV)**

Non-invasive ventilation (NIV) is positive pressure ventilation applied to patient’s upper respiratory passage via a nasal, nasal-oral or full mask. It enables mechanical ventilatory support to be applied without the need for tracheal intubation \textsuperscript{22}. Non-invasive ventilation is best delivered using a purpose built ventilator that copes with mask leaks more effectively than a standard ICU ventilator. NIV fails in about one third of the patients and this failure must be recognized promptly and invasive ventilation instituted through a tracheal tube to prevent deterioration to cardiopulmonary arrest \textsuperscript{4}.

An endotracheal tube weakens and predisposes to the acquisition of nosocomial pneumonia. The increase in sedation required to tolerate the tube suppresses the cardiovascular system and increases the incidence of ventilator associated pneumonia \textsuperscript{10}.

Reduction in mortality associated with NIV as compared to invasive ventilation has been demonstrated in exacerbations of chronic obstructive airway diseases and during weaning from mechanical ventilation \textsuperscript{9}. While using a modern intensive care ventilator or a portable purpose built machine, NIV is usually applied using either Biphasic positive airway pressure (BIPAP\textsuperscript{TM}) or pressure
support ventilation (PSV) with addition of positive end expiratory pressure (PEEP)\textsuperscript{22}.

**The following criteria has been used for selecting patients for NIV**

1. Alert and co-operative
2. Haemodynamically stable
3. No need for endotracheal intubation to protect airway or to remove excess secretions
4. No acute facial trauma
5. Properly fitted mask \textsuperscript{9,22}

**Continuous positive airway pressure (CPAP).**
This is a simple form of mechanical respiratory support using a face mask which can improve oxygenation by normalizing the functional residual capacity of the lungs, thereby improving lung compliance and reducing the work of breathing. It also improves ventilation - perfusion matching and reverses atelectasis \textsuperscript{22}. CPAP is very effective in pulmonary edema due to left ventricular failure, because the increase in mean thoracic pressure reduces excessive right-sided filling pressures (pre-load) and reduces cardiac after-load. However, CPAP may cause cardiovascular collapse in hypovolemic patients who cannot tolerate the fall in cardiac pre-load. It is also effective in recruiting collapsed alveoli in post-operative atelectasis \textsuperscript{8,21}.

**INVASIVE VENTILATION**

This is positive pressure ventilation applied to a patient’s trachea via an endotracheal tube or a tracheostomy tube \textsuperscript{22}. A patient with respiratory failure in whom it is predicted that CPAP or NIV will not be tolerated or who has failed on either of these therapeutic interventions will require tracheal intubation and mechanical ventilation \textsuperscript{11}.
Endotracheal intubation

Only trained personnel should use anaesthetic drugs to perform tracheal intubation. In unconscious patients intubation can be performed without sedation, but oxygenation is usually maintained with bag and mask ventilation. In situations of a full stomach, rapid sequence induction should be performed to prevent aspiration of regurgitated stomach contents. Trauma, shock and opioids may delay gastric emptying. Manual ventilation of lungs via facemask during periods of apnea before intubation should be avoided to prevent gastric inflation and increased risk of regurgitation. Pre oxygenation with 100% oxygen for 3 minutes is performed before induction to increase reserve of oxygen in lungs by washing out alveolar nitrogen. Position of endotracheal tube must always be checked by auscultation of the lungs and chest radiograph. End tidal carbon-dioxide monitoring is now mandatory in many situations to confirm correct placement of the tube. In the critically ill patients intubation is often followed by a period of hypotension owing to the vasodilator effects of the anaesthetic agents in patient who are dehydrated. Positive pressure ventilation reduces venous return by raising mean intrathoracic pressure and a fall in partial pressure of carbon dioxide as a result of improved ventilation causes a reduction in sympathetic drive, hence venous access must be available for fluid resuscitation and vasoactive drugs such as ephedrine or epinephrine should they be needed.

Tracheal intubation can be achieved by an oral or nasal endotracheal tube. Oral intubation is easier and safer in an emergency. It is usual to use a tube of 8.5mm internal diameter in males and 8mm diameter in females. Oral tubes are rarely used in alert patients and may cause nausea, vomiting and coughing. A patient may prefer nasal tracheal tube and needs less sedation but nasal endotracheal intubation is associated with a risk of epistaxis, sepsis and maxillary sinusitis especially in patients requiring prolonged mechanical
ventilation. A difficult oral intubation is often an easy nasal intubation and vice versa 

There are several formulae for estimating the proper endotracheal tube size and depth that exist but the following are commonly used in paediatric practice. The internal diameter of the tube in millimeters is approximated by 16+age (years)/4 or 18+age (years), the latter yielding external circumference in millimeters in French (F) size. The oral depth in centimeters from the teeth or the gums is calculated by 12+age(years)/2 or 12+weight(kg)/5. Nasal depth is calculated by adding 2 to 3 centimeters to the oral depth.

Tracheostomy

This is performed in the critically ill-patients to provide prolonged airway care during slow weaning from assisted ventilation. It offers significant advantage over prolonged translaryngeal intubation. Less discomfort allows a reduction in analgesia, sedation and muscle relaxation. The clearance of airway secretions, mouth care and enteral nutrition are facilitated. Airway resistance and anatomical dead space are reduced, reducing the work of breathing and improving the speed and overall success in weaning from mechanical ventilation. It allows a seamless transition between different modes of assisted ventilation and weaning modes without trials of extubation and re-intubation. There is reduced frequency of accidental extubation and endotracheal re-intubation. As the patient recovers, a fenestrated tracheostomy tube may be inserted or cuff deflated to allow phonation and better communication. It also allows an earlier discharge from an intensive care unit to a high dependency unit or ward. Follow-up by an outreach team may improve safety and acceptance of patients with a tracheostomy outside a critical area. Other indications for tracheostomy in ICU include; acute or chronic neuromuscular conditions, poor
Timing of tracheostomy in a patient receiving mechanical ventilation is controversial and depends on patient's condition and expected duration of mechanical ventilation. Timing of when to convert translaryngeal intubation to tracheostomy is again controversial and daily assessment of the risks and benefit of performing a tracheostomy should be carried out. Tracheostomy has an appreciable incidence of serious complications but incidences of laryngeal injury and subglottic stenosis increases significantly over time with prolonged translaryngeal intubation. Translaryngeal intubation is commonly converted to tracheostomy at 7 - 14 days, unless rapid improvement is likely to make tracheostomy unnecessary. There is increasing evidence for better outcomes associated with tracheostomy within the first few days in intensive care in patients who require prolonged ventilatory support.

The following general points should be noted in the absence of enough evidence to guide routine timing of converting a translaryngeal intubation to tracheostomy;

1. The risk of long term airway complications increases significantly with translaryngeal intubation for more than 10 days.
2. Early tracheostomy should be considered for all patients with severe trauma or burns to the face, neck and airway if an upper airway obstruction is a possibility.
3. Early tracheostomy should be considered in all patients with neurological injury who are unable to protect their airway because of bulbar dysfunctions, reduced level of consciousness or neuromuscular weakness like Guillain Barre Syndrome.
4. Reductions in mortality and length of stay in ICU have been demonstrated in medical ICU patients given early (within 48 hours) tracheostomy. The
Intensive care society is conducting a trial to compare early (within 48 hours of admission) and late (10 days after admission) tracheostomy. With the introduction of the technique of percutaneous tracheostomy, tracheostomies are being performed earlier in patients stay in intensive care units. However, tracheostomy is associated with a significant morbidity and mortality, whether performed surgically or percutaneously and should not be undertaken without consideration of risks and benefits. Tracheostomy has a mortality rate of 3%.

**VENTILATORS**

Intensive care ventilators are computerized and provide many ventilation modes. Most modes can be classified by considering phases of ventilation (Inspiration and expiration) and events that trigger the ventilator to cycle from inspiration to expiration.

**Inspiration phase**

**Constant flow generators**
The flow to patients' airway remains constant. Airway pressure increases to enable the tidal volume to remain constant when lungs become stiff or when airway narrows. Increase in airway pressure can be detrimental to the patient, hence constant flow generators are pressure limited ensuring cessation of inspiration before the pressure reaches inappropriately high levels.

**Constant pressure generators**
The pressure applied to patient airway remains constant. Tidal volume falls when lungs become stiff or airway narrows. A fall in tidal volume will potentially protect the lungs from barotrauma and volutrauma but may cause hypoxemia and respiratory acidosis.
Cycling from inspiration to expiration

Volume cycled
The ventilator changes from inspiration to expiration phase as soon as the tidal volume is achieved. This is the commonest form of a fully supported ventilation.

Pressure cycled
Ventilation changes from inspiration to expiration as soon as the pressure is achieved. The delivered tidal volume varies with alterations in lung mechanics and minute ventilation is not assured. Pressure limited forms of mechanical ventilation such as pressure controlled inverse ratio ventilation are being increasingly used because they lessen volutrauma in acute lung injury.

Flow cycled
The ventilator changes from inspiration to expiration phase as soon as the flow is achieved. A preset airway pressure is applied once machine is triggered and is cycled off after inspiratory flow decreases to a predetermined percentage of its peak value.

Time cycled
Inspiration time, inspiration pause time and expiration time are set on a ventilator. Both the volume of gas delivered and resultant airway pressure varies from breath to breath as a function of changes in lung mechanics.

Expiration phase
Expiration is passive. The valves in the ventilator open to atmospheric pressure. There is a reliance on the elastic recoil of the lungs and chest wall for expiration. When PEEP is used, ventilator circuit opens to a positive pressure rather than atmospheric pressure.
MODES OF MECHANICAL VENTILATION

Some ventilatory modes enable interaction of the patients with the ventilator, allowing them to provide part of their respiratory effort. This reduces the overall mechanical ventilation requirements. The reduced mean intrathoracic pressure provides greater haemodynamic stability. A degree of patient effort reduces respiratory muscle atrophy associated with ventilation. The ability to extend expiration time in bronchospasms avoids dangerous dynamic hyperinflation. The mode of ventilation chosen changes depending on the changing pathological status of the patient in the course of their critical illness.

Volume controlled ventilation allows close control of arterial partial pressure of carbon dioxide but not airway pressures. Pressure control limits airway pressure and theoretically minimizes risk of barotraumas. The decelerating inspiratory flow pattern that characterizes pressure control may improve gaseous exchange and is more comfortable to the patient. Minute ventilation is however not tightly controlled and pressure control is not recommended when management of PaCO$_2$ is crucial; e.g. raised intracranial pressure. Modern ICU ventilators offer modes that combine advantages of volume and pressure control ventilation. In these dual modes, tidal volume is preset but delivered in a square wave of pressure with a decelerating inspiratory flow pattern. Despite the theoretical advantages of pressure control, there is no clinical evidence that patient outcome is influenced by the mode of ventilation.

Laboratory studies and recent clinical trials have demonstrated that exposing injured lungs to excessive tidal volume and pressure result in an insidious and progressive worsening of underlying lung injury. Over distension (volutrauma) and tidal lung recruitment - derecruitment (atelectrauma) appear to be important mechanisms. Barotrauma describes extra pulmonary air (pneumothorax, subcutaneous emphysema) and appears to be more a consequence of exposing...
injured lungs to positive pressure ventilation rather than excessive airway pressure \(^4, 17, 29\).

Regardless of the mode used, tidal volume should be 8-10mls/kg ideal body weight in normal lungs and 6-8mls/kg in acute lung injury. The end expiratory plateau pressure (Pplat) reflects alveolar distension and should usually be limited to a maximum of 30cmH\(_2\)O. Pplat depends on required minute ventilation which should be set according to PH rather than the arterial partial pressure of carbon dioxide (PaCO\(_2\)). \(^4, 11\)

\(\text{PaO}_2\) is maintained above 8Kpa by adjusting the inspired oxygen tension and level of PEEP. Prolonged exposure to high inspired oxygen tension should be avoided to reduce risk of pulmonary oxygen toxicity. Excessive PEEP increases risk of barotrauma and may reduce cardiac output and oxygen delivery. Empirical titration of PEEP and fractional concentration of inspired oxygen (FiO\(_2\)) to target \(\text{PaO}_2\) appears to be a pragmatic and effective method \(^40\).

FiO\(_2\) is determined by the severity of patient’s gas exchange abnormality. High FiO\(_2\) (0.6 – 0.8) is initially set and adjusted when results of blood gas analysis are available. It is usual to maintain \(\text{PaO}_2\) at 8 – 12 Kpa. Tidal volume is set at 6 – 10 mls/kg and there is increasing evidence that values greater than these can cause lung damage. \(^11\) Ventilator rate is set at 10 – 12 breaths/minute.

**Continuous mandatory ventilation (CMV)**

This mode is frequently used on simple ventilators in operating theatres. It should be used only if modes allowing patient’s interaction are contraindicated or if equipment is not available \(^22\). The minute ventilation is completely dependent upon the rate and tidal volume set on the ventilator. Inspiratory efforts made by patients do not contribute to minute ventilation. It is indicated in patients who have no inspiratory efforts e.g. spinal cord injury, drug overdose and those subjected to pharmacological paralysis. Oxygen consumption
decreases with neuromuscular paralysis, hence combination of neuromuscular paralysis and controlled ventilation is sometimes used in patients with acute respiratory distress syndrome. Combined neuromuscular paralysis and controlled mechanical ventilation can also be used to avoid volutrauma in patients with ARDS and to avoid barotrauma in asthmatics who are difficult to ventilate. In these settings, hypercapnia is accepted provided oxygenation is maintained. Muscle relaxation and CMV improve oxygen delivery and reduces oxygen consumption by reducing the work of breathing. It however has the disadvantage of sedation and respiratory muscle atrophy.

**Intermittent mandatory ventilation (IMV)**

IMV is a development of CMV. A patient can make a respiratory effort rather than attempt to breathe against a closed valve. A preset tidal volume and rate is set determining mandatory minute ventilation. In addition, the patient is allowed to breathe spontaneously through the ventilator circuit at a tidal volume and rate determined according to need and capacity. IMV has a disadvantage that if a patient take a deep spontaneous breath just before an IMV breath is due to be delivered patient lungs are forced to receive a double breath with an excessive tidal volume.

**Synchronised intermittent mandatory ventilation (SIMV)**

Intermittent ventilator breaths are synchronised with inspiratory effort by the patient. It requires a preset tidal volume and rate but allows a patient to increase minute volume with spontaneous breaths between mandatory breath. Prior to each mandatory breathes; a “window of time” is defined by ventilator. If a patient begins a spontaneous breath during this time, mandatory breath is synchronised with it preventing “breath staking” associated with IMV. This synchrony requires a trigger modality; either a demand valve or a flow-by, both of which require patient’s effort; hence increasing work of breathing. SIMV has an advantage of a good patient ventilator interaction; allowing minimally sedated patient to cope with mechanical ventilation. Respiratory muscles are
only partially rested and therefore are protected against atrophy. Mean intrathoracic pressures are reduced improving haemodynamic stability in some patients. Gradual weaning from ventilator is possible by slowly reducing mandatory breaths rate until patient is breathing with minimal support\(^1\),\(^3\),\(^2\).

**Assist/control mechanical ventilation (A/C) mode.**

The ventilator senses an inspiratory effort by the patient and responds by delivering a preset tidal volume. Every inspiratory effort that satisfies the ventilator’s demand valve trigger threshold initiates delivery of preset tidal volume. A control mode back-up rate is set in the ventilator to prevent hypoventilation. Patient work is required to trigger ventilator and continues during inspiration\(^2\). A/C ventilation is better suited to critically ill-patients who require full ventilatory support and in whom fluctuations in tidal volume are undesirable.\(^1\)

**Pressure support ventilation (PSV) or assisted spontaneous breathing**

This is a flow-cycled mode of ventilation. It is pressure controlled in that once triggered by a demand value, preset pressure is sustained until the respiratory flow tapers; usually 25% of its maximal value. In this mode; the work of breathing performed by the patient is shifted to the machine in a manner inversely proportional to the level of pressure support\(^2\),\(^2\). It is used sandlely or with other modes of ventilation i.e BIPAP\(^TM\) and SIMV to support spontaneous breaths permitted in these modes. Each patient breath detected is augmented by set pressure from ventilator. Patient must generate his own breath for this mode to be effective since the ventilator does not produce any mandatory breaths.\(^1\)

It can be added during full or partial support with SIMV to overcome endotracheal tube and ventilator circuitry resistance encountered during spontaneous breathing. Resistance of endotracheal tube varies as a function of tube diameter and inspiratory flow rate\(^7\),\(^3\),\(^3\). Pressure support in excess of 10CmH\(_2\)O may be
needed to overcome resistance of endotracheal tube particularly with small (<7MM) endotracheal tube. At higher levels of pressure support (>10cmH2O) tidal volume is augmented and respiratory rate slows. 23.

Providing full ventilatory support to patients with PSV often requires relatively high levels of pressure since low pressure increase risk of alveoli collapse. In one report of 8 patients with acute respiratory failure, PSV level of $27 \pm Cm H_2O$ were required to attain a normal breathing pattern 23. The use of lower levels of PSV in conjunction with adequate PEEP has been reported in selected patients with acute lung injury and an intact respiratory drive. Although patients who successfully tolerate this approach are usually able to be ventilated at PSV level below 20cmH2O these patients are less severely ill than those who cannot tolerate this modality. Patient comfort was greatest in the middle ranges around 10-15cm H$_2$O 23. Pressure support is slowly reduced as patients respiratory muscle improves making it an excellent mode for weaning 16,22.

**Bi-level or Biphasic positive airway pressure (BIPAP$^TM$) Ventilation**

BIPAP$^TM$ is a technique where a ventilator can provide two levels of positive pressures. The ventilator is set to cycle between two pressures at predetermined times ($t_{high}$, $t_{low}$) or triggered to cycle by patient's respiratory efforts. It requires more sophisticated equipment and expertise. It however has been shown to accelerate weaning in some patients 16,22.

**Proportional pressure Support (PPS).**

This mode is similar to pressure support ventilation. Instead of augmentation of patient breath to a set pressure, level of support is in proportion to the patients' own effort. This promote patient – ventilator synchrony 16, 22.

**Automatic tube compensation (ATC).**

Breathing through endotracheal tube increases the work of breathing. Resistance caused by the tube is related to its internal diameter and gas flow
through it varies throughout the ventilatory cycle.\textsuperscript{7,16} To compensate for this, the ventilator can calculate the extra support required to overcome this resistance. When set on ATC alone, the patient perception of breath is as if no tube is present. If a patient is coping well on ATC alone, extubation may be possible\textsuperscript{22}.

**Inverse ratio Ventilation (IRV)**

In this mode of mechanical ventilation, increases in mean airway pressures are developed by prolonging inspiration-expiration ratio\textsuperscript{23}. In spontaneous breathing inspiration occupies about 25 – 30\% of each respiratory cycle. To reproduce this in mechanical ventilation would require high airway pressures to produce sufficient tidal volume and the long expiration time would increase airway collapse; hence inspiration-expiration ratio is usually 1:2. In inverse ratio ventilation, the normal ratio of 1:2 is reversed to 2:1 increasing mean thoracic pressure but allowing each breath to be delivered over a proportionately longer time\textsuperscript{11}. Suggested mechanisms of improved arterial oxygenation with IRV include.

1. Reduced arteriovenous shunting.
2. Improved ventilation – perfusion matching
3. Decreased dead space ventilation

Whether these effects are preferentially produced by IRV is unproven since most studies have been small and have not shown a clinical advantage to IRV\textsuperscript{28}.

In one study, no difference in oxygenation was noted in patients who were mechanically ventilated using volume controlled ventilation, pressure controlled ventilation or pressure controlled IRV as long as the total amount of positive end expiratory pressure (PEEP) was left constant. Carbon-dioxide elimination increased slightly during IRV, but cardiac index and oxygen delivery were depressed by this mode\textsuperscript{29}. Inverse ratio ventilation requires heavy sedation or implementation of neuromuscular paralysis to ensure patients' tolerance and coordination with an unnatural pattern of respiration. Although it may be well
tolerated haemodynamically, invasive haemodynamic monitoring is essential to ensure that oxygen delivery is not compromised.

WEANING FROM VENTILATORY SUPPORT

Abnormality of arterial blood gases depends on the severity of the acute episode and degree of chronic impairment of respiratory function. The decision to commence ventilatory support depends more on clinical assessment than on an arbitrary blood gas values. Severe hypoxemia (PaO2 <8Kpa) despite high flow oxygen or deteriorating respiratory acidosis (PH <7.3) are common indications for instituting ventilatory support.

Discontinuing mechanical ventilation presents a significant challenge in certain patients especially those with acute on chronic respiratory failure or those who have required prolonged ventilatory support. More than 50% of the time that patient receive ventilatory support may be taken by attempts at weaning. Discontinuing mechanical ventilation at the earliest opportunity decreases risk of developing ventilator associated pneumonia and upper airway injury from prolonged intubation. This needs to be balanced against increased morbidity and mortality associated with premature extubation and re-intutabation.

Impaired conscious level from excessive administration of opioids and sedatives delays weaning and this can be avoided by regular evaluation of sedative requirements. A sedation break should be considered each day that the patient continues to require ventilatory support.

Suitability for weaning

Once the underlying condition for which the patient was ventilated has improved, the decision to wean a patient is based on clinical assessment. Patient must be pain free, able to maintain the airway and to clear secretions.

The patient should be able to maintain a gaseous exchange with an FIO2 of less than 0.5, a PEEP of less than or equal to 4cmH2O and a minute ventilation of
less than 20 liters. He should be co-operative and have a stable circulation without requirement for high doses of inotropes. Electrolyte abnormalities including hypokalemia, hypophosphatemia and hypomagnesaemia are associated with muscle weakness and should be corrected. Metabolic demands are increased by pyrexia and overfeeding which may be important in adversely affecting weaning in some patients.  

**Predictive tests**

The requirement for continuing mechanical ventilatory support should be reviewed daily. Failed attempts at weaning have adverse effects on the mental and physical well being of the patient. The ability to develop a vital capacity over 10mls/Kg and maximum inspiratory pressure of less than negative 20cm H₂O are some of respiratory function tests that have been evaluated and found to be sensitive but not specific. Rapid shallow breathing index is the most sensitive and specific predictor of weaning failure. This is assessed during a trial of spontaneous breathing or with minimal level of pressure support ventilation (< 8cm H₂O). A rapid shallow breathing index is calculated by dividing respiratory rate by tidal volume in liters and an index of more than 105 predicts weaning failure in 97% of patients. A graded approach to increasing respiratory work load with periods of increased respiratory work interspersed with rest periods is often required. Patients who are ventilated for more than 7 days need a tracheostomy inorder to be weaned.

**WEANING TECHNIQUES**

There are many ways of weaning a patient from mechanical ventilation and all have comparable effectiveness.

**T-Piece trial**

This is traditionally used in relatively uncomplicated cases. Patients are allowed to breathe independently from a ventilator using a T-piece supplied
with humidified oxygenated gases attached to tracheal tube for increasingly long periods of time. This is continued until the patient can breathe reliably unaided. Endotracheal tube and T-piece offer substantial resistance to gas flow hence increasing the work of breathing. This resistance is decreased when a tracheostomy tube and a T-piece are combined.

Synchronised intermittent mandatory ventilation (SIMV)
This requires gradual reduction of mandatory respiratory rate until the patient has an appropriate spontaneous rate.

BIPAP™
This is performed by either reducing the rate as happens with SIMV or slowly reducing stepwise the upper pressure level until it is equal to the lower pressure level. At this point the patient is effectively on CPAP alone. CPAP is then slowly reduced.

Pressure support ventilation
This is done by gradually reducing pressure support level until the patient is left on only a modest level of support commensurate with that required for overcoming the increased work of breathing associated with tracheal tube.

Non Invasive ventilation
The extubation of a patient with good conscious level but still requires ventilatory support is done. The patient is immediately initiated on non-invasive ventilation to assist weaning and the potential complications of intubation are avoided. This method has been shown to improve outcome in some patients groups.

The superiority of daily T-piece trials and pressure support over SIMV has been confirmed during two large randomized controlled trials. Failure during a weaning trial is assessed clinically from the onset of a rapid shallow breathing,
evidence of respiratory distress including use of accessory muscles of respiration and a paradoxical respiratory pattern, haemodynamic instability, alteration in conscious level and excessive diaphoresis. If a patient can manage 30 minutes of spontaneous breathing without signs of failure, they should be considered for extubation which depends on their ability to clear secretions and protect their airway. More prolonged T-piece trials do not increase their predictive value.

**Management of a patient who is difficult to wean**

Assessment and investigation of the patient’s underlying respiratory, cardiac and neuromuscular status may reveal a contributory unrecognised chronic disease. Non invasive ventilation can be used successfully in patients who fail convention weaning trials. The patient can be extubated directly to non-invasive ventilation which is then gradually reduced. This approach reduces the duration of ventilatory support and improves outcome in patients with chronic obstructive airway disease who have undergone a period of invasive ventilatory support. Left ventricular afterload increases following sudden withdrawal of positive pressure ventilation and this may be a contributory factor in failure to wean. If left ventricular dysfunction is suspected, judicious use of diuretics and other drugs to reduce after load including angiotensin converting enzyme inhibitors may be effective.

Neuropathy and myopathy associated with critical illness contribute to weaning failure. Neurophysiologic investigations with electromyography and nerve conduction studies confirm diagnosis and exclude other rare causes of weaning failure including unrecognized Guillain Barre Syndrome. There is no specific treatment for critical illness myopathy and neuropathy and generally improves gradually when sepsis is controlled. The patient who is difficult to wean requires a multidisciplinary approach to ensure optimal physical and psychological condition. Tracheostomy is usually performed to assist gradual reduction of respiratory support in a fully conscious patient. Underlying
cardio respiratory disease should be optimized, adequate nutrition ensured, sleep deprivation prevented and stress reduced. Communication aids can help to reduce the frustration associated with tracheostomy.

A weaning plan should be produced with gradually increasing periods of unassisted spontaneous breathing. Successful management of the long term ventilated patient depends on the appropriate management of their psychological state with counseling sessions.

**Ventilator associated pneumonia**

This is the most commonly encountered nosocomial pneumonia infection in ICU. It usually affects mechanically ventilated patients. It has an attributable mortality rate of 10 - 50%. It is defined as Pneumonia acquired after hospital admission and it is divided into:

1. Early onset (<5 days after hospital admission or intubation)
2. Late onset (>5 days after hospital admission or intubation)

The causative organisms are: Klebsiella Pneumoniae (10% - 20% cases), Pseudomonas aeruginosa (10% - 15% cases), Staphylococcus Pneumoniae (about 10% cases) and Haemophilus influenzae (about 5% cases). Mycoplasma Pneumonia is a relatively uncommon cause. In some studies it has been reported that aerobic gram negative bacilli and staphylococcus aureas account for 50% - 70% of all cases. The division of early onset and late onset is important in terms of etiology and treatment. Early onset nosocomial pneumonia commonly result from aspiration of endogenous community acquired pathogens e.g. streptococcus spp with tracheal intubation and impaired consciousness being the main risk factors. Late onset follows aspiration of oropharyngeal or gastric secretions containing potentially drug resistant nosocomial pathogens such as Methicillin resistant staphylococcus aureas (MRSA) and gram negative bacilli. Only late onset ventilator associated pneumonia is associated with an excess mortality.
The risk factors for ventilator associated Pneumonia include: multiple antimicrobial therapy, intubation-reintubation, nasotracheal intubation, supine body position; Pharmacological paralysis and daily change of ventilator circuit.

Diagnostic strategies
Clinical criteria for diagnosis of suspected ventilator associated pneumonia include a new and persistent infiltrate on the chest radiograph, fever, hypothermia, leucocytosis, leucopenia and prominent tracheo – bronchial secretions. Changes in oxygenation and signs of severe sepsis and shock may occur. These criteria are however nonspecific and considerable diagnostic doubt is common. Independent microbiological criteria using bronchoscopic technique of bronco-alveolar lavage and protected specimen brushing have high rates of false positive and false negative results of up to 50%. These microbiological results using the invasive techniques are similar to those from simple tracheo-bronchial aspiration. Isolation of pathogenic microorganisms in the respiratory tract without clinical signs of ventilator associated pneumonia implies colonization and does not require therapy.

Many studies regarding optimal diagnostic strategy have been published with conflicting results and no clear framework has emerged. Current thinking suggests:

1. A low threshold for the diagnosis and empirical antimicrobial treatment of ventilator associated pneumonia
2. Empirical treatment is guided by time of onset.
3. Selection of anti-microbial therapy is influenced by local patterns of microbial resistance.
4. Regular surveillance and quantitative culture of tracheal bronchial aspirates from intubated patients can refine local empirical antimicrobial policies.
Recommendations for empirical anti-microbial treatment

In patients with early onset ventilator associated pneumonia and no risk factors, the core organisms such as community endogenous pathogens and non-resistant Gram-Negative Enterobactericeae (GNEB) including Escherichia coli, Klebsiella Pneumoniae, Enterobacter Spp serratia spp and proteus spp should be covered appropriately.\(^{10,14,41}\) In patients with late onset ventilator associated Pneumonia and no risk factors, potentially drug resistant micro-organisms must be taken into account. These include; MRSA, GNEB, Pseudomonas aeruginosa and Acinetobacter spp. Although not evidence based strategy, most authorities recommend combination therapy.\(^{10,41}\)

Treatment for early onset or late onset ventilator associated pneumonia with risk factors is similar to late onset ventilator associated pneumonia without risk factors except when Legionella species are suspected.

This general framework for empirical initial anti-microbial treatment must be modified according to local requirements.\(^{10,12}\)

Most aerobic gram negative bacilli are sensitive to a broad spectrum cephalosporin and cefotaxime or ceftazidime are indicated for their treatment\(^{1,2,3}\). If Pseudomonas aeruginosa is suspected ceftazidime may be useful. Anti-Pseudomonal penicillin e.g. ticarcillin or piperacillin may be used as an alternative to ceftazidime. Both ticarcillin and piperacillin are susceptible to B-Lactamases\(^{1,2,3}\). They can be administered together with B- Lactamase inhibitor such as clavulanic acid (ticarcillin) or tazobactam (piperacillin). In the presence of tazobactam, piperacillin is the penicillin that exhibits the broadest spectrum of anti-microbial activity\(^{41}\). When hospital acquired Pneumonia causes severe illness an aminoglycoside such as gentamicin can be added to the regimen. In cases of suspected atypical pneumonia, treatment can be done with a macrolide antibiotic such as erythromycin, clarithromicin or azithromicin. If Chlamydia Pneumoniae or mycoplasma Pneumonia is suspected a tetracycline may be used.
as an alternative to the macrolide. If Legionella Pneumophilla is suspected rifampicin should be added to the treatment with a macrolide \cite{1,2,3,10,12,41}.

**Complications of mechanical ventilation**

1. Displacement/ blockage of endotracheal tube. Intubated patients require constant and skilled supervision to ensure that these are identified and corrected promptly.

2. Cardiovascular dysfunction: Positive pressure ventilation increases intrathoracic pressure and reduces venous return leading to hypotension \cite{23,38}. Drugs used to sedate patients exacerbate this hypotension. Adequate fluid resuscitation is necessary to compensate for the fall in cardiac output \cite{4,22}.

3. Aspiration: This may occur despite use of a cuffed endotracheal tube. The risk of aspiration is increased in critically ill patients who may have delayed gastric emptying. They should be nursed slightly head up to reduce risk of aspiration. This may also reduce the risk of ventilator associated Pneumonia \cite{8,10}.

4. Pneumothorax: A diagnosis of tension Pneumothorax must be considered always if there is a sudden deterioration in the oxygenation of a ventilated patient. This is increased if high inflation pressures are used \cite{8}.

5. Ventilator associated lung injury: Evidence suggest that large (>10Ml/Kg) tidal volumes and high inflation pressures (>30cm H$_2$O) can cause acute lung injury that is indistinguishable from acute respiratory distress syndrome \cite{8,17}.

6. Ventilator associated Pneumonia: This is the most common nosocomial infection in ventilated patients. It is associated with increased length of hospital stay and causes a mortality risk of greater than 25%. Aerobic gram negative bacilli and staphylococcus aureas account for 50%- 70% of all cases \cite{8,10,41}.
Critical incidents in mechanical ventilation

Critical Incidents are defined as human errors or equipment failures that can lead (if not discovered or corrected in time) to an undesirable outcome, ranging from increased length of hospital stay to death 34. Critical incident technique is applied in the study of anesthesia mishaps and the approach does not require death or injury (Substantive negative outcome) to identify errors. It utilizes not just the small visible tip of mortality of the metaphorical “Iceberg of clinical anesthesia mistakes” but also samples the relatively large and to date mostly untapped body of errors that do not cause patient harm 35.

The ten most common incidents account for 39% of the total cases. In a study that reviewed 11 years of malpractice claims in Washington from 1971 to 1982, it was found that 61% of anesthesia related deaths and 88% of anesthesia related brain damage were due to embarrassment of the respiratory system. The three most common causes of respiratory events leading to claims were inadequate ventilation, unrecognized esophageal intubation and airway obstruction. It was noted that in 48% of these cases, auscultation of the chest failed to detect an esophageal intubation. The study also showed that human error was a factor in 82% of the incidents and equipment failure accounted for 14% 36.
Ten most frequent critical incidents

<table>
<thead>
<tr>
<th>Critical incident – descriptions</th>
<th>Percentage of total critical incidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Breathing circuit disconnection</td>
<td>8</td>
</tr>
<tr>
<td>2. Inadvertent gas flow change</td>
<td>6</td>
</tr>
<tr>
<td>3. Syringe swap</td>
<td>5</td>
</tr>
<tr>
<td>4. Gas supply problem</td>
<td>4</td>
</tr>
<tr>
<td>5. Intravenous apparatus disconnection</td>
<td>3</td>
</tr>
<tr>
<td>6. Laryngoscope malfunction</td>
<td>3</td>
</tr>
<tr>
<td>7. Premature extubation</td>
<td>3</td>
</tr>
<tr>
<td>8. Breathing circuit disconnections error</td>
<td>3</td>
</tr>
<tr>
<td>9. Hypokalemia</td>
<td>3</td>
</tr>
<tr>
<td>10. Tracheal airway device position change</td>
<td>2</td>
</tr>
</tbody>
</table>


It is however noted that these factors deal exclusively with the performance of critical care practitioner and the equipments used to maintain the patient. Variation in outcome may not be solely determined by the practitioner and his equipment. Quality experts suggest that processes not individuals should be the object of quality improvement. The quality of intensive care rendered also depends on data supplied by other medical consultants, medical records, clinical laboratories and diagnostic services within and outside the hospital 4.
JUSTIFICATION OF THE STUDY

Mechanical ventilation is one of the most important interventions done in any intensive care unit. In this country, the problem of providing care and support to patients who require mechanical ventilation is particularly challenging especially in rural areas because there are relatively few health facilities and adequately trained providers available.

Kenyatta National Hospital ICU is the largest public health institution that offers mechanical in Kenya. It has a capacity of 20 beds. In 2006, a total of 395 adult (15 years and above) patients admitted to the ICU required mechanical ventilation at some stage during their hospital stay.

The cost of mechanical ventilation is significant to the admitting facility as well as the relatives who suffer both physical and psychological pain on finding their sick relative on a mechanical ventilator. The Government has recognized the need to train more anesthesiologists in order to staff the ICUs in provincial hospitals with competent personnel who can administer mechanical ventilation. This training is a prerequisite to the establishment of ventilatory support centers in most provincial hospitals in the country.

The administration and practice of mechanical ventilation in a cost effective way while simultaneously providing high quality services is a challenge. This study was meant to elucidate the various aspect of mechanical ventilation that would improve the overall management of patients in ICU. The results of the study would:

1. Have a practical application and theoretical relevance
2. Help in formulating or altering the current practices or policies of mechanical ventilation.
3. Act as a future reference point for training and decision making on issues pertaining to mechanical ventilation.
OBJECTIVES

MAIN OBJECTIVE
The main objective of this study was to describe the pattern of ventilatory support to patients admitted in Kenyatta National Hospital intensive care unit.

SPECIFIC OBJECTIVE
1. To determine the diagnoses of ventilated patients and duration of mechanical ventilation
2. To elucidate the weaning outcomes in patients under mechanical ventilatory support.
3. To elucidate the common complications associated with mechanical ventilation
4. To describe any critical incidents encountered during mechanical ventilation.
5. To identify the commonest micro organisms isolated from tracheal aspirates.

METHODOLOGY

STUDY DESIGN
This was a descriptive prospective study. All patients who met the inclusion criteria were followed and monitored closely until they were weaned off from the mechanical ventilator and either discharged from the unit or died.

STUDY AREA
The study was carried out in KNH intensive care unit. This unit admits patients 24 hours a day. There is a registrar covering the unit for 24 hours and this is intended to ensure patients are attended to promptly. Ward rounds are done daily in this unit both by a consultant or a senior registrar and a registrar. This enables patients to be sorted out as soon as possible after admission. Baseline investigations like random blood sugar, arterial blood gases and levels of
hemoglobin are done immediately on admission to help the attending physician to determine the management. Tracheal aspirates for culture and sensitivity patterns are done routinely on patients on mechanical ventilation.

STUDY PERIOD
The study started as soon as the proposal was cleared by the ethical committee and lasted until the sample size was achieved. This was between 2nd January and 29th March 2007.

STUDY POPULATION – RECRUITMENT
Recruitment of patients into the study was done at the time of admission as long as they required mechanical ventilation and met the inclusion criteria. This included patients from wards in KNH, casualty, theatre and referrals from other facilities.

SAMPLING AND SAMPLE SIZE DETERMINATION
All patients who met the inclusion criteria were recruited for the study. The sample size was determined by the following formula as recommended by Fisher

\[ n = \frac{z^2 pq}{d^2} \]

Where
\[ n = \text{the desired sample size if population > 10,000} \]
\[ z = \text{Standard normal deviate at the required confidence level of 1.96} \]
\[ P = \text{Proportion in the target population estimated to have the characteristic being measured which was 0.5} \]
\[ q = 1 - p \text{ which was 0.5} \]
\[ d = \text{the level of statistical significance; 0.05} \]
Since the target population was less than 10,000 the formula used was;

$$nf = \frac{n}{1+n/N}$$

Where

$nf$ = Desired sample size; population $<$ 10,000

$n$ = Desired sample size; population $>$ 10,000

$N = 395$ which was the average number of patients who required mechanical ventilation in the year 2006$^{43}$.

The sample size calculation was done as follows;

$$n=1.96 \times 1.96 \times 0.5 \times 0.5 = 384 \times 0.05 \times 0.05$$

$$nf = \frac{384}{1 + 384/395}$$

= 195

A sample of 195 patients was taken and consecutive sampling was done until the sample size was achieved.
INCLUSION CRITERIA
1. Male and female adult patients (over 15 years) admitted in ICU who required mechanical ventilation.
2. Male and female patients admitted in the unit and while in the unit developed a need for mechanical ventilation.
3. The above that consented for the study.

EXCLUSION CRITERIA
1. Patients who declined to consent for their inclusion in the study.
2. Patients on mechanical ventilation from other hospitals.
3. Those who never satisfied the inclusion criteria

ETHICAL CONSIDERATIONS
Participation of the patients was voluntary. All information about the research was explained to the patient or the guardian(s) and that information was treated with utmost confidentiality. The proposal was submitted to the ethical and research committee of KNH for approval before commencement of the study.

FINALIZING AND REVIEWING THE RESEARCH PLAN
The research plan was reviewed by the supervisor before it was actually implemented. The suggestions offered were incorporated in order to improve the study design.

CONDUCTING THE PILOT STUDY AND MAKING REVISIONS
This was done two weeks before the commencement of the study. It was meant to avoid introducing modifications or stopping the study when it had already begun. A pilot study or a trial run of the major study was done to:
1. Obtain information for improving the project.
2. Assess the studies feasibility, sustainability and practicability.
The study showed whether the items in the questionnaire were rightly presented.
DATA COLLECTION AND QUALITY CHECK

Patients were reviewed and the relevant information was filled in the structured questionnaires.

The quality of the data was checked by:

Field editing
The questionnaires were checked daily by the principal investigator for correctness and completeness. This was done to make any corrections on figures e.g. hours or days and re-writing in full any abbreviations that may have been made.

Central editing
This was done after all the questionnaires were filled. Any changes were done in a distinctive colour, initialed and date of editing indicated on each completed form.

DATA MANAGEMENT

All responses in completed and cleared questionnaires were coded. A code book was created. The research information was transferred from the questionnaires into computer files.

Both qualitative and quantitative data analyses were done. Tabulation was done using a computer and descriptive statistics performed. Statistical analysis was applied to test if there were significant differences between individuals or relationships among variables. Data analysis was conducted using SPSS.
CONSTRAINTS AND LIMITATIONS OF THE STUDY

Since this was a prospective study, research information was obtained by observing and noting the progress reports from the clients' files. Some changes in the mode of mechanical ventilatory support are usually done during some procedures like chest physiotherapy and may not be indicated in the files. The sample size chosen may not have been the best for a good generalization of the findings and a longer duration of study would have been more preferable. Most patients immediately after intubation are put on IPPV before they settle on a different mode. Despite these limitations, the findings generated from the study were useful and met the objectives of the study as envisaged.
RESULTS
A total of 195 patients satisfied the inclusion criteria and were recruited into the study.

DEMOGRAPHIC AND GENDER CHARACTERISTICS
A total of 125 males (64.1%) and 70 females (35.9%) were seen (Table 1) with male to female ratio of 1.8:1. The mean age was 38.4 years, median of 34 years and a range of 81 years with a maximum of 96 years and a minimum of 15 years. The 15-24 year's age group had the highest admission of 56 patients (29.5%) which accounted for almost a third of all admissions. The economically active age group between 25-64 years accounted for 58% of all admissions (Table 2).

Table 1
Table for sex distribution

<table>
<thead>
<tr>
<th>SEX</th>
<th>No of Patients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>125</td>
<td>64.1</td>
</tr>
<tr>
<td>Female</td>
<td>70</td>
<td>35.9</td>
</tr>
<tr>
<td>TOTAL</td>
<td>195</td>
<td>100</td>
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</table>

Table 2
Table for age groups distribution

<table>
<thead>
<tr>
<th>AGE GROUPS</th>
<th>No of patients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-24</td>
<td>56</td>
<td>29.5</td>
</tr>
<tr>
<td>25-34</td>
<td>41</td>
<td>21.5</td>
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<tr>
<td>35-44</td>
<td>28</td>
<td>14.5</td>
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<td>45-54</td>
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<tr>
<td>55-64</td>
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<td>10.3</td>
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<tr>
<td>65-74</td>
<td>12</td>
<td>6.2</td>
</tr>
<tr>
<td>&gt;75</td>
<td>16</td>
<td>6.6</td>
</tr>
<tr>
<td>TOTAL</td>
<td>195</td>
<td>100</td>
</tr>
</tbody>
</table>
DIAGNOSES DISTRIBUTION

Combinations of surgical and medical patients were admitted for ventilatory support. Severe head injuries accounted for a third (29.7%) of all admissions followed by severe pneumonias; 21 patients (10.8%), cerebral vascular accidents 20 patients (10.3%). Heart diseases accounted for 7.2% of all admissions. (Table3)

During admission and initiation of mechanical ventilatory support, 125 patients (64.4%) had severe Glasgow Coma Scale (GCS) of 3-8, 56 patients had moderate GCS of 9-12 and 14 patients had mild GCS of 13-15. The mean GCS was 7.5, median of 7 and a mode of 6 (Table4)

Table 3
Table for diagnoses distribution

<table>
<thead>
<tr>
<th>DIAGNOSIS</th>
<th>No of patients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe head injuries</td>
<td>58</td>
<td>29.7</td>
</tr>
<tr>
<td>Severe pneumonias</td>
<td>21</td>
<td>10.8</td>
</tr>
<tr>
<td>Cerebral vascular accidents</td>
<td>20</td>
<td>10.3</td>
</tr>
<tr>
<td>Heart diseases</td>
<td>14</td>
<td>7.2</td>
</tr>
<tr>
<td>Septic shock</td>
<td>9</td>
<td>4.6</td>
</tr>
<tr>
<td>Brain tumours</td>
<td>8</td>
<td>4.1</td>
</tr>
<tr>
<td>Burns</td>
<td>7</td>
<td>3.6</td>
</tr>
<tr>
<td>Chronic renal failure</td>
<td>6</td>
<td>3.1</td>
</tr>
<tr>
<td>Abdominal injuries</td>
<td>6</td>
<td>3.1</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>4</td>
<td>2.1</td>
</tr>
<tr>
<td>Others</td>
<td>42</td>
<td>21.5</td>
</tr>
<tr>
<td>TOTAL</td>
<td>195</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 4
Table for Glasgow Coma Scale (GCS) at admission

<table>
<thead>
<tr>
<th>GCS</th>
<th>No of patients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe</td>
<td>125</td>
<td>64.4</td>
</tr>
<tr>
<td>Moderate</td>
<td>56</td>
<td>29.3</td>
</tr>
<tr>
<td>Mild</td>
<td>14</td>
<td>6.3</td>
</tr>
<tr>
<td>TOTAL</td>
<td>195</td>
<td>100</td>
</tr>
</tbody>
</table>
REFERRAL SYSTEMS FOR VENTILATORY SUPPORT

Fifty three patients (27.2%) were referred from District hospitals, 45(23.1%) from KNH wards, 41(21%) from theatres and 33(16.9%) from the casualty (Table 5). Of those referred from the operating theatres, 21 patients (51.2%) were reversed from muscle relaxants. The non reversed patients were brought to continue with mechanical ventilation in order to be weaned gradually (Table 6). Of the 33 patients from the casualty, 19(57.6%) were intubated by anaesthiologists and the rest by non anaesthiologists (Table 7).

Table 5
Table for referral sources

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>No of patients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>District hospital</td>
<td>53</td>
<td>27.2</td>
</tr>
<tr>
<td>KNH wards</td>
<td>45</td>
<td>23.1</td>
</tr>
<tr>
<td>KNH theatres</td>
<td>41</td>
<td>21</td>
</tr>
<tr>
<td>Casualty</td>
<td>33</td>
<td>16.9</td>
</tr>
<tr>
<td>Provincial hospitals</td>
<td>23</td>
<td>11.8</td>
</tr>
<tr>
<td>TOTAL</td>
<td>195</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 6
Table for muscle relaxants status

<table>
<thead>
<tr>
<th>STATUS</th>
<th>No of patients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reversed</td>
<td>21</td>
<td>51.2</td>
</tr>
<tr>
<td>Not reversed</td>
<td>20</td>
<td>48.8</td>
</tr>
<tr>
<td>TOTAL</td>
<td>41</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 7
Table for intubations done in casualty

<table>
<thead>
<tr>
<th>DONE BY</th>
<th>No of patients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anaesthesiologist</td>
<td>19</td>
<td>57.6</td>
</tr>
<tr>
<td>Non anaesthesiologist</td>
<td>14</td>
<td>42.4</td>
</tr>
<tr>
<td>TOTAL</td>
<td>33</td>
<td>100</td>
</tr>
</tbody>
</table>
VENTILATORY SUPPORT PATTERNS

Of the 195 patients in the study, 99 (50.8%) were intubated on admission or immediately on admission while 96 (49.2%) were intubated in the course of their stay in the unit (Table 8). Similarly 154 patients (79%) were put on an invasive mode of mechanical ventilation and 41 (21%) were initiated on a non invasive mode (Table 9).

Among the 154 patients on an invasive mode 124 (80.5%) received ventilatory support through endotracheal intubation and 30 (19.5%) through tracheostomy (Table 10)

Table 8
Table for Intubation status

<table>
<thead>
<tr>
<th>STATUS</th>
<th>No of patients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intubated</td>
<td>99</td>
<td>50.8</td>
</tr>
<tr>
<td>Not intubated</td>
<td>96</td>
<td>49.2</td>
</tr>
<tr>
<td>TOTAL</td>
<td>195</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 9
Table for initial ventilatory support on admission

<table>
<thead>
<tr>
<th>VENTILATORY SUPPORT</th>
<th>No of patients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invasive</td>
<td>154</td>
<td>79</td>
</tr>
<tr>
<td>Non invasive</td>
<td>41</td>
<td>21</td>
</tr>
<tr>
<td>TOTAL</td>
<td>195</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 10
Table for different invasive modalities

<table>
<thead>
<tr>
<th>MODALITY</th>
<th>No of patients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Endotracheal tube</td>
<td>124</td>
<td>80.5</td>
</tr>
<tr>
<td>Tracheostomy</td>
<td>30</td>
<td>19.5</td>
</tr>
<tr>
<td>TOTAL</td>
<td>154</td>
<td>100</td>
</tr>
</tbody>
</table>
INVASIVE MODALITIES

Among the invasive modalities currently in use, SIMV was the most popular with almost half of the patients initiated on it, i.e. 76 patients (49.2%). This was followed by CMV/IPPV with 38 patients (24.6%). Pressure support alone accounted for 16 patients (10.6%). (Table 11)

Thirty patients (19.5%) out of 154 on invasive modalities had a tracheostomy tube in place. They were initially on an endotracheal tube before conversion into tracheostomy. The majority of the patients with tracheostomy i.e eleven out of thirty (36.7%) had translaryngeal intubation converted into tracheostomy at 10-14 days while a third (33.3%) at 5-9 days. The mean number of days for converting translaryngeal intubation to tracheostomy was 12 with a median of 12 (Table 12).

Although the duration of mechanical ventilatory support differed between patients, the majority 110 patients (56.4%) required support between 1-5 days, 44 patients (22.6%) between 6-10 days. The mean duration for mechanical ventilation was 10.4 days; median of 5 days and a mode of 2 days. Twenty two patients (11.2%) were supported for over 30 days. Two patients were still on support for over 3 months (Table 13)

<table>
<thead>
<tr>
<th>MODE</th>
<th>No of patients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIMV</td>
<td>76</td>
<td>49.2</td>
</tr>
<tr>
<td>CMV/IPPV</td>
<td>38</td>
<td>24.6</td>
</tr>
<tr>
<td>CPAP</td>
<td>24</td>
<td>15.6</td>
</tr>
<tr>
<td>PSV</td>
<td>16</td>
<td>10.6</td>
</tr>
<tr>
<td>TOTAL</td>
<td>154</td>
<td>100</td>
</tr>
</tbody>
</table>
Table 12
Table for the duration of translaryngeal intubation before converting to tracheostomy

<table>
<thead>
<tr>
<th>DURATION</th>
<th>No of patients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4</td>
<td>2</td>
<td>6.7</td>
</tr>
<tr>
<td>5-9</td>
<td>10</td>
<td>33.3</td>
</tr>
<tr>
<td>10-14</td>
<td>11</td>
<td>36.7</td>
</tr>
<tr>
<td>15-19</td>
<td>7</td>
<td>23.3</td>
</tr>
<tr>
<td>TOTAL</td>
<td>30</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 13
Table for the total duration of mechanical ventilation in days

<table>
<thead>
<tr>
<th>DURATION</th>
<th>No of patients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5</td>
<td>110</td>
<td>56.4</td>
</tr>
<tr>
<td>6-10</td>
<td>44</td>
<td>22.6</td>
</tr>
<tr>
<td>11-15</td>
<td>9</td>
<td>4.6</td>
</tr>
<tr>
<td>16-20</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>21-25</td>
<td>5</td>
<td>2.6</td>
</tr>
<tr>
<td>26-30</td>
<td>5</td>
<td>2.6</td>
</tr>
<tr>
<td>&gt;31</td>
<td>22</td>
<td>11.2</td>
</tr>
<tr>
<td>TOTAL</td>
<td>195</td>
<td>100</td>
</tr>
</tbody>
</table>
THE WEANING PROCESS AND OUTCOME

In the current study, doctors attempted weaning in 160 patients (82.1%) while in 35 patients (17.9%) it was never. (Table 14). Of the 160 patients who had attempted weaning 81 patients (50.6%) were successful and were discharged to the general wards while 72 patients (45%) died while being weaned. In 4.4% of the patients, there was a weaning failure and the patients became ventilator dependent (Table 15).

Table 14
Table for attempted weaning

<table>
<thead>
<tr>
<th>STATUS</th>
<th>No of patients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attempted</td>
<td>160</td>
<td>82.1</td>
</tr>
<tr>
<td>Not attempted</td>
<td>35</td>
<td>17.9</td>
</tr>
<tr>
<td>TOTAL</td>
<td>195</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 15
Table for weaning outcomes

<table>
<thead>
<tr>
<th>OUTCOME</th>
<th>No of patients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Successful</td>
<td>81</td>
<td>50.6</td>
</tr>
<tr>
<td>Died while being weaned</td>
<td>72</td>
<td>45.0</td>
</tr>
<tr>
<td>Failed</td>
<td>7</td>
<td>4.4</td>
</tr>
<tr>
<td>TOTAL</td>
<td>160</td>
<td>100</td>
</tr>
</tbody>
</table>
TRACHEAL ASPIRATES AND ISOLATED MICRO-ORGANISMS

Tracheal aspirates of 106 patients (54.4%) were done. In 39 of those patients (36.8%) no organisms were isolated. Pseudomonas aeruginosa was isolated in 21 patients (19.8%) followed by staphylococcus aureus in 11 patients (10.4%). Klebsiella and Gram Negative Enterobactericeae (GNEB) accounted for 8.5% and 9.4% respectfully. Others including Acinetobacter and a mixed growth of klebsiella, pseudomonas and staphylococcus accounted for 5.7% (Table 16 and 17).

Table 16
Table for the status of tracheal aspirates

<table>
<thead>
<tr>
<th>STATUS</th>
<th>No of patients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Done</td>
<td>106</td>
<td>54.4</td>
</tr>
<tr>
<td>Not done</td>
<td>89</td>
<td>45.6</td>
</tr>
<tr>
<td>TOTAL</td>
<td>195</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 17
Table for isolated micro-organisms from tracheal aspirates

<table>
<thead>
<tr>
<th>STATUS</th>
<th>No of patients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>39</td>
<td>36.8</td>
</tr>
<tr>
<td>Pseudomonas</td>
<td>21</td>
<td>19.8</td>
</tr>
<tr>
<td>Staphylococcus</td>
<td>11</td>
<td>10.4</td>
</tr>
<tr>
<td>GNEB</td>
<td>10</td>
<td>9.4</td>
</tr>
<tr>
<td>Kleb+pseudomonas</td>
<td>10</td>
<td>9.4</td>
</tr>
<tr>
<td>Klebsiella</td>
<td>9</td>
<td>8.5</td>
</tr>
<tr>
<td>Others</td>
<td>6</td>
<td>5.7</td>
</tr>
<tr>
<td>TOTAL</td>
<td>106</td>
<td>100</td>
</tr>
</tbody>
</table>
VENTILATOR ASSOCIATED PNEUMONIA

83 patients (42.6%) developed clinical features of ventilator associated pneumonia while 112 (57.4%) did not. Among those who had clinical features, purulent tracheal bronchial secretions presented in 14 patients (16.9%) while fever and leucocytosis presented each in 13.3% of all cases. New or persistent chest x-ray infiltrates featured in 10.8% of all patients (Table 18 and 19)

Table 18
Table for the presence of clinical features of ventilator associated pneumonia

<table>
<thead>
<tr>
<th>STATUS</th>
<th>No of patients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present</td>
<td>83</td>
<td>42.6</td>
</tr>
<tr>
<td>Absent</td>
<td>112</td>
<td>57.4</td>
</tr>
<tr>
<td>TOTAL</td>
<td>195</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 19
Table for the clinical features of ventilator associated pneumonia

<table>
<thead>
<tr>
<th>CLINICAL FEATURES</th>
<th>No of patients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fever</td>
<td>11</td>
<td>13.3</td>
</tr>
<tr>
<td>Hypothermia</td>
<td>5</td>
<td>6.0</td>
</tr>
<tr>
<td>Leucocytosis</td>
<td>11</td>
<td>13.3</td>
</tr>
<tr>
<td>Purulent tracheo-bronchial discharge</td>
<td>14</td>
<td>16.9</td>
</tr>
<tr>
<td>New/Persistent x-ray infiltrates</td>
<td>9</td>
<td>10.8</td>
</tr>
<tr>
<td>Fever/purulent discharges</td>
<td>6</td>
<td>7.2</td>
</tr>
<tr>
<td>Hypothermia/leucopenia</td>
<td>8</td>
<td>9.6</td>
</tr>
<tr>
<td>Others(combination of above)</td>
<td>19</td>
<td>22.9</td>
</tr>
<tr>
<td>TOTAL</td>
<td>83</td>
<td>100</td>
</tr>
</tbody>
</table>
80 patients (41%) developed some complications during ventilatory support. The commonest complication was tube blockage and displacement which was noted in 23 patients. Cardiovascular dysfunctions were noted in 19 patients. Ventilator associated lung injuries and pneumonias were noted in 6 (7.5%) and 7 (8.8%) cases respectfully (Table 20 and 21)

Table 20
Table for the presence complications during mechanical ventilation

<table>
<thead>
<tr>
<th>STATUS</th>
<th>No of patients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present</td>
<td>80</td>
<td>41</td>
</tr>
<tr>
<td>Absent</td>
<td>115</td>
<td>59</td>
</tr>
<tr>
<td>TOTAL</td>
<td>195</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 21
Table for complications of mechanical ventilation

<table>
<thead>
<tr>
<th>COMPLICATIONS</th>
<th>No of patients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tube displacement</td>
<td>23</td>
<td>28.8</td>
</tr>
<tr>
<td>Cardiovascular dysfunctions</td>
<td>19</td>
<td>23.7</td>
</tr>
<tr>
<td>Aspiration</td>
<td>14</td>
<td>17.4</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>8</td>
<td>10.0</td>
</tr>
<tr>
<td>Vent associated pneumonia</td>
<td>7</td>
<td>8.8</td>
</tr>
<tr>
<td>Vent associated lung injuries</td>
<td>6</td>
<td>7.5</td>
</tr>
<tr>
<td>Others</td>
<td>3</td>
<td>3.8</td>
</tr>
<tr>
<td>TOTAL</td>
<td>80</td>
<td>100</td>
</tr>
</tbody>
</table>
CRITICAL INCIDENTS DURING MECHANICAL VENTILATION

A total of 61 patients (31.3%) had isolated episodes of critical incidents reported. The most common incident was breathing circuit disconnection which was reported in 29 patients (47.5%) followed by premature extubation in 13 patients (21.4%). Inadvertent extubation was reported in 1 patient (1.67%). (Table 22 and 23)

Table 22
Table for reported critical incidents

<table>
<thead>
<tr>
<th>STATUS</th>
<th>No of patients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present</td>
<td>61</td>
<td>31.3</td>
</tr>
<tr>
<td>Absent</td>
<td>134</td>
<td>68.7</td>
</tr>
<tr>
<td>TOTAL</td>
<td>195</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 23
Table for critical incidents

<table>
<thead>
<tr>
<th>INCIDENTS</th>
<th>No of patients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breathing circuit disconnection</td>
<td>29</td>
<td>47.5</td>
</tr>
<tr>
<td>Premature extubation</td>
<td>13</td>
<td>21.4</td>
</tr>
<tr>
<td>Inadvertent gas flow change</td>
<td>8</td>
<td>13.2</td>
</tr>
<tr>
<td>Laryngoscope malfunction</td>
<td>6</td>
<td>9.8</td>
</tr>
<tr>
<td>Syringe swap</td>
<td>3</td>
<td>4.9</td>
</tr>
<tr>
<td>Gas supply problem</td>
<td>1</td>
<td>1.6</td>
</tr>
<tr>
<td>Inadvertent extubation</td>
<td>1</td>
<td>1.6</td>
</tr>
<tr>
<td>TOTAL</td>
<td>61</td>
<td>100</td>
</tr>
</tbody>
</table>
DISCUSSION

DEMOGRAPHIC AND SEXUAL CHARACTERISTIC

There are many factors that affect the decision to initiate mechanical ventilation. Because no mode of mechanical ventilation can cure a disease process, the patient should have an underlying problem that can resolve with the support of mechanical ventilation. This intervention should not be started without thoughtful consideration because intubation and positive pressure ventilation are not without potentially harmful effects.

In the current study, 64.1% were males and 35.9% were females. The 15-24 year's age group accounted for 29.5% of all admissions. This is an age group mainly in their formative years of their future productive lives. Since they are mainly in high schools and colleges, their prolonged stay in hospitals can lead to missed opportunities. Similarly the 25-64 year's age group is economically productive and constituted 58% of all admissions, hence a significant loss of incomes. The high number of males compared to females can partly be explained by the fact that males are more prone to head injuries and in this study a third of all admissions (29.7%) were occasioned by head injuries.

DIAGNOSES DISTRIBUTION

The current study revealed multifarious morbidity patterns with almost all body systems involved. This is because many systems must be functioning for a patient to be able to self ventilate. In this study, head injuries accounted for a third of all admissions (29.7%), followed by severe pneumonias (10.8%) and cerebral vascular accidents at (10.3%). 65.4% had severe Glasgow Coma Scale (GCS) of 3-8 and 29.3% had GCS of 9-12. The mean GCS was 7.5 and a median of 7. The multiple nature of diseases that occasioned mechanical ventilation shows how different systems affect the patients spontaneous ventilation adequacy to sustain life. Ventilatory support was therefore indicated
as a measure to control ventilation in a critically ill patient and as a prophylaxis for impending collapse of other physiologic systems. Physiologic indications included respiratory or mechanical insufficiency and ineffective gas exchange.

Patients who require mechanical ventilation should be referred to ICU physician at an early stage to avoid the need for intubation of the patient in extremis. An assessment of the reversibility of the patient's illness and prognosis should be done and a discussion made before intubation is done. However the prognosis of many diseases will change with advances in medical therapies. Some patients with respiratory failure caused by pneumocystis carinii pneumonia who had poor prognosis in the 1980s may now benefit from respiratory support while the underlying condition is being treated.

The initiation of mechanical ventilatory support to patient with severe GCS of 3-8 which constituted the majority of all admissions at 65.4% raises some important diagnostic and ethical issues. According to some studies 50% of patients with GCS of 8 or less die within 6 hours. The emergence of critical care units have enabled access to life sustaining therapies for many patients who would otherwise have died. While some of them will be restored to normal functional existence, such interventions applied inappropriately can give rise to a population who survive in chronic persistent ill health. Many of these will proceed to a slow death which will not only have an emotional impact in terms of human suffering on the patient and relatives but will also impose a financial burden on limited resources. The practices of preserving life at all costs must be re-evaluated and instead the provision of quality end of life should be a priority and an obligation of all health care providers. In the context of the critically ill and the dying patient, provision of care that cannot reverse their decline can as well be futile, which is defined as a situation in which a treatment cannot within
a reasonable probability cure, ameliorate, improve or restore a quality of life that would be satisfactory to the patient \(^{45}\)

REFERRAL SOURCES FOR VENTILATORY SUPPORT

The referral of patients from District hospitals was 27.2%. This indicates the paucity of these services in these areas; either due to lack of equipments or qualified manpower. The figure is also consistent with the high numbers of District hospitals as opposed to Provincial hospitals (11.8%). Theatre referrals were 21% with 51.2% of those well reversed from muscle relaxants and brought for observations only. Equipping the post anaesthetic care unit (PACU) and adequate staffing will reduce these referrals and limit them to those who are not reversed. This reduction in patient load in ICU will create room for other needy patients.

Casualty referrals of 16.9% could be reduced by expanding the already existing Accident and Emergency department to cater for some of those patients. This suggestion is supported by the finding in this study that the majority of patients (56.4%) required ventilatory support between 1-5 days with a mode of 2 days. Casualty intubations by Non_Anaesthesiologists of 42.4% indicate the role they play in patients' resuscitation before skilled services are available. Referrals from the wards of 23.1% could be reduced by better utilization and equipping of intensive care rooms available in some medical and surgical wards.

VENTILATORY SUPPORT PATTERN

Patients who require ventilatory support are referred to an ICU physician at an early stage to avoid intubation when the patient is in extremis \(^{11}\). The current study has revealed that 50.8% were intubated on admission or immediately on admission while 49.2% were intubated in the course of their stay in the unit.
The latter were started on mechanical ventilation due to increasing severity of the illness that led to their admission in the unit. 79% of the patients were put on an invasive mode and 21% on a non-invasive mode. The invasive modalities were administered through translaryngeal intubation (80.5%) and tracheostomy (19.5%). SIMV was the most popular modality for initial invasive support (49.2%) followed by CMV/IPPV (24.6%). PSV in isolation for initial ventilatory support was initiated in only 10.6% of the cases.

The patients with tracheostomy were initially ventilated though endotracheal tube before it was converted into tracheostomy. 36.7% had translaryngeal intubation converted into tracheostomy at 10-14 days with a mean of 12 days and a median of 12 days respectfully. Although tracheostomy has many benefits compared to translaryngeal intubation, it was used to deliver invasive ventilatory support in only 19.5% of the cases. This could partly be explained by the controversies that surrounds its timing. The current study has shown that 36.7% of translaryngeal intubations’ conversion into tracheotomies were done between 10-14 days and 33.3% between 5-9 days, hence a total of 70% conversions were done between 5-14 days which is consistent with other studies that recommend 7-14 days.

The initial mode of ventilation chosen should be the assist-control mode in which tidal volume and respiratory rate are preset and guaranteed. Both SIMV and CMV guaranteed this as was the practice during this study (73.8%). Although reduction in mortality associated with NIV as compared with invasive modes has been demonstrated, only 21% of the patients were initiated on NIV. The main reason for this finding is that NIV is best delivered using a purpose built ventilator that copes well with mask leaks than standard ICU ventilators which are currently not available in the unit.

The current ventilators in the ICU offer limited range of invasive modalities and this could explain why other modes like BIPAP, PPS and ATC were not used.
in administering mechanical ventilation during the study period or at any other time.

DURATION OF MECHANICAL VENTILATION AND WEANING OUTCOMES

The study showed that 82.1% had weaning attempts while 17.9% did not. The success rate of weaning was 50.6% and 45% of the attempted patients died during the process of weaning since their diseases' conditions did not improve with initiation of mechanical. Weaning failure rate was 4.4% and these patients became ventilator dependent.

56.4% of the patients were supported for 1-5 days while 22.6% were supported for 6-10 days. 11.2% had to be supported for more than one month. The mean duration of mechanical ventilatory support was 10.4 days, a median of 5 days and a mode of 2 days. 2 patients were still on support after three months at the completion of the study.

The duration of mechanical ventilation varies between patients depending on the diagnosis and the severity of the illness. A median of 5 days and a mode of 2 days indicate a high turnover of patients. Some studies have demonstrated that 80% of patients receiving mechanical ventilatory support do not require prolonged weaning. These findings are supported by two large multicentre studies that demonstrated that mechanical ventilation can be discontinued abruptly in 75% of the patients whose underlying cause of respiratory failure has either improved or resolved. The remaining patients will need progressive withdrawal from ventilatory support.

The weaning failure rate was 4.4%. Causes of failure to wean are multifactorial and indicates incomplete resolution of the illness that precipitated the need for mechanical ventilation or development of new problems. Studies elsewhere
have shown that 50% of the time patients receive mechanical ventilation may be taken by attempts at weaning \(^4,10\ 16\). There are no standard recommended protocols in the ICU for weaning but the commonly used methods elsewhere are SIMV, PSV and T-tube trials \(^4,16\ 18\ 25\). SIMV is the least effective among the three approaches but a clear superiority of one technique over the other among the PSV and T-tube trials has not yet been established. It is recommended that clinicians should choose the method they feel most comfortable with and individualize the strategy to meet patients' needs \(^51,52\).

The current study has shown that 79% of the patients required support between 1-10 days and 11.2% over one month. 2 patients were on mechanical ventilatory support over three months. Concerning the 11.2% of the patients on support for over one month, there was a constant need to evaluate who should continue receiving that life sustaining intervention and in what circumstances as well as when that support should be withdrawn. The issue of finance in determining continuation/discontinuation of care impacts on the principle of justice in medical ethics. In the current climate of limited financial resources, the question would be whether it is justifiable to continue a seemingly futile intervention at the expense of giving greater benefits to other people. Studies elsewhere in similar situations recommend continuing dialogue with patients' proxies as paramount to ensure appropriate decisions are made regarding continuation, escalation, withholding or withdrawing support. The underlying principle regarding any decision must be to protect the dignity, rights and the comfort of the patients, and where possible take into consideration the wishes of the patients' or their proxies \(^46\).

**TRACHEAL ASPIRATES AND ISOLATED ORGANISMS**

During this study 54.4% of the patients had their tracheal aspirates taken for culture and sensitivity. 36.8% of these aspirates were sterile. The 45.6% of the patients whose aspirates were not taken could be explained by the high turnover.
of the patients in the unit, a probability of having been discharged before they were done.

Pseudomonas aeruginosa was isolated in 19.8% of the cases which was the commonest followed by staphylococcus aureas at 10.4%. Klebsiella pneumoniae was isolated in 8.5% of the cases. These findings are consistent with studies elsewhere that isolated pseudomonas in 10–19%, staphylococcus in 10% and klebsiella in 10–20% of cases respectfully.

Apart from tracheal aspirates for ventilator associated pneumonia, the frequencies of various presenting clinical features were examined. This was because ventilator associated pneumonia is life threatening with some studies attributing it a mortality rate of 33–50% and others 10–50%. In this study the most frequent presenting feature was purulent tracheal bronchial discharges at 16.9%, fever and leucocytosis at 13.3% each. Multiple clinical presenting features were noted in 22.9% of all cases. There is no identified standard clinical criteria for diagnosis, but most studies observes new or persistent chest x-ray infiltrates, purulent tracheo-bronchial discharges, leucocytosis, fever, hypothermia and leucopenia as common features.

Other conditions that can mimic ventilator associated pneumonia include; aspiration pneumonitis, pulmonary thromboembolism, drug reactions, radiation induced pneumonitis and sepsis. These conditions should be considered along with ventilator associated pneumonia.

**COMPLICATIONS OF MECHANICAL VENTILATION**

The commonest complication was tube displacement during physiotherapy and nursing procedures and blockade by viscid mucous and secretions (28.8%) followed by cardiovascular dysfunctions (23.7%). Ventilator associated pneumonia was reported in 8.8% and aspiration in 17.4% of the cases.
respectfully. These findings are almost consistent with studies elsewhere that found ventilator associated pneumonia in 10—25% and aspiration in 8—17% of the cases respectfully \textsuperscript{45, 53}. The cardiovascular complications affect renal blood flow resulting in gradual fluid retention. Similarly, the incidence of stress ulcers and sedation related ileus is increased making mechanical ventilation an indication for gastro-intestinal tract prophylaxis \textsuperscript{54}.

Although this study did not address oxygen toxicity as a significant complication of mechanical ventilation, other literature elsewhere considers it relevant. It is attributed to the production of free radicals including superoxide anions, hydroxyl radicals and hydrogen peroxide. Oxygen toxicity can lead to other complications ranging from mild tracheobronchitis, absorptive atelectasis and hypercarbia to diffuse alveolar damage indistinguishable from ARDS. The level of FIO\textsubscript{2} required to cause oxygen toxicity has not been established by consensus, but it has been reported even in FIO\textsubscript{2} of 50%. The use of the lowest FIO\textsubscript{2} that accomplishes the needed oxygenation is recommended \textsuperscript{53}.

CRITICAL INCIDENTS DURING MECHANICAL VENTILATION

31.3\% of the patients had an episode of critical incident reported. Among these incidents, breathing circuit disconnection was reported in 47.5\% of the cases; followed by premature extubation at 21.4\%. Equipment failure (laryngoscope malfunction and gas supply problems) accounted for 11.4\%. Studies done elsewhere attributed equipment failure as 14\% and human error as 82\% \textsuperscript{36}.

Critical incidents being major or permanent impairments of bodily functions or deaths that are not ordinarily expected as a foreseeable results of the patient condition or of appropriately selected and administered treatments should be avoided since they have given rise to claims and litigations elsewhere \textsuperscript{42}. Inadvertent intubation of the right main bronchus has been reported in 3—9\% of all intubations in adult \textsuperscript{53}. Thoughtful analysis of the process of care and prompt
recognition of events that herald swift and potentially catastrophic critical incidents should be embraced. In addition to these, additional training, improved supervision or second opinion, specific protocol development, equipment and apparatus inspection and improvement of human and equipment factors have been suggested in order to reduce these incidents.

Since critical incidents are preventable, some authors suggest that areas of their occurrence including operating rooms, post anaesthetic care unit, patient transport between critical areas and in pain management should be noted. The philosophy of continuous quality improvement must be adopted to seek knowledge necessary for breakthroughs in patient safety.
CONCLUSIONS

The following conclusions can be drawn from this study;
Most of the patients were males (64.1%) with male to female ratio of 1.8:1. The commonest cause for admission was head injuries which accounted for almost a third of all admissions for ventilatory support (29.7%). Almost two thirds (65.4%) of the patients were admitted with severe Glasgow Coma Scale of between 3-8. Referrals from the District hospitals were the commonest accounting for almost a quarter of the patients (27.2%). Half of the patients admitted (50.8%) were already intubated or were intubated immediately on admission.
Four fifth (80.5%) of the patients were mechanically ventilated through translaryngeal intubation while 70% of translaryngeal intubations were converted into tracheostomies between 5-14 days. Over half of the ventilated patients (56.4%) were supported for 1-5 days with 50.6% successfully weaned. Pseudomonas aeruginosa was the commonest micro-organism isolated from tracheal aspirates (19.8%). The commonest complication was tube blockage/displacement (28.8%) while critical incidents were reported in almost a third of the patients (31.3%).
RECOMMENDATIONS

1. Special intensive care units for head injury patients should be established

2. Better utilization of Acute and Emergency department, intensive care rooms in medical and surgical wards and post anaesthetic care unit will reduce the number of referrals to the ICU

3. Clearly elaborated admission criteria for mechanical ventilatory support should be prepared and availed to all admitting doctors

4. A weaning protocol for use by all critical care teams should be made
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APPENDIX 1

PATIENT/GUARDIAN INFORMATION FORM

My name is DR Njoroge from the department of surgery; anaesthesiology in the University of Nairobi. I'm undertaking a study on the practice of mechanical ventilation in KNH intensive care unit. This study has been approved by KNH research and ethical committee which regulates such studies. My supervisor is Professor Ngumi, an Associate Professor of anaesthesiology in the University of Nairobi. The objectives of the study are to elucidate the diagnoses of patients under mechanical ventilation, duration of ventilatory support and the weaning outcomes among others.

This study will be conducted in this unit between January until the sample size is achieved. In this study I will review the treatment you receive, the investigations done and the procedures you undergo. Your progress and any complications will be noted. This information will be treated confidentially and your identity will not be revealed since you will be marked by a code number which will not bear your name.

Your participation in the study is voluntary and no direct or indirect risks will be incurred by your participation. I will not influence or alter the management of your disease to suit my study. You have an absolute right to withdraw from the study at any time with no penalties instituted whatsoever.

Once you sign the informed consent form, I will fill a structured questionnaire with the information thus obtained and all the questionnaires will be kept in safe custody to ensure confidentiality.

Your data and data obtained from others with similar problems will be analyzed and the information obtained will benefit future patients as well as advance medical knowledge.

April, 2007

Dr Njoroge
APPENDIX II

INFORMED CONSENT FORM

I __________________________________________ patient/guardian do hereby consent
to be included/ for my patient to be included in the study on practice of
mechanical ventilation in KHH intensive care unit.
I confirm that I have been fully informed about the benefits/risks of the study,
the procedure and the voluntary nature of the study. I fully understand the right
of withdrawal at any time.
I hereby give my informed consent without any duress or coercion whatsoever.

Sign ________________________________ Date _____________________________
Witness ___________________________ Date _____________________________

Principal investigator’s telephone number: 0725650354

FOMU YA KUKUBALI KUHUSISHWA

Mimi ______________________________ mgojwa/mtunzi nakubali
kuhusishwa/mgojwa wangu kuhusishwa kwa utafiti kuhusu jinsi vile wagojwa
wanasaidiwa kupumua kwa vifaa katika hospitali ya Kenyatta chumba cha
wagojwa mahututi
Nathibitisha ya kwamba nimeelezwa kuhusu huo utafiti na ninaelewa haki yangu
ya kutoendelea katika utafiti wakati wowote. Natia hii sahihi bila tashwishi
yeyote ama kulazimishwa.

Sahihi _____________________________ Tarehe ____________________________
Shahidi ____________________________ Tarehe ____________________________

Nambali ya simu ya mtafiti 0725650354.
APPENDIX 111

DATA COLLECTION TOOL (QUESTIONNAIRE)

1) Patients numbers: Study No. / / / / Adm. No./ / / / / / / / / / / / / / / / / / / / / / /

2) Sex of the patient Male/female

3) Age of the patient in years / / /

4) Initial diagnosis at time of admission
   (a) ___________ (c) ___________
   (b) ___________ (d) ___________

5) Glasgow coma scale at admission: ___________

6) Patient referred from:
   (a) Provincial hospital
   (b) District hospital
   (c) Wards in KNH
   (d) Theatre
   (e) Casualty

7) Was the patient reversed from muscle relaxants if from theatre YES/NO/NA

8) Was the patient intubated at admission YES/NO

9) If intubated at casualty; who did the intubation (a) Anesthesiologist (b) non-anaestheologist (c) NA

10) Initial mode of ventilatory support on admission
    (a) Invasive (b) Non-invasive

11) Method of administering mechanical ventilation
    (a) Through endotracheal intubation
    (b) Through tracheostomy
    (c) NA

12) If invasive (10 above) which mode
    (a) IPPV or CMV
    (b) SIMV
    (c) CPAP
    (d) BIPAP™
    (e) PSV
    (f) PPS
    (g) ATC
    (h) NA
13) If the patient is getting ventilatory support through tracheostomy, what was the duration of tranlaryngeal intubation before converting to tracheostomy
(a) Number of days / / /
(b) Number of weeks / / /
(c) NA

14) Total duration of mechanical ventilation
(a) Number of days / / /
(b) Number of weeks / / /

15) Was the weaning process ever attempted
YES/NO

16) Outcome of the weaning process
(a) Successful (b) Failed (c) Died while being weaned (d) NA

17) Was tracheal aspirate for culture and sensitivity done?
(a) YES (b) NO

18) Micro-organisms isolated from tracheal aspirate
(a) Klebsiella spp
(b) Pseudomonas aeruginosa
(c) Staphylococcus spp
(d) Gram Negative enterobactericeae
(e) Others
(f) None
(g) NA

19) Drug(s) which these micro-organism(s) are sensitive to:
   a) Meropenem  
   b) Piperacillin  
   c) Tazobactam  
   d) Augmentin  
   e) Tetracycline  
   f) Macrolides  
   g) Cefotaxime  
   h) Ceftazidime  
   i) Ceftriazone  
   j) Gentamicin/Amikacin  
   k) Others  
   l) None  
   m) NA

20) Clinical features for suspected ventilator associated pneumonia noted
(a) Fever  
(b) Hypothermia  
(c) Leucocytosis  
(d) Leucopenia  
(e) purulent tracheal bronchial secretions  
(f) New/persistent chest radiograph infiltrates  
(g) None

21) Complications during mechanical ventilation
(a) Displacement/blockage  
(b) Cardiovascular dysfunction  
(c) Aspiration  
(d) Pneumothorax  
(e) Ventilator associated lung injury  
(f) Ventilator associated pneumonia  
(g) None

22) Critical incidents reported during mechanical ventilation
(a) Breathing circuit disconnection  
(b) Inadvertent gas flow change  
(c) Syringe Swap  
(d) Gas supply problem  
(e) Others  
(f) None  
(g) Premature extubation  
(h) Laryngoscope malfunction
Ref: KNH-ERC/01/4052

26th January 2007

Dr. Njoroge P.N.
Dept of Surgery,
School of Medicine
University of Nairobi

Dear Dr. Njoroge

RESEARCH PROPOSAL: "A STUDY ON THE PRACTICE OF MECHANICAL VENTILATION IN KENYATTA N. HOSPITAL, INTENSIVE CARE UNIT (P186/09/2006)

This is to inform you that the Kenyatta National Hospital Ethics and Research Committee has reviewed and approved your revised research proposal for the period 26th January 2007 – 25th January 2008.

You will be required to request for a renewal of the approval if you intend to continue with the study beyond the deadline given. Clearance for export of biological specimen must also be obtained from KNH-ERC for each batch.

On behalf of the Committee, I wish you fruitful research and look forward to receiving a summary of the research findings upon completion of the study.

This information will form part of database that will be consulted in future when processing related research study so as to minimize chances of study duplication.

Yours sincerely

PROF A N GUANTAI
SECRETARY, KNH-ERC

Prof. K.M.Bhatt, Chairperson, KNH-ERC
The Deputy Director CS, KNH
The Dean, School of Medicine, UON
The Chairman, Dept. of Surgery, UON
Supervisor: Prof. Z. Ngumi, Dept. of Surgery, UON