CHANGES IN SELECTED ELECTROLYTES IN ADULT INTENSIVE CARE PATIENTS AT THE UNIVERSITY TEACHING HOSPITAL, LUSAKA, ZAMBIA

By

Dr Ninza Sheyo

A dissertation submitted to the University of Zambia as partial fulfilment of the requirements for the award of the degree of the Master of Medicine in Anesthesia and Intensive Care

THE UNIVERSITY OF ZAMBIA

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DECLARATION

I, **Ninza Sheyo,** hereby declare that this dissertation herein presented for the award of the degree of Master of Medicine in Anesthesia and Intensive Care has not been previously submitted neither in whole or in part for any other degree at this University nor any other University.

Signed: ………………………………………………………

Student: Dr Ninza Sheyo **BScHB, MBChB**

Signed: ………………………………………………………

Supervisor: Prof Bellington Vwalika **BScHB, MB ChB, MMED, MSc**

Signed: ………………………………………………………

Supervisor: Prof John Kinnear **MBBCh MSc(MedEd) MBA DCH DObst DA FRCA FFICM FAcadMEd FHEA**

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CERTIFICATE OF APPROVAL

The dissertation of **Dr Ninza Sheyo** is approved as fulfilling part of the requirements for the award of the degree of the Master of Medicine in Anesthesia and Intensive Care conferred by the **University of Zambia.**

Signed by:

Name	**Signature**	**Date**
____________________ (Examiner one)	____________________	____________________
____________________ (Examiner two)	____________________	____________________
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ABSTRACT

The importance of regulating potassium and sodium levels is well recognized in most Intensive Care Units (ICU). Various institutions across the globe have found varying figures on the extent and causes of electrolytes derangements in ICUs. Some tertiary hospitals in Africa similar to the University Teaching Hospital (UTH), Lusaka, have reported prevalence's of over 66% of the patients in ICU having multiple electrolyte abnormalities. However, the extent of electrolyte derangements in patients admitted to the Main Intensive Care Unit (MICU) at UTH, Lusaka, Zambia is unknown. This study aimed to evaluate the twenty-four-hour changes in selected electrolytes in adult patients admitted to MICU at UTH, Lusaka, Zambia. An Observational Cross-Sectional Study. Blood samples obtained from a peripheral vein in Heparinized bottles for renal function tests were measured using the Beckman Counter/Au480 (Serial: 2013102691) machine at UTH. Normal serum concentrations of sodium and potassium were considered as 135-145 and 3.5 - 4.5mmol/L, respectively. Statistical analysis was performed with Stata. A total number of one hundred (100) patients were enrolled in this study with a mean age of 36.8 (SD = 12.1). The mean value of sodium level was 136.7 (SD = 8.9) mmol/L and 139.0 (SD = 11.6) mmol/L, on admission and 24 hours post admission respectively. This difference in serum sodium level was shown to be statistically significant with a P-value = 0.005. Hypernatremia was shown to be associated with an increased risk of death (p = 0.02) in the Unit with an odds ratio of 4.3at 95% confidence interval of 1.3 to 13.9. Hyponatremia was the most prevalent electrolyte imbalance but was neither shown to be associated with mortality (P-value = 0.2) nor prolonged ICU stay at 24 hours post admission. The mean value of potassium level was 4.2 (SD = 1.1) mmol/L and 4.3 (SD = 1.1), on admission and 24 hours post admission respectively. This difference was shown to be not statistically significant (P-value = 0.6). Neither hypokalaemia (p = 0.2) nor hyperkalaemia (p = 0.1) were associated with mortality at 24 hours post admission and there was no association with duration of stay in ICU. There is a significant change in serum sodium levels after 24 hours post admission but there is no significant change in potassium level. Hyponatremia being the most prevalent. Hypernatremia remains significantly associated with mortality and therefore, correcting electrolyte imbalances in ICU patients is an urgent necessity.

Keywords: *Hypernatremia, Hyponatremia, Hypokalaemia, Hyperkalaemia, Electrolytes*

DEDICATION

This thesis is dedicated to my late father, **Adam Sheyo**, who taught me that you can reach greater heights if you work hard and put in your best effort and that the best kind of knowledge to have is that which is learned for its own sake. It is also dedicated to my mother, **Angela Mukuka Mumba**, who taught me that even the largest task can be accomplished if you put everything in God's hands.

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CHAPTER 1: INTRODUCTION

1.1 Background

A report of the task force of the World Federation of Societies of Intensive and Critical Care Medicine has defined Intensive Care Unit (ICU) as an organized system for the provision of care to critically ill patients that provides intensive and specialized medical and nursing care, an enhanced capacity for monitoring, and multiple modalities of physiologic organ support to sustain life during a period of acute organ system insufficiency (Marshall, 2017). The acute phase of a critically ill patient is very important if not the most important because it is during this phase of the illness that they rapidly deteriorate due to their dynamic/labile physiologic and catabolic state (Kapoor, 2014). It is during this phase of the illness that patients require an early diagnosis and prompt treatment to have good patient outcome (Kapoor, 2014). Fluid and electrolyte balance is among the key physiologic processes in maintenance of body homeostasis, and it plays very important roles in cellular function, myocardial function, neurological function, enzymatic function, tissue perfusion, oxygen delivery and acid base balance (Balci, 2013). The Main Intensive Care Unit (MICU) at the University Teaching Hospital (UTH) is the largest ICU in the Republic of Zambia with a bed capacity of ten. It accommodates both medical and surgical patients requiring ventilator support and close monitoring. Appropriate fluid and electrolyte management is a challenge and presents a problem with patient treatment in MICU due to limited human resource (staffing) and technological capabilities. This is compounded by the non-availability of laboratory results of electrolytes at the time of admission and/or during patient review rounds. This results in delay in recognition and treatment of electrolyte disturbances, and their presumptive treatment results in iatrogenic derangements.

Various institutions and hospitals across the globe have found varying figures on the extent and cause of electrolytes derangements in Intensive Care Units. However, as early as the 1990s, Devita et al had shown that hyponatremia is the single most frequent electrolyte disturbance encountered in adults in ICU, affecting as many as 24.5% of the patients (Devita, 1990). Depending on the definitions used and the frequency/interval of sample testing, it has been reported to occur in about 30 – 40% of hospitalized patients which is higher than previous estimates of 24.5% by Devita et al in the early nineties (Sedlacek M, 2006). In Calgary, Canada a study done to ascertain the incidence density for the first episode of ICU-acquired hyponatremia and hypernatremia were found to be 3.1 and 7.4 per 100 days of admissions, respectively (Stelfox, 2008). In Europe, Netherlands at the University of Groningen the incidences of mild and severe hypokalemia were found to be 20.2% and 3.3% respectively whilst the incidences of mild and severe hyperkalemia were 17.0% and 3.6% respectively (Hessels, 2015). A study in Lagos, Nigeria, about the incidence of electrolyte and acid base abnormalities in a tertiary hospital similar to the University Teaching Hospital (UTH) in Lusaka found that over 66.78% of the patients in the intensive care unit had multiple electrolyte and acid base abnormalities (Adekola, 2012). However, in East Africa at Makerere University, Mulago Hospital, a study in children showed the contrary to the above-stated statistics in adults with acidosis as the commonest abnormality in children at 65.9% followed by hyperkalemia 14.3%. The extent of electrolyte and fluid imbalance in patients being admitted and already admitted to MICU at UTH Lusaka Zambia is unknown. This is because studies of this nature have not yet been done in Zambia. The situation has remained so despite several studies regionally and internationally that have shown that electrolyte and acid base disturbances are common in ICU.

This study was aimed to ascertain changes in selected electrolytes in patients admitted to the MICU at UTH Lusaka, Zambia.

1.2 Statement of the problem

MICU has a limited capacity of ten beds and the hospital has a high demand for critical care services. Due to service pressures patients need to be optimally treated for their life-threatening conditions and transferred out of the MICU as soon as possible. This includes timely diagnosis and treatment of electrolyte disturbances that the patient is admitted with or acquires during the stay in MICU. An observational study by Damon et al on thirteen Intensive Care Units showed that “about a third of critically ill patients had a mild to moderate dsynatremia at the time of admission and a further third developed dsynatremia during their intensive care stay” (Damon, 2013).

Kapoor et al in 2014 documented in their study that "electrolyte disturbances result in difficulty in weaning patients off the ventilator, prolonged stay in intensive care unit, preventable cardiac arrhythmias, and arrests" (Kapoor, 2014). In order to improve outcome and care of patients, optimal treatment of electrolyte disturbances is of outmost importance and should be expedited. However, the extent of the derangements in MICU is unknown. Currently the treatment of fluid and electrolyte imbalances is empirical due to the lack of results for urea, creatinine, and electrolytes at the time of admission. Hence the subsequent changes in electrolytes after the various interventions done upon admission in the acute phase of the critical illness is not known.

1.3 Study justification

UTH is a resource-limited tertiary institution with limited intensive care bed space and technological capabilities. Early detection and correction of electrolyte disturbances in MICU will reduce morbidity and mortality in the Unit. In addition, early detection of electrolyte abnormalities and correction of the derangements will reduce the length of stay in MICU. Prolonged Intensive care unit stay increases the risk of nosocomial infections which further increases morbidity and mortality.

As already stated in the study by Lee et al earlier on in the previous sections, it is worth noting that fluid and electrolyte abnormalities in critically ill patients can lead to fatal consequences if not detected and/or corrected (Lee, 2010). However, at UTH, there is no data on electrolyte changes in patients admitted to MICU with deranged electrolytes or those who acquire iatrogenic electrolyte disturbances during their Intensive Care Unit stay. Data on electrolyte changes will lead to the development of locally applicable standardized fluid and electrolyte management protocols. A study by Darmon et al argued that "dsynatremia, including mild to moderate changes in serum sodium concentration, is an independent risk factor for hospital mortality and should not be neglected" (Damon, 2013).

This forms the justification for the assessment of the extent of electrolyte disturbances in the first twenty-four-hours post admission to MICU.

1.4 Research question

Do patients admitted to MICU undergo progressive electrolyte derangements during the acute phase of their critical illness?

1.5 Objectives

General

To study the twenty-four-hour changes in selected electrolytes in adult patients in MICU at UTH, Lusaka, Zambia.

Specific

1. To determine changes in serum sodium and potassium
2. To determine the magnitude of serum sodium and potassium derangements
3. To determine if serum sodium and potassium derangements are associated with mortality
4. To determine if serum sodium and potassium derangements are associated with length of ICU stay

CHAPTER 2: LITERATURE REVIEW

2.1 Body fluid compartments

Fluid and electrolytes are present in all compartments in the body. The body fluids can be conceptually divided into compartments as plasma, intracellular fluid (ICF) and interstitial fluid (ISF). Plasma is the fluid component of blood whilst intracellular fluid is the fluid within body cells and interstitial fluid is the fluid found between cells outside blood vessels (McCormick, 2008). Water can pass freely between the three compartments (plasma, ICF and ISF) depending on the osmotic and hydrostatic pressures gradients between the compartments (McCormick, 2008). Together the interstitial fluid and plasma make up the extracellular fluid (ECF) which make up one third of the total body water. Of the total adult body weight, water accounts for approximately 60% which can be divided into two thirds ICF and a third is ECF. Plasma accounts for a quarter of ECF and interstitial fluid accounts for three quarters of ECF. The electrolyte composition of the major fluid compartments is as shown in Table 1.

Table 1: Composition of plasma, interstitial fluid, and intracellular fluid

Cation	**Plasma**	**Interstitial fluid**	**Intracellular fluid**
Na	139.0 mmol/L	145.0mmol/L	10.0 mmol/L
K	4.2 mmol/L	4.0 mmol/L	160 mmol/L
Ca	5.2 mmol/L	5.0 mmol/L	2.0 mmol/L
Mg	1.7 mmol/L	2.0 mmol/L	26.0 mmol/L
Total	150.1 mmol/L	156.0 mmol/L	198.0 mmol/L
Anion			
Cl	103.0 mmol/L	114.0 mmol/L	3.0 mmol/L
HCO3	25.8 mmol/L	31.0 mmol/L	10.0 mmol/L
Proteins	16.0 mmol/L	1.0 mmol/L	53.0 mmol/L
Others	5.0 mmol/L	7.0 mmol/L	0.3 mmol/L
Total	149.8 mmol/L	153 mmol/L	66.3 mmol/L

Fluid and electrolyte replacement is a delicate balance between patient intake and output which should address daily maintenance, deficits, and ongoing abnormal losses or complex internal redistribution issues (Karsten Bartels, 2013). Routine maintenance fluid prescriptions should provide at least the minimal requirements of water and the main electrolytes which include but are not limited to sodium, potassium, calcium, magnesium, and chloride (Karsten Bartels, 2013). The daily requirements of some electrolytes are as follows in Table 2. However, this study will focus on sodium and potassium.

Table 2: Daily electrolyte requirements

Ion	Daily requirement
Sodium	2 – 4 mmol/kg
Potassium	2 – 4 mmol/kg
Chloride	2 – 4 mmol/kg
Calcium	0.5 – 2.5 mmol/kg
Magnesium	0.25 – 1mmol/kg

Intravenous fluids (IVF) can be broadly classified into crystalloids and colloids. Crystalloids are IVFs which are true solutions that contain relatively small molecules that are dissociated into ions capable of passing through a semipermeable membrane. Unlike crystalloids, colloids are not true solutions. They contain larger molecules dispersed throughout a solvent and therefore do not form true solutions and their molecules are not capable of passing through a semipermeable membrane. The non-permeability of colloid molecules makes them able to stay longer in the intravascular space compared to crystalloids. This paper will focus on crystalloids because these are the most commonly used IVFs at the University Teaching Hospital. Colloids are rarely used and stocked due to limited resources and costs. The commonly used and available crystalloids at UTH include normal saline, ringers lactate, and dextrose solutions. The table below shows the constituents of these commonly used crystalloids.

Table 3: Comparison of the constituents of crystalloids

Column1 (mmol/L)	Na	K	Ca	Cl	HCO3	Osmolality	pH
Normal Saline	154	0	0	154	0	300	5
5% Dextrose	0	0	0	0	0	280	4
4% Dextrose,0.18% Sodium Chloride	30	0	0	30	0	255	4
Ringers Lactate	131	5	2	111	29	278	6

As can be noted by comparison of the composition of the body fluids compartments listed in Table 1 and the composition of the various fluids listed in Table 3 available for intravenous administration at UTH, there is no one perfect match for maintenance and replacement. One or more of the electrolytes needs to be added to the intravenous fluid in order to maintain the physiologic composition. Prolonged administration of the above fluids will likely cause a shift or derangement in the physiologic status in one or more of the electrolytes. Red blood cell solutions after storage in citrate and at temperatures of 1^0C - 6^0C have been shown to cause metabolic acidosis with a decrease in the concentration of 2, 3-diphosphoglycerate (2, 3-DPG), leakage of intracellular potassium and accumulation of sodium within the cytoplasm (Angelo D'Alessandro, 2010). Therefore, stored blood is not as physiologic as fresh blood, hence, when administered it can lead to hyperkalemia and acid base imbalances.

Furthermore, several papers and case studies have been published over the years since the Devita study in 1990 that states that disturbances in fluid and electrolytes are among the most common clinical problems encountered in ICU (Lee, 2010) (Balci, 2013) (Bouchard, 2010). Mousavi et al concluded that electrolyte monitoring of patients in intensive care unit is of utmost importance and treatment is a necessity (Mousavi, 2012).

This was in support of the conclusion by Lee Jaw Wood that electrolyte abnormalities in critically ill patients can lead to fatal consequences and therefore close monitoring and early treatment is essential for prevention of mortality. The commonly measured electrolytes at UTH are potassium, sodium, chloride, urea, and creatinine. However, magnesium, calcium and phosphate are not routinely done as well as pH and bicarbonate. Blood gas analysis is a scare resource in MICU at UTH. The focus of this study is potassium and sodium due to their documented high prevalence's in most ICUs as evidenced by the study of Balci et al which stated that the most important and prevailing electrolyte imbalances are hypo- and hyper – states of sodium, potassium, calcium and magnesium (Balci, 2013).

2.2 Hyponatremia

Hyponatremia is defined as plasma sodium levels less than 135mmol/l whilst severe hyponatremia is plasma sodium less than 120mmol/l (Lee, 2010). These definitions of hyponatremia are the same as that used at UTH main laboratory, which defines hyponatremia as any serum sodium levels less than 135mmol/l. As already stated hyponatremia is the most common electrolyte imbalance in intensive care unit patients (Devita, 1990). Critically ill patients in ICU have multiple factors which render them susceptible to hyponatremia. These factors include; current or concurrent comorbid states such as heart failure, excessive water retention by the kidneys, drugs like diuretics and overzealous administration of hypotonic IVFs.

Clinical presentations of hyponatremia can range from an asymptomatic patient, subtle cognitive deficiencies to life threatening neurological impairment which may include status epilepticus, brain herniation and coma (Lee, 2010). Hyponatremia is usually asymptomatic until it is either severe (less than 125mmol/l) or there is a rapid decline in plasma sodium concentration. However, most published papers agree that seizures usually start to occur when plasma sodium falls below 110mmol/l and that the most severe complication is acute cerebral edema (Al-Salman, 2002) (Lee, 2010). These factors are well known to be closely associated with altered or poor prognosis among critically ill patients (Devita, 1990). This has been shown to be true even with mildly low levels of plasma sodium levels (Rafat, 2015). The pathophysiology of hyponatremia can be summarized as follows: water passes freely across cell membranes via osmosis from a compartment of high concentration to a lower concentration of water. On the other hand, solutes do not cross the cell membrane freely unless actively transported in many cases. Since solutes are usually confined to one compartment they tend to hold on to water towards them. These solutes that hold water in one fluid compartment are called active osmolytes. Hence water is always in a state of equilibrium between compartments depending on the osmolarity of the compartments. An alteration in osmolarity in one compartment leads to a change in the other compartment to restore the equilibrium. The body tends to maintain a constant extracellular osmolarity. This is under the control of the hypothalamus via the posterior pituitary gland which secretes antidiuretic hormone (ADH). The osmolarity of plasma is detected in the hypothalamus and depending on whether its high or low, ADH is either secreted or not, respectively. ADH acts on the renal tubules to promote water retention or reabsorption.

The main extracellular solute is sodium, whose concentration determines the volume status of the patient and the hydration status.

Therefore, hyponatremia can be classified depending on the volume status of the patients as hypovolemic, euvolemic and hypervolemic. Management of hyponatremia presents a great challenge for intensivists and indeed other clinicians. Failure to correct imbalance places the patient at risk of hyponatremic encephalopathy, seizures and brain herniation (Rafat, 2015). Correction of plasma sodium is an emergency in symptomatic patients. Those symptomatic and with acute onset of less than 48 hours needs prompt treatment with normal saline and would benefit from treatment with hypertonic saline (3%) at the rate of 1 – 2ml/kg/hr. to raise sodium by 1 – 2mmol/l/hr. which has been shown to be of benefit in patients with acute cerebral edema (Lee, 2010). However, the correction should not exceed 12mmol/l for 24 hrs. as rapid correction greater than 12mmol/l increases the risk of osmotic demyelination (Lee, 2010).

Asymptomatic euvolemic hyponatremia does not require urgent therapy and treatment of the cause of the electrolyte abnormality usually corrects the hyponatremia. In this state the brain cells have adapted to hypo osmolality of plasma and these patients are asymptomatic. However fluid restriction is important in this group of patients. Hypovolemic hyponatremia results from loss of both water and sodium with a greater loss of sodium and treatment is normal saline. Hypervolemic hyponatremia occurs when both water and sodium are retained in the body but water to a greater extent. Overzealous administration of sodium-free fluids should be stopped and diuretics such as furosemide can be given.

2.3 Hypernatremia

Polderman et al in 1999 conducted a retrospective study in a medical ICU in Netherlands looking at the incidence and prevalence of dsynatremia's. They reported that hypernatremia occurred in 9% of patients admitted to the ICU and went on to report that even after ICU admission, as many as 6% of additional patients develop hypernatremia during their intensive care unit stay (Poldeman, 1999). The same study by Polderman further went on to evaluate the association between hypernatremia and mortality and they found that patients who presented with hypernatremia had a 20% hospital mortality rate compared with 32% in patients who acquired hypernatremia during their ICU stay (Poldeman, 1999). Lindner and colleagues described a similar incidence of hypernatremia in a medical ICU in Austria but reported higher hospital mortality rates than in the Dutch study by Polderman; as high as 43% (lindner, 2010). Another study by Stelfox and colleagues showed that acquired hypernatremia is associated with an increase in hospital mortality (Stelfox, 2008).

Patients in ICU are at risk of developing hypernatremia for various reasons (Lee, 2010). These include the following, but this list is not exhaustive:

1. Gastrointestinal fluid losses through nasogastric suctioning and secretions
2. Traumatic brain injury with or without pituitary infarction
3. Water loss through fever, drainages, third spaces and open wounds
4. Drug related sodium load – sodium bicarbonate, lithium, amphotericin – B, mannitol, hypertonic saline and normal saline

Basically, hypernatremia is a net loss of water in comparison to sodium loss or a hypertonic sodium gain due to treatment with sodium-rich substances. Its detection and treatment are not a one size fits all type of approach. It requires recognition of symptoms, and identification of the cause of water deficit then correction of volume disturbances, and of hypertonicity. Treatment should be approached with caution just like that of hyponatremia. The rate of correction should depend on the rate of development of hypernatremia and whether it is symptomatic or not. The study by Lee and colleagues recommended that half of the water deficit be replaced in 12 to 24 hours with monitoring of neurological status (Lee, 2010). The remaining half should be replaced over the next 48 hours and the maximum rate of plasma decrease should not exceed 2mmol/l/hr. (Lee, 2010).

2.4 Hypokalemia and hyperkalemia

The major cation in the intracellular fluid is potassium. Potassium is another electrolyte in addition to sodium whose homeostasis is frequently disturbed in critically ill patients admitted to ICU (Kraft, 2005). It is the most abundant ion in the intracellular environment and is required for maintenance of ICF osmotic pressure but has other vital functions such as in conversion of dextrose into ATP and in nerve impulse transmission in excitable tissues. Intracellular concentration of potassium is maintained by the sodium potassium ATPase pump which actively transports three Na^+ ions out of the cell and two K^+ ions into the cell. Many drugs used in the intensive care unit can alter the physiology of the sodium-potassium ATPase pump. Commonly used drugs that alter the pump include insulin, beta agonists, and adrenaline. (Kraft, 2005). Potassium imbalances can be caused by either medical or surgical conditions. Among medical conditions causing potassium imbalances are diabetes mellitus, sepsis, renal failure, and gastroenteritis. Surgical conditions are mostly intra-abdominal pathologies such as peritonitis and intestinal obstruction. Kidneys are essential in potassium homeostasis. About 90% of filtered K^+ is reabsorbed in the proximal tubule and loop of Henle, and less than 10% reaches the distal nephron. The rate of K^+ secretion by the distal nephron varies and is regulated according to physiologic needs. Therefore, kidney disease results in dyskalemias. Despite dyskalemias being a common occurrence in intensive care unit patients, there is sparse data on the relation between mortality in patients in intensive care unit and the disorders of potassium. Both hypo- and hyperkalemia have been well documented to cause arrhythmias, asystole and altered neuromuscular control (Kraft, 2005). Therefore, monitoring for dyskalemias should be mandatory in all high-risk patients and derangements in serum potassium levels should be treated promptly and if possible avoided. (Hessels, 2015).

Hypokalemia is treated with potassium replacement. Unless it is an emergency such as symptomatic hypokalaemia or severe hypokalemia (less than 2.5mmol/l) the preferred mode of replacement is oral. (Lee, 2010). Intravenous replacement requires close monitoring in ICU or HDU with electrocardiography and regular sampling to check for the raise in serum levels. In adults, the rate of IV replacement should not exceed more than 20mmol per hour. Lee et al recommend that the initial dose should be in the range of 40–80mmol and the total daily amount of potassium should be less than 240–400mmol/day (Lee, 2010).. It is recommended that the fluid of choice for IV replacement of potassium should be glucose free in order to avoid rapid intracellular movement. Hence ringers lactate or normal saline would be appropriate.

The treatment of hyperkalemia depends on whether it is mild or severe. Mild hyperkalemia can be corrected by treating the underlying cause only, provided it is not symptomatic. Severe hyperkalemia is a medical emergency and should be treated promptly. Intravenous calcium gluconate should be administered to protect the myocardium from lethal complications and then measures to push potassium into cells should be instituted. Among the strategies used to drive potassium into cells are a bolus of 10 units soluble insulin with 50ml of 50% dextrose, bicarbonate infusion and intravenous beta agonists such as salbutamol. Lee states that “Insulin with 50% dextrose has been shown to be the most effective for rapid movement of potassium into cells” (Lee, 2010).

CHAPTER 3: METHODOLOGY

3.1 Study design

This study was a cross – sectional study of adult patients 18 years and above admitted to the main intensive care unit (MICU) at the University Teaching Hospital (UTH), Lusaka, Zambia. The target population were critically ill patients in UTH admitted to MICU of which the study population were patients who met the eligibility criteria. The criteria included patients above 18 years old admitted for at least 24 hours in the unit. These patients were both medical and surgical regardless of the primary diagnosis from their respective wards (medical wards, surgical wards and obstetrics and gynecologic wards). The patients were admitted for either close monitoring and/or ventilatory support. Re – admissions were excluded from the study. This study focused on the abnormalities of sodium and potassium.

3.2 Definitions

The derangements or abnormalities of sodium can be categorized into mild, moderate, and severe hypernatremia or hyponatremia whilst those of potassium are categorized as mild, moderate, and severe hyperkalemia or hypokalemia. Table 4 illustrates the ranges of the above-mentioned derangements.

Table 4: Sodium and potassium abnormalities

	Mild	Moderate	Severe
Hypernatremia	146 – 150 mmol/l	151 – 155 mmol/l	>156 mmol/l
Hyponatremia	130 – 134 mmol/l	125 – 129 mmol/l	<125 mmol/l
Hyperkalaemia	5.6 – 6.0 mmol/l	6.1 – 7.0 mmol/l	>7.0 mmol/l
Hypokalaemia	3.0 – 3.4 mmol/l	2.5 – 2.9 mmol/l	<2.5 mmol/l

3.3 Sample size calculation and sampling methods

Sample size calculation

Sample size calculation formulae for prevalence

$$N=Z^2 X P (1-P)/ (E)^2$$

Where

N=sample required

Z=Z statistic=1.96(95% CI)

P=expected prevalence 0.07 (assuming regional complication rate of 7% for severe derangements)

E=confidence interval 0.05

Therefore $N= (1.96)^2 X 0.2(1-0.2)/ (0.05)^2=$**100**

Sample size calculated from the formulae is 100 patients

Sampling methods

This clinical study was a consecutive case series. A random starting patient was picked who met the inclusion criteria then all eligible patients thereafter. The patients were recruited in the order in which they were identified by meeting the inclusion criteria during the study period in MICU.

3.4 Data management

Data was collected from patients who met the inclusion criteria with an informed consent obtained from the patient, next of kin or the Senior Medical Superintendent in case the patient is unknown. These patients were enrolled upon admission to MICU and followed up until either their transfer to the ward or death within the Unit. The first panel of investigations was collected upon admission to MICU. This data was obtained from the routine baseline investigations obtained from every patient admitted to the Unit which included a full blood count, renal function tests and liver function tests. The second set of investigations was collected 24 hours post admission to MICU. This set of investigations are part of the daily routine investigations of patients in a well-equipped institution. The blood samples were obtained from a peripheral vein in EDTA bottles for full blood count and HEPARINIZED bottles for renal function tests. The samples were analyzed from the UTH main laboratory. Serum electrolyte measurements were measured using the BECKMAN COULTER/AU480 (SERIAL: 2013102691) machine.

In addition, the patient's co-morbidities, fluid balance sheet, and medications were obtained and entered together with the panel of investigations. Together this data was entered into a data collection sheet. Figure 4 shows the stages through which the data was collected and entered into the data collection sheet.

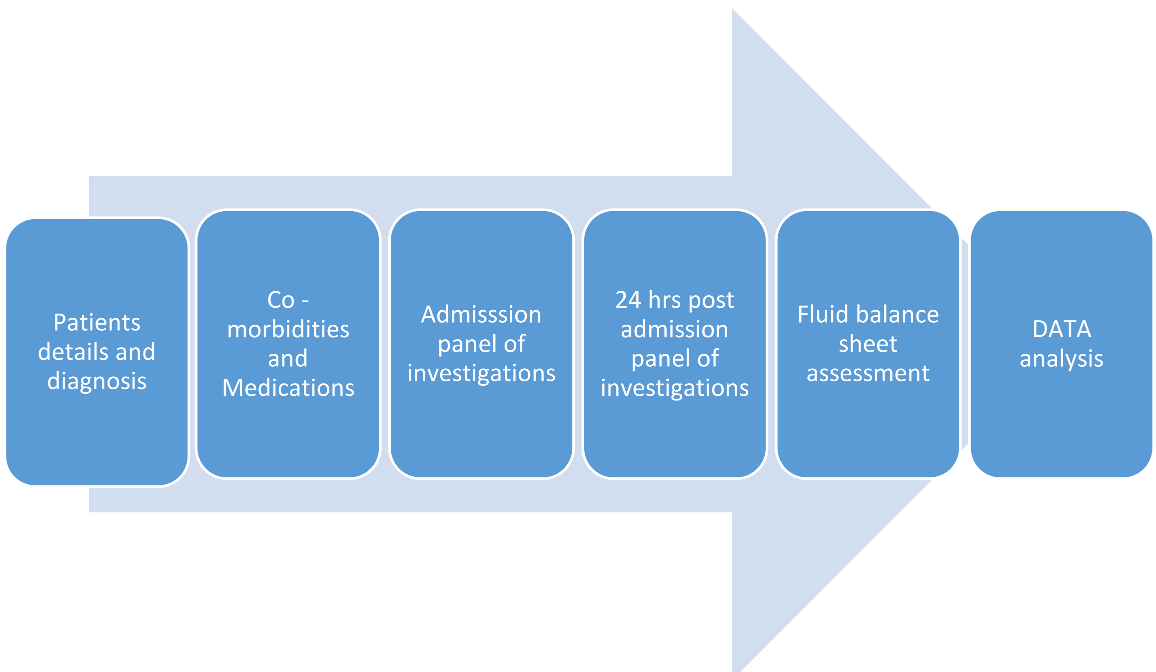

Figure 1: Flow chart of data collection and management

3.5 Strategy for data analysis

To prevent errors double entry and consistent checks were done. The data collected was then computed into an excel spread sheet. Data from excel spread sheet was imported into STATA special edition 13.0 for statistical analysis. The data was summarized and expressed as mean, median and standard deviation. Comparisons between means were done with paired t-test and non-parametric data with the Wilcoxon signed rank test. Association between categorical variables were studied with the Chi – square test. Logistic regression Analysis was used to investigate the relationship between dependent and independent variables. The independent variables included in the model were hyponatremia, hypernatremia, hypokalemia, and hyperkalemia. The dependent variables were mortality within ICU and prolonged stay in the unit. A p – value < 0.05 was considered statistically significant.

3.6 Ethical consideration

The purpose of the study was explained to all patients who were conscious and with intact mental faculties. In those that were under constant sedation and those that were unconscious for reasons other than sedation, the information was given to the next of kin. Only those who understood and consented to take part in the study by either appending a signature or thumb print were recruited. In unconscious patients who were unknown at the time of admission, the consent was obtained from the Senior Medical Superintendent for recruitment in the study. Participation in the study was voluntary and the patient or next of kin could withdraw the patient at any point during the study without any compromise in there medical or surgical treatment. Patients or the next of kin were not be coerced to give consent or receive any remuneration (monetary or otherwise) during the study.

In addition, all patient records were protected and kept confidential as stipulated in the Health Professions Act. No 24 of 2009. Full privacy and confidentiality of the patients was followed as per the set rules and regulations of the Health Professions Council of Zambia (HPCZ). The information obtained was used only for research purposes and access to this information was restricted to the principal investigator and the supervisors. However, any information pertinent to the patient's wellbeing was communicated to the attending medical team. All procedures performed on the patient were in accordance with the underlined treatment plan. The information obtained from this study will not only add to the body of knowledge but could benefit other patients admitted to the intensive care unit. Ethical approval was sought from the University of Zambia Research Ethics Committee and granted on 28th November 2016. Ethical clearance number: **UNZABREC (REF. NO.006-10-16).** Permission to utilize MICU for research was sought from the hospital director of clinical care and permission was granted on the 16th of September 2016.

3.7 Limitations

This research was carefully designed, developed, and executed but I am still aware of its limitations.

1. The research was conducted in a single center with limited bed capacity of ten beds.
2. Short follow up of patients (only 24 hours)
3. Non-measurement of fluid balance and fluid type used
4. Non-measurement of sodium load in the first 24 hours
5. The inconsistent supply of laboratory reagents and other related consumables coupled with intermittent machine breakdowns resulted in fallout and exclusion of patients whose panel of investigations could not be done or completed.

CHAPTER 4: RESULTS

A total number of one hundred (100) patients were included in this study with a mean age of 36.8 (SD = 12.1). Most patients were males 55 (55%) and in the age group of 18 to 73 years, median age of 34 years. The females were 45 (45%) and in the age group of 20 to 70 years, median age of 35 years. The average length of stay was 5.5±4.7 days in MICU until death/transfer to other wards. Of the total admission, 52% were transferred to other wards whilst 48% died in the unit. The results are summarized in Table 5.

Table 5: Demographic characteristics of patients

Age (Years)	**Total**	**Gender**	
		Male	**Female**
Percentage (%)	100	55(55%)	45(45%)
Mean	36.8	35.9	37.7
Median		34	35
Standard deviation	12.1	11.9	12.1

The mean value of sodium level was 136.7 (SD = 8.9) mmol/L and 139.0 (SD = 11.6) mmol/L, on admission and 24 hours post admission respectively. This difference in serum sodium level was statistically significant with a P-value = 0.005. The mean value of potassium level was 4.2 (SD = 1.1) mmol/L and 4.3 (SD = 1.1), on admission and 24 hours post admission respectively. This difference was not statistically significant (P-value = 0.57). These results are summarized in Table 6 on the next page.

Table 6: Main Clinical variables of patients

	0 hours	24 hours	P - value
Serum sodium level	136.7±8.9	139.0±11.6	0.005
Serum potassium level	4.2±1.1	4.3±1.1	0.568
Serum sodium status	**0 hours**	**24 hours**	
Hyponatremia	128.6±5.4	127.7±7.3	
Normal	138.5±2.8	139.1±2.6	
Hypernatremia	142.3±7.2	155.6±9.0	
Serum potassium status	**0 hours**	**24 hours**	
Hypokalemia	3.1±0.4	3.0±0.5	
Normal	3.9±0.3	4.0±0.3	
Hyperkalemia	5.6±0. .8	5.5±0.9	

Hypernatremia was shown to be associated with an increased risk of death (p = 0.015) in the Unit with an odds ratio of 4.30 at 95% confidence interval of 1.3 to 13.9. However, hypernatremia was not shown to be associated with prolonged stay (P = 0.44) in MICU. This is illustrated in Table 7 below.

Table 7: Logistic regression results for increased risk of Mortality in MICU

Independent variables	Odds Ratio	[95% Conf. Interval]	P>|z|	St. Err	z	Coef.
Sodium						
Hyponatremia	0.5	0.1 - 1.4	0.210	0.51	-1.26	-0.64
Hypernatremia	4.3	1.3 - 13.9	0.015	0.60	2.44	1.46
Potassium						
Hypokalaemia	1.8	0.6 - 5.5	0.294	0.56	1.05	0.59
Hyperkalemia	2.5	0.9 - 6.7	0.074	0.50	1.79	0.90
Constant	0.5	0.2 - 1.1	0.079	0.39	-1.75	-0.69

Table 8 illustrates that hyponatremia was not associated with prolonged Intensive Care Unit stay (P = 0.56) at 24 hours post admission. In addition, it also shows that neither hypokalaemia (p = 0.29) nor hyperkalemia (p = 0.07) were associated with increased duration of stay in the unit, hypokalaemia (P = 0.09) and hyperkalemia (P = 0.49).

Table 8: Logistic regression results for prolonged duration of Stay in MICU

Independent variables	**Odds Ratio**	**[95% Conf. Interval]**	**P>|z|**	**St. Err**	**z**	**Coef.**
Sodium						
Hyponatremia	0.8	0.3 – 2.0	0.559	0.49	-0.58	-0.29
Hypernatremia	1.6	0.5 - 4.8	0.446	0.57	0.76	0.43
Potassium						
Hypokalaemia	2.7	0.9 - 8.3	0.091	0.58	1.69	0.98
Hyperkalemia	1.4	0.6 - 3.5	0.485	0.48	0.70	0.33
Constant	1.1	0.5 - 2.3	0.799	0.37	0.25	0.94

As can be seen in Table 9, the longest duration of stay in the unit during the time of study was 30 days. The three longest-staying patients were head injury patients due to trauma because of road traffic accidents. All three patients were transferred to the wards with poor neurological outcome and dependent on tracheostomy. At day five, 62 percent of patients were still admitted in MICU, but that figure dropped by more than half to 29 percent at day 10. The drop in the number of patients post admission on days 5 and 10 can be attributed to the high mortality rate which usually occurs in the first 48 hours of admission in MICU. In addition, surgical patients for post-operative recovery are discharged between day 3 and day 5 to the surgical wards.

Table 9: Relationship of the Duration of Stay in MICU to Sodium and Potassium before and after 24 hours.

Duration of stay	Frequency	Sodium (mmol/L)		Potassium (mmol/L)	
		0 hrs.	**24 hrs.**	**0 hrs.**	**24 hrs.**
0 - 5	62	136.0	137.6	4.2	4.3
6 - 10	29	138.2	140.6	4.2	4.3
11 - 15	6	137.7	144.8	3.8	3.7
16 - 20	1	134	141	3.9	4.0
21 - 25	1	131	146	7.4	4.5
26 - 30	1	135	136	4.5	3.2

Table 10 summarizes the reasons for ICU admission in the MICU at UTH. The commonest reasons for ICU admission were sepsis (27%) and surgical interventions (27%). Surgical interventions included postoperative patients needing ICU due to either the severity of the illness or the nature of the operation. Sepsis and surgical interventions were followed by cardiovascular disorders (19%) and trauma (15%).

Table 10: Reasons for ICU admission

Disease	Percentage (%)
Sepsis	27
Surgical interventions	27
Cardiovascular Disorders	19
Trauma	13
Status Epilepticus	5
Organophosphate Poisoning	4
Others*	5
Total	**100**

Others*: Tetanus, GBS, Alcohol intoxication etc.

CHAPTER 5: DISCUSSION

In this study, serum sodium changes were evaluated in the first twenty-four hours of MICU admission and the difference in serum sodium level between 0 hour and 24 hours was statistically significant with a P-value = 0.0051. The mean sodium level was 136.7 (SD = 8.9) mmol/L and 139.0 (SD = 11.6) mmol/L, 0 hours and 24 hours post admission respectively. Hyponatremia was the most prevalent electrolyte imbalance on admission whilst hyperkalemia was the most prevalent electrolyte abnormality 24 hours post admission. Hypernatremia was the least prevalent electrolyte abnormality both on admission and 24 hours post admission but was associated with an increased risk of death (p = 0.021) in the Unit with an odds ratio of 4.0 at 95% confidence interval of 1.3 to 13.9. However, hyponatremia was neither associated with mortality (P-value = 0.18) nor prolonged MICU stay at 24 hours post admission (P – value = 0.56). The mean potassium level was 4.1 (SD = 1.1) mmol/L and 4.3 (SD = 1.1) mmol/L, on admission and 24 hours post admission respectively. This difference was not statistically significant (P-value = 0.56). Neither hypokalemia nor hyperkalemia were associated with mortality and prolonged ICU stay.

The most prevalent electrolyte abnormality at the point of admission was hyponatremia (36%) followed by hyperkalemia (28 %), hypokalaemia (24%) and the least was hypernatremia (13%). 24 hours post admission in the intensive care unit, there was no significant changes in potassium levels. However, there were significant changes in sodium levels with the notable change in patients with hypernatremia. There was a significant increase in the number of patients with hypernatremia by almost twice the number at 24 hours from the number recorded at admission. This reflects the study by Polderman that “hypernatremia is an indicator of quality of care in Intensive Care Unit”. One explanation for this blood picture is possible dehydration resulting from the high incidence of patients not fed orally (65%) in the first 24 hours of admission (Poldeman, 1999). This was mostly in surgical patients whose treatment plan required them to be zero per oral. Other losses may be related to active nasogastric or oral gastric tubes. Hypernatremia may also be due to increased losses from the kidneys due to renal impairment in critically ill patients coupled with reduced water intake. In medical patients, the commonest reason for not feeding or giving fluids orally was an active nasogastric or orogastric tubes. The unit doesn't have a clear policy or guideline at which volume of aspirate should lead to restrictions of oral feeds and fluids. This results in patients being starved and fluid restricted unnecessarily. Fluid replacement is key in maintaining fluid balance. In MICU, there are only two working infusion pumps against ten patients in the unit. This poses a challenge in replacing fluids and titrating fluids as prescribed in MICU resulting in the developing of hypernatremia. Rosner et al 2010 stated that hypernatremia in the Intensive Care Unit is often iatrogenic and due to inadequate free water replacement of ongoing water losses.

Normal saline was a commonly used crystalloid in MICU despite having a high concentration of sodium and a tendency of causing hyperchloremic acidosis. This could be the cause of hypernatremia in certain patients with impaired homeostasis. Hypernatremia was also shown to be associated with poor outcome (mortality) but not with prolonged ICU stay. The unadjusted OR of death within 24 hours of admission was 3.99 with sodium level >145 mmol/L. Rosner Et al 2010 demonstrated that "hypernatremia present on admission or developing in ICU is an independent risk factor for poor prognosis" (Rosner, 2010). This was earlier documented by Bagshaw Et al 2009 that "hypernatremia in hospitalized patients is iatrogenic and may contribute to serious morbidity and increased risk of death" (Bagshaw, 2009). Another study showed that "the development of hypernatremia is associated with adverse outcomes for patients developing hypernatremia in the ICU and hypernatremia could potentially be used as an indicator of quality of care in the medical ICU" (Lobo, 2006).

There was a slight decrease in the patients with hyponatremia, but it remained the second most common electrolyte abnormality at 24 hours post admission. Damon et al., 2013 reported findings that "there is a high prevalence of dsynatremia's at ICU admission and that even mild to moderate abnormal concentrations are risk factors for ICU mortality" (Damon, 2013). Despite being the most prevalent electrolyte abnormality, hyponatremia was not associated with mortality and prolonged ICU stay. This result is unlike the studies by Rosner Et al 2010 and Bagshaw Et al which showed an increased risk of mortality in patient with hyponatremia (Bagshaw, 2009) (Rosner, 2010). This disparity may be due to the reduction in the number of patients with hyponatremia 24 hours post admission.

The high frequency of hyponatremia can be attributed to administration of hypotonic fluids (5% dextrose and 10% dextrose) and impaired water secretion and retention.

The increase in incidence of hyperkalemia after admission may be explained by the pre – existing renal failure or indeed the developing renal failure with delay in dialysis. Prevalence of hypokalaemia remained the same. Patients with hypokalemia were postoperative patients for abdominal pathologies such as peritonitis and bowel obstruction. Other patients with hyponatremia were on medical treatment with beta – blockers, insulin and adrenaline. In this study hyponatremia, hypokalaemia and hyperkalemia were all not shown to be associated with either poor outcome or prolonged duration of stay. This lack of statistical significance is probably a consequence of the weakness in the sample size of this study, or the degree of change in electrolyte in a 24-hour period may not have produced significant disturbances to support the already existing literature. Further research may need to be done to compare the changes at subsequent times e.g. 48 hours, 72 hours, or 5 days post admission.

As stated by Balci et al" fluid and electrolyte balance is one of the key issues in maintaining homeostasis in the body, and it also plays important roles in protecting cellular function" (Balci, 2013). Therefore, a change in serum electrolytes in the various fluid compartments may result in impairment of cellular function and homeostasis. In the Intensive Care Unit, the patients are in a dynamic physiologic state which may rapidly deteriorate (Kapoor, 2014). Hence, slight changes in the electrolyte and fluid status can have significant impact on the outcome and duration of stay in Intensive Care Unit if these patients are not appropriately and promptly managed (Damon, 2013).

During the period of study at the UTH, a total number of one hundred (100) patients were included in this study with a mean age of 36.8 years (SD = 12.1). Fifty six percent (56%) of the patients admitted to MICU were admitted for ventilator support whilst 44% were admitted for close monitoring only. The high percentage of patients admitted for close monitoring only in MICU was due to a lack of high dependency units (HDUs) in the various departments in the hospital. In addition, MICU is an open ICU. This has left the power of admission to the respective medical and surgical specialties to admit their patients to MICU without consultation with intensivists. The surgery department had the highest number of admissions (49%) into the unit followed by internal medicine (37%) and the least was obstetrics and gynecology (14%). Similar findings were reported in Nigeria (Onyekuwulu et al., 2015) where surgical admission was the most common followed by internal medicine and lastly obstetrics (Onyekwulu, 2015). Of the surgical patients admitted 41% died whilst 59% of the medical patients died and 43% of the obstetric and gynecologic patients died. The overall mortality rate was 48%. This is similar to that reported in comparable ICUs across Africa. In Kenya (Lalani et al., 2017) the mortality rate was at 53.6%, and in Nigeria (Onyekuwulu et al., 2015) it was at 34.6% and in Uganda (Kwizera., 2012) it was at 33.2% (Lalani, 2017) (Onyekwulu, 2015) (Kwizera A, 2012). Unfortunately, the mortality rate in Zambia and some other African countries is very high compared to high income countries where the average mortality rate is 7% (Siddiqui, 2015).

The commonest diagnoses that led to MICU admission were sepsis and surgical interventions followed by cardiovascular disorders. This is a different picture from what was reported in Ethiopia (Agalu et al., 2014) where the commonest diagnosis was cardiovascular disorders (Agalu, 2014). The average length of stay was 5.48±4.70 days in the Intensive Care Unit till death/transfer to other wards.

The most common co-morbidity was HIV (25%) followed by renal failure (18%). Others included hypertension (6%), diabetes (4%), and liver failure (4%). Similar findings were reported in Ethiopia (Agalu et al.,2014) where infectious diseases were the most common co-morbidity rather than cardiovascular disorders such as hypertension (Agalu, 2014). Renal failure had a huge impact on the management of fluid and electrolytes because of the delay in access to dialysis. Delay in accessing dialysis was due to various factors beyond the scope of this study.

CHAPTER 6: CONCLUSION AND RECOMMEDATIONS

6.1 Conclusion

The results from this study shows that electrolyte and fluid disturbances can occur as early as 24 hours post admission into ICU. Therefore, electrolyte imbalances can occur as early as the first day of admission in ICU with fatal complications. Hyponatremia was the most prevalent abnormality in the patients admitted to the unit but there was a tendency of the blood picture to change towards hypernatremia as the patient stayed longer in the unit. There was a significant change in serum sodium levels after 24 hours post admission but there was no significant change in potassium level. Hypernatremia remained significantly associated with mortality and therefore, correcting electrolyte imbalances in ICU patients is an urgent necessity and should not be delayed. We should therefore manage electrolytes better in ICU. Hence early treatment and correction of electrolyte disturbances can reduce the high mortality rate which currently stands at 48%.

6.2 Recommendations

There is a high mortality rate in the main intensive care unit at UTH. To help reduce this high mortality rate and improve fluid and electrolyte management, the following recommendations are proposed:

1. Further research should be done to assess the changes in electrolytes at 48 hours, 72 hours and subsequent days e.g. day 4.5 etc.
2. Further research should be done to assess the sodium load given to patients when admitted to ICU
3. To develop an electrolyte management policy in the intensive care unit which will lead to the timely diagnosis and treatment of the identified electrolyte abnormalities
4. Procurements of more types of intravenous fluids for treatment of electrolytes disturbances which are very prevalent.

5. Adequate stocking of laboratory reagents and other related consumables so that timely electrolyte analysis is performed for prompt treatment of electrolyte abnormalities
6. The Main Intensive Care Unit needs to be well equipped with fluid pumps for fluid replacement

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APPENDICES

Appendix 1: Information sheet

TITLE: CHANGES IN SELECTED ELECTROLYTES IN ADULT INTENSIVE CARE PATIENTS AT THE UNIVERSITY TEACHING HOSPITAL, LUSAKA, ZAMBIA

Introduction

I am **Dr Ninza Sheyo**, a Doctor in the Department of Anesthesia and Intensive Care at the University Teaching Hospital pursuing a master's degree in Anesthesia and Intensive Care with the University of Zambia. I am doing a research on the problem of electrolytes changes in critically ill patients admitted to the Main Intensive Care Unit at the University Teaching Hospital. I would like to give you information and invite you to be part of this research. You do not have to decide immediately on whether or not you will participate in the research. Before you decide, you can talk to anyone you feel comfortable with about the research.

This consent form may contain words that you do not understand. Please ask me to stop as we go through the information and I will take time to explain. If you have questions later, you can either ask me or my supervisor.

Purpose and method of the study

The research is in partial fulfilment of the requirements for the award of the Degree of the Master of Medicine in Anesthesia and Intensive Care. It is hopeful that this research will help in the care of very sick patients. Very sick patients requiring admission to Intensive Care Unit have bodily functions that worsen easily and can lead to death if intervention is not timely done. Among the issues needed to maintain normal bodily function is electrolyte balance. It's been discovered from research in developed countries and indeed in some African countries that changes in electrolytes is a common problem and that it leads to worsening of the disease and eventually can lead to death. This research intends to find out the extent and magnitude of this problem in our Intensive Care Units in Zambia so that timely intervention can be done to prevent death.

Procedures

You will be subjected to a series of needle pricks in order to collect blood for electrolyte analysis. You will be subjected to the collection of first samples of blood on admission to the Main Intensive Care Unit as part of routine blood collection required of all patients admitted to Main Intensive Care Unit. After 24 hours of admission, the second set of samples will be collected. In addition, the file will be reviewed for further information relevant to the research.

Potential Risks

You will not be exposed to any additional risks by participating in this research

Potential Benefits

There will be no direct benefit to you or your relatives, but your participation is likely to help us find out more about how to treat and care for critically ill patients admitted to MICU and in turn help reduce mortality.

Right as a research participant

Your participation in this research is entirely voluntary. It is your choice whether to participate or not. If you choose not to participate all the treatment and care you receive in the Main Intensive Care Unit will continue and nothing will change. And if during the study we find a problem, we will notify your attending physician for immediate attention

Confidentiality

The information obtained will be used only for research purposes and access to this information will be restricted to my assistant, me and my supervisors. In addition, all patient records will be protected and kept confidential. None of the information that we will collect from the study will be shared with anybody outside the research team, and nothing will be attributed to you by name. However, any information pertinent to the you or your relative's wellbeing will be communicated to the attending medical team.

Remuneration

You will not be provided any incentive to take part in the research

Further Information

If you have any questions or concerns regarding ethical issues in the conducting of this study, you may contact:

Dr Ninza Sheyo
Phone: 096 744 0748
Email: Ninza.sheyo@gmail.com

The chairperson,

University of Zambia Biomedical Research Ethics Committee (UNZABREC)

School of Medicine

Ridgeway Campus

Tel: +260 211 256 067

E-mail: unzarec@unza.zm

Appendix 2: Consent form

I, ______________________________________ hereby confirm that the nature of this clinical study has been explained to me. I am aware that my personal details will be kept confidential and I understand that I may voluntarily, at any point, withdraw my participation without suffering any consequences. I have been given sufficient time to ask questions and seek clarifications, and of my own free will do hereby declare my participation in this research.

I have received a signed copy of this agreement

Name of participant: _______________________________________

Signature/Thumb print: ____________________________________

Date: _____/ _____ / _____

Name of witness: ____

Signature/Thumb print: ___________________________________

Date: ______ / ______ / ______

Appendix 3: Data collection sheet

ENTRY NUMBER: …………………… FILE NUMBER: ………………………………

	M	F
Sex	**0**	**1**
		Reason For admission
Ventilator		**0**
Observations		**1**
Both		**2**
Diagnosis		
		Admitting Department
Surgery		**0**
Medicine		**1**
Obs Gyn		**2**
		Co-morbidities
HIV		**0**
HTN		**1**
DM		
Renal Failure		**2**
Liver Failure		**3**
Others		**4**
Fasted	**Vol.feed ml**	
Yes		**0**
No		**1**

PANEL OF INVESTIGATIONS:

Day…	0 Hours	24 Hours
HB		
HCT		
Na		
K		
Cl		
Urea		
Cr		
ALT		
AST		

1. **Drug History**

Drug	Yes	No
Thiazide/Loop Diuretics	0	1
Osmotic Diuretics	0	1
ACE/ARB	0	1
Amphotericin - B	0	1
Beta Blockers	0	1
Insulin	0	1

2. FLUID BALANCE:

- 24hrs Intake:

- 24hrs Output:

3. TYPE OF FLUIDS GIVEN:

Fluid	Code
Ringers Lactate	0
Normal Saline	1
Dextrose Saline	2
Free Water	3

4. DURATION OF STAY IN MICU:

5. OUTCOME:

Discharge	0
Mortality	1

THE UNIVERSITY OF ZAMBIA

BIOMEDICAL RESEARCH ETHICS COMMITTEE

Telephone: 260-1-256067
Telegrams: UNZA, LUSAKA
Telex: UNZALU ZA 44370
Fax: + 260-1-250753
E-mail: unzarec@unza.zm

Ridgeway Campus
P.O. Box 50110
Lusaka, Zambia

Assurance No. FWA00000338
IRB00001131 of IORG0000774

28th November, 2016.

Our Ref: 006-10-16.

Dr. Ninza Sheyo,
University of Zambia,
School of Medicine,
Department of Anaesthesia,
P/Bag RW 1X,
UTH,
Lusaka.

Dear Dr. Sheyo

RE: RESUBMITTED RESEARCH PROPOSAL: **"TWENTY-FOUR HOUR CHANGES IN SELECTED ELECTROLYTES IN ADULT PATIENTS ADMITTED TO THE MAIN INTENSIVE CARE UNIT AT THE UNIVERSITY TEACHING HOSPITAL, LUSAKA, ZAMBIA" (REF. NO. 006-10-16)**

The above-mentioned research proposal was presented to the Biomedical Research Ethics Committee on 25th November, 2016. The proposal is approved.

CONDITIONS:

- This approval is based strictly on your submitted proposal. Should there be need for you to modify or change the study design or methodology, you will need to seek clearance from the Research Ethics Committee.
- If you have need for further clarification please consult this office. Please note that it is mandatory that you submit a detailed progress report of your study to this Committee every six months and a final copy of your report at the end of the study.
- Any serious adverse events must be reported at once to this Committee.
- Please note that when your approval expires you may need to request for renewal. The request should be accompanied by a Progress Report (Progress Report Forms can be obtained from the Secretariat).
- **Ensure that a final copy of the results is submitted to this Committee.**

Yours sincerely,

Dr. S.H Nzala
VICE-CHAIRPERSON

Date of approval: 28th November, 2016. **Date of expiry:** 27th November, 2017.

THE UNIVERSITY OF ZAMBIA

SCHOOL OF MEDICINE

Telephone : +260211252641
Telegram: UNZA, Lusaka
Telex: UNZALU ZA 44370
Email: assistantdeanpgmedicine@unza.zm

P.O Box 50110
Lusaka, Zambia

12 September 2016

Dr. Ninza Sheyo
Department of Anaesthesia and Intensive Care
School of Medicine
UNZA
LUSAKA

Dear Dr. Sheyo,

RE: GRADUATE PROPOSAL PRESENTATION FORUM

Following the presentation of your dissertation entitled **"Twenty-four Hour Changes in Selected Electrolytes in Adult Patients Admitted to the Main Intensive Care Unit at the University Teaching Hospital, Lusaka, Zambia."**, your supervisor has confirmed that the necessary corrections to your research proposal have been done.

You can proceed and present to the Research Ethics.

Yours faithfully,

Dr. S.H. Nzala
ASSISTANT DEAN, POSTGRADUATE

UNIVERSITY OF ZAMBIA
SCHOOL OF MEDICINE
14 SEP 2016
ASSISTANT DEAN (PG)
P.O. BOX 50110, LUSAKA.

cc: HOD, Department of Anaesthesia and Intensive Care