EVALUATING INFERIOR VENA CAVA DIAMETER TO ASSESS FLUID RESPONSIVENESS IN ICU PATIENTS AT THE KENYATTA NATIONAL HOSPITAL

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DECLARATION

This is my original work, and to the best of my knowledge, it has not been presented anywhere else.

Investigator:

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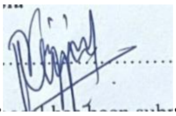

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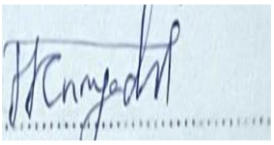
Signature:  **Date: 20th June, 2022**

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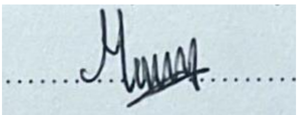

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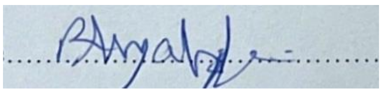

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ABBREVIATIONS

ICU – intensive care unit

KNH – Kenyatta National Hospital

IV – intravenous

ARDS – Acute respiratory distress syndrome

RAP – right atrial pressure

IVC – inferior vena cava

CO – cardiac output

CVP – central venous pressure

PCWP – pulmonary capillary wedge pressure

POC – point of care

WHO – world health organisation

AP – anteroposterior

PAOP – pulmonary artery occlusion pressure

SVC – superior vena cava

NICU – neonatal intensive care unit

PICU – pediatric intensive care unit

HDU – high dependency unit

ROC – receiver operating characteristic

CI – confidence interval

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ABSTRACT

Background: For better prognosis of critically ill patients with hypotension or shock, controlling fluid responsiveness is essential. Currently, central venous pressure (CVP) is used as a standard volume status indicator, but CVP monitoring is costly, intrusive, difficult, and there is evidence in recent literature that CVP is an inaccurate volume status predictor. A healthy, non-invasive and potentially more accurate indicator of volume status is an ultrasound of the inferior vena cava (IVC) diameter. It can be used in patients to predict fluid responsiveness.

Aim of the study: The clinical utility of ultrasound of the IVC in assessing patients in ICU for fluid responsiveness

Materials and Methods: This study used a prospective observational study design of adult patients admitted to the ICU who underwent fluid therapy between February 2021 – May 2021. 79 patients were enrolled after obtaining informed consent. Ultrasound was done by the principal investigator under the supervision of a consultant radiologist. Measurements of the IVC diameter before and after fluid bolus and the distensibility index were calculated. Data was analyzed using SPSS version 23, Microsoft Access and Excel

Results: The paired Student *t* test was used to compare between hemodynamic data before and after a bolus of fluid. The study focused on 79 adult patients admitted to the intensive care unit who were receiving fluid therapy. Out of the 79, 63 patients had an inferior vena cava diameter of less than 1.5cm while 16 of the patients had an inferior vena cava diameter of 1.5-2.5cm.

The data was then used to calculate the distensibility index of inferior vena cava (dIVC) to assess for fluid responsiveness. The rate was represented in percentage and 18 patients had a

distensibility index of less than 18% while majority represented by 61 had a distensibility index of greater than 18%.

Before 500mls of fluid bolus, the pre-hydration mean was 1.25 while after 500mls the mean was 1.53. The difference between the means was 0.28 which indicated that the response was moderate.

The t-value was -12.6 while the p-value was represented by a value less than0.001 indicating the study is statistically significant. The pair sample correlation was represented by 0.652 indicating a positive strong relationship between the inferior vena cava diameters to assess fluid responsiveness in ICU patients

1.INTRODUCTION

1.1 Background of the Study

Intensive Care Units (ICUs) admit more than 15 million patients annually worldwide. Because of the high incidence of circulatory insufficiency in the ICU, these patients need continuous assessment of their hemodynamic status (1). Circulatory dysfunction causes insufficient blood perfusion and oxygenation, the core functions of the cardiovascular system, leading to poor cardiac output (2). The functioning of the pump (cardiac contractility), the tubing (vasomotor tone), and the fluid (intravascular volume) decide the cardiac output. Uncorrected hypovolemia may increase organ hypoperfusion and ischemia due to decreased cardiac output. The first stage in the resuscitation of hemodynamically unstable patients is known to be fluid loading (3). However, several studies indicate that only about 50 percent of patients with hemodynamically dysfunctional ICU respond to a fluid test.(4). This is because it is extremely difficult to determine the intravascular volume of critically ill patients. Due to this difficulty almost half of patients undergo excessive fluid resuscitation leading to extreme levels of intravascular volume which is detrimental to the patient(5). This is why it is important for physicians in the ICU to be able to objectively and accurately distinguish between hypovolemia and volume overload.

Circulatory dysfunction attributable to hypovolemia may be due to a plethora of causes arising from limited consumption, unnecessary losses, or extracellular space fluid shifts. In many scenarios patients are admitted in the emergency room for evident acute body fluid losses. Dehydration is the end result of total body water loss. The average healthy adult requires approximately 1 to 1.5 litres of water per day. Water losses occur from urine, faeces, sweating, and respiration. These losses increase with renal concentrating problems, medication effects, diarrhoea, vomiting, environmental exposure, and fever. Fluid losses with vomiting, diarrhea, etc. and/or decreased fluid intake – and even the fluid shifts that can occur with ascites, effusions, and sepsis – can result in effective volume depletion and clinical dehydration. The diagnosis of hypovolemia is almost probable, together with the existence of clinical symptoms of hemodynamic dysfunction, and the patient will benefit from fluid therapy..

Fluid responsiveness is defined as an increase in stroke volume of > 10% after a fluid challenge (6). The goal of fluid resuscitation in dehydration, resulting in shock, is to increase the stroke volume and enhance the supply of oxygen and vital organ perfusion (7). In patients with dehydration, fluid responsiveness is critical in mitigating the dangers of over-resuscitation when using IV fluids (6). However, despite being widely used, only about 50% of hospitalized patients undergoing fluid resuscitation due to acute circulatory failure are deemed to be fluid receptive due to a related rise in stroke volume (8). Right arterial pressure (RAP) raised the remainder, but there was no improvement in stroke volume(9). This can cause fluids to leak into the extravascular space and cause damage that causes dysfunction and end-organ oedema(10). Kidney dysfunction, extended ICU stay, ARDS, extended inpatient treatment and elevated mortality when adjusted for disease seriousness have been correlated with high volume fluid reanimation and a healthy net fluid balance (11).

Inferior vena cava (IVC) diameter respiratory variation has been described as an easy, non-invasive measure that can be used in different patient settings to predict fluid responsiveness (12). Among the advantages of IVC ultrasound is that it is widely available, inexpensive, and can be done with minimal training by health workers. An ultrasound of the lungs and heart may also be used to provide a complete sonographic view of each patient's underlying physiology.(13).

Different experiments with different methodologies and findings have been performed that have examined IVC diameter respiratory heterogeneity as a measure of fluid responsiveness. Two papers which used a study of 62 patients and IVC diameter as an index test for predicting fluid responsiveness were examined by Mandeville & Colebourn (13). No metaanalysis was conducted due to heterogeneity. Researchers (14) reviewed eight experiments using a group of 235 patients to examine the usefulness of IVC diameter respiratory heterogeneity to predict fluid responsiveness. The thesis evaluated the description and calculation methodology for the concept of fluid responsiveness, predictive test used, fluid challenge length, and IVC diameter brink shift. For heterogeneous variables, the pooled region under the curve was estimated as 0.84 (95 percent CI: 0.79–0.89). The predictive potential of IVC ultrasound has been discussed by many other research papers. Much of the study already carried out was in classes and aetiologies far from our local clinical practice. This study would aim to contribute to the body of literature by testing the use of inferior vena cava diameter respiratory variance to assess fluid responsiveness in KNH ICU patients.

1.2 Problem Statement

When the heart can no longer deliver enough blood to the body, 15-30 percent of shock occurs; blood pressure decreases, and tissue perfusion is not able to maintain aerobic metabolism, leading to widespread damage to ischemic tissue(15). Hypovolemic shock can be fatal easily, and is a complication that happens most in patients at risk(16). Unfortunately, one of the most daunting activities of clinical practice is the evaluation of declining volume status(17). At the start of hypovolemia, the body of a patient will try to compensate by raising the heart rate (to continue to supply oxygen for the reduced volume of blood to the extremities). However, to assess the need for emergent therapies, heart rate alone is not adequate, as it is non-specific(18). The respiratory rate can increase, but this is always a late change, and mechanical ventilation may mask it. Peripheral blood vessels constrict, reducing perfusion in the extremities, causing slight changes in the face of the recipient, such as paleness, long capillary refill periods, or low turgor of the skin(19). These improvements are common for practitioners to ignore, however, and there appear to be no conclusive findings on the predictive potential or pathogenesis of these signs(20).Thus, the body's hemodynamic compensation mechanisms can mask underlying deterioration the patient is experiencing.

Therefore, during anaesthesia and in the critical care setting, ensuring sufficient tissue perfusion and oxygenation is of utmost importance. An integral determinant of this therapeutic objective is to develop sufficient cardiac performance (CO). Therefore, there has been a growing interest in the continuous calculation of CO under different clinical conditions over the past decade. The therapeutic gold standard for CO calculation is thermodilution, although this procedure involves the insertion of a particular intra-arterial or pulmonary artery catheter that may lead to different complications(21). Therefore, the need for minimally invasive and constant surveillance of CO is increasing. This new methodology could satisfy the required criteria of precision, operator independence, protection, ease of use and continuous use. In addition, as a result of diagnostic manoeuvres and interventions, a fast-continuous approach may be helpful in monitoring CO improvements. Although there are a range of methods available for non-invasive CO calculation, none of these techniques respond to all requirements, and thus further research needs to be done on the use of these non-invasive methods, especially in underdeveloped economic settings, to enhance their use in diagnosis and management. As a fluid status and cardiac output monitoring technique, ultrasound has gained a lot of popularity because it is safe, fast, non-invasive and can be taken to the bedside. Bedside ultrasound is a radiological survey that can include a concentrated assessment to address a clinical question. The conventional hydration status testing approaches include physical inspection, laboratory tests, and central venous pressure calculation. The accuracy of the physical test will differ according to the qualifications and level of experience of the bedside practitioner(22). Invasive diagnostics are both experimental tests and central venous pressure evaluations that may be difficult for the ICU patient and can be unavailable based on the facilities of a particular medical facility.

1.3 Research Objectives

Main objective: The clinical utility of ultrasound of the IVC in assessing fluid responsiveness in ICU patients.

Specific objectives

i. To determine the inferior vena cava diameter and respiratory variability in assessing fluid status of patients admitted at the Kenyatta National Hospital ICU
ii. To assess the use of respiratory variability in inferior vena cava diameter in analysing fluid responsiveness of ICU patients at Kenyatta National Hospital
iii. To evaluate the use of POC ultrasound of the inferior vena cava diameter in fluid management of ICU patients at Kenyatta National Hospital

1.4 Significance of the Study

In clinical practice, determining the intravascular volume of patients is a daunting and significant task. For volume measurement use, conventional approaches, such as blood pressure, heart rate, skin turgor, capillary refill time, and urine production, are neither precise nor reliable(23). In the perioperative time, traditional hemodynamic screening was also found to be incapable of detecting occult hypovolemia(24). Central venous pressure (CVP) is a conventional static pressure-based variable that is still in clinical use today to determine intravascular volume. In a systematic analysis, however, CVP was found to have low association with measured volume of blood and low predictability after fluid challenge for hemodynamic responsiveness(25). Pulmonary capillary wedge pressure (PCWP), another static pressure-based measure, has also been found to not correlate with changes in stroke volume (SV) or cardiac production (CO) after colloid bolus, suggesting its inability to represent changes in intravascular volume (26). In addition to this, PCWP surveillance involves the insertion of a pulmonary artery catheter that may pose additional risks to patients, such as hematoma, sepsis, pulmonary embolism and collapse of the pulmonary artery. Only 50 percent of patients show an adequate response to fluid administration as a consequence of the unreliability of volume assessment(4).

Ultrasound examination of the inferior vena cava (IVC) has recently been adopted to determine volume status, with the increasing availability of point-of - care ultrasound that can be done at the bedside(27). Thanks to the non-invasive aspect of ultrasound, quick bedside

IVC ultrasound may be very effective in directing perioperative fluid control as well as in resuscitating trauma and critically ill patients. This study would explore the usefulness of IVC diameter to determine fluid status in Kenyatta National Hospital ICU patients and then explore the usefulness of IVC diameter POC ultrasound.

Kenyatta National Hospital, the largest public hospital in East Africa, is a tertiary care facility with 1800 beds. Statistics from 2016 and 2017 revealed that patients presenting at KNH ranged between 31, 978-61, 840, with admissions ranging from 20, 267-21, 731 each year, via the injuries and emergency service. A critical care survey developed in Kenya found that Kenya had a total of 130 ICU beds for a population of 44 million, converting 0.29 beds per 100,000 population into an ICU strain (28). Critical care beds should make up 20-40 percent of the total hospital capacity, according to the Society of Critical Care Medicine, while WHO suggests 10-20 percent of the maximum hospital capacity. There are 36 ICU beds in KNH, which constitutes just 1.8 percent of the total hospital capacity. This is well below the guidelines of the WHO, suggesting a large ICU strain at KNH.

CHAPTER TWO

2. LITERATURE REVIEW

2.1 Ultrasound Evaluation of the Inferior Vena Cava

Inferior vena cava (IVC) ultrasound analysis and the Collapsibility Index were first studied for patients on dialysis by nephrologists. Cardiologists later researched it as a supplementary criterion for right atrial strain, and more recently adopted it as an easy and non-invasive tool for evaluating intravascular volume status by intensive unit practitioners and emergency physicians (29). The IVC assessment can be used to rapidly affirm or refute severe intravascular volume state disruptions (depletion or overload) in suspicious subjects.

For example, in patients with indistinguishable conditions, who are likely to include multiple organ systems the test is often taken, and in these cases, the IVC evaluation is typically part of a more thorough ultrasound evaluation that may include the heart, lungs, pleural areas and the peritoneal cavity. Since the ultrasound examination is non-invasive and quick, it may be carried out as much as possible and is also useful to assess the patient improvement and/or response to treatment (14). However, like most bedside ultrasonography, there are both techniques for making evaluation easier and more precise and potential errors if the physician is not careful, however the necessary skill for the IVC evaluation can be learned quite easily.

The IVC is the largest vessel for the organization. In short, it is primarily a pool that supplies the right side of diastole, with a ready blood supply. This explains why the vessel explains relatively wide with walls folding and falling in overload states (10), as the pressure variations between the iliac veins and the right atrium are minimal. In cardiocascular and pulmonary processes, the diameter of IVC varies.

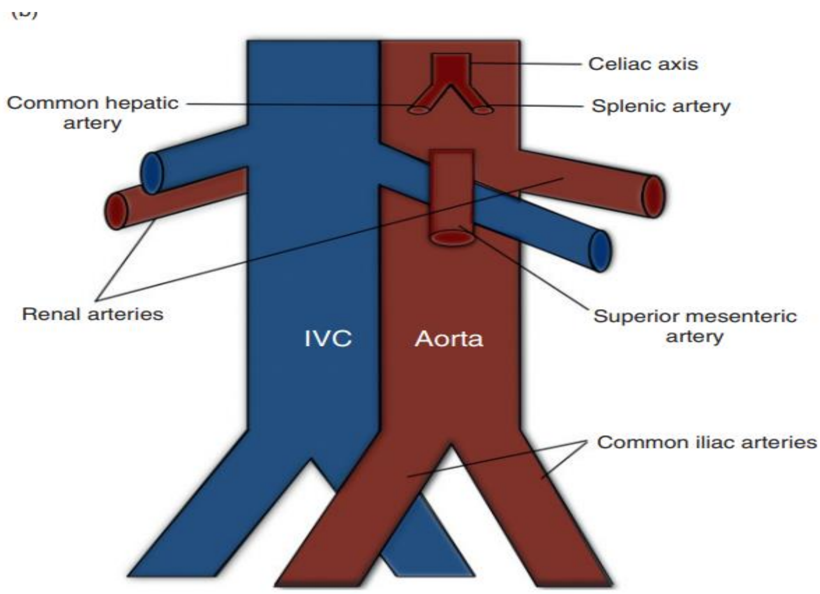
As for the cardiac cycle, the IVC is most probably collapsing in the early diastole soon after the opening of the tricuspid valve and it is most distended at the end of the ventricular diastole when the atrial contractures (30). The triple waveform of the inner jugular vein can still be identified in a relatively weak IVC. It is necessary to differentiate the heart and respiratory cycles in the evaluation of IVC collapsibility. The above are longer, the IVC is at most relaxed during expiry and the inspiration has most fallen. The respiratory transition over the beat-to-beat heart waveform (31) is superimposed.

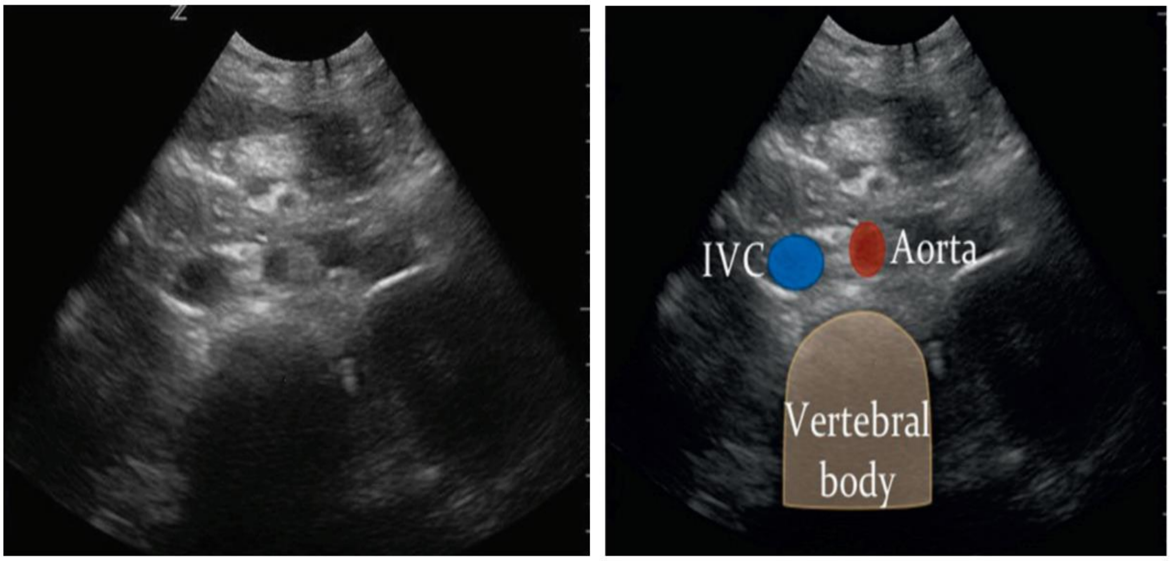
A broad literature reveals the association of the IVC measures acquired with the intravascular and cardiac strain. Growing intravascular volume (IVC not totally relaxed) in a given patient can lead to increased IVC diameter, decreased vessel breath fluctuation and more circular cross-section (32). The reverse would be the case (unless the IVC was still absolutely empty) Intravascular volume reduction.1.

2.1.1 Sonographic Technique

The IVC is best viewed with a phased-arrray or 2–4 MHz curvilinear transducer. For the IVC assessment, the regular window is the sub-xiphoid and the transhepatic window into the right intercostal spaces. There are two windows accessible for this assessment. Ultrasound waves are transmitted through the liver in any case. The downside of the subxiphoid view is that in many patients the liver window is small or missing and it may be difficult to to withstand the pressure of the transducer required to obtain an adequate vision, especially in patients with the protuberant abdomen and/or shortness of the breath (33).

The first task is to locate the IVC and to isolate the aorta in the upper abdomen, irrespective of the window picked. The two vessels should be represented in a single transversal image in order to distinguish between the two vessels (34). In the cross section over the black artifact of the spinal bodies, both vessels can be identified. Whereas it is more aorta-loud than the one obscured by the lung and passes through the diaphragm to the rear thoracic across the 12 thoracic spinal body, it is usually important for the two vessels to be separated at this stage (35). The IVC will then be accompanied by a cephalad, which is visible in real time on the right atrium.





The IVC diameter and fall is usually determined directly below the hepatic vein (such as '1–3 cm' under the diaphragm). The right atrium to transition to an IVC in real time is seen by a Transverse Subxiphoid View to the heart and then downgrade to the transducer (36). Inexperienced sonographers are the most frequent occurrence where any other framework, such as the IVC, is misidentified whenever the IVC fails entirely. The aorta is the structure most often replaced but it may also cause errors in the liver veins, door veins, gallbladder and pleural effusion (37). Both aorta and IVC should be established in the cross plane, as should the visualization in the right atrium of the IVC. The IVC should be better defined.

The vessel's pulsatility cannot be used to describe the IVC as the IVC is a pulsating vessel as described above. Experience has shown that caval pulsations in which the quickest acceleration at the beginning of the diastole is to be separated by aortic pulsations in which the greatest activity at the beginning of the systole is to be found outside (38). However, this difference is only acknowledged with extensive IVC sonography experience. Both transversal and longitudinal planes have potential vulnerabilities which can only be determined on the complementary plane by sonographical assessment. Consequently, the IVC in both planes is always essential to image.

2.1.2 IVC measurements

Most of the studies identified the sonographic assessment of the longitudinal IVC diameter, using the calipers on still images of maximum inspiration and expiration (39). The IVC is most generally measured in the subxiphoid view, where the walls are parallel, usually 1 cm before the confluence of the hepatic veins (or 2 cm before the diaphragm). The diameter of the AP can also be measured using the M-mode. By positioning the M-mode cursor on the longitudinal view of the IVC at the level of the hepatic veins or approximately 2 cm apart from the diaphragm, the AP diameter of the vessel can be determined over time. It is important to note that since the curved abdominal probe produces a pie-shaped image, it may be difficult to position the M-mode cursor on the true AP diameter.

2.2 Interpretation of the Ultrasound Examination

The IVC is evaluated both qualitatively (shape) and quantitatively (absolute size and index of collapse).

2.2.1 Qualitative Assessment

The IVC configuration also provides the physician valuable information. For example (40), with intravascular volume decline the cross-section of the IVC was shown to become more and more flat and gradually sliced as with severe hypo-volemia through respiratory and cardiac cycles. On the other hand, the IVC of a hypervolemic patient seems circular in diameter.

Experienced physicians are able to accurately distinguish IVC as being circular or entirely flat with minor respiratory and cardiac variation and the different grading between those two extremes (41). A clinical assessment may be done effectively to assess if further volume expansions or diuresis are identical, based on how flat or plethoric the vessel appears.

2.2.2 Quantitative Assessment

As quantitative metrics for the IVC, the diameter and collapsibility index can be used. If intravascular disorder is measured with an isolated IVC measurement, the absolute size is usually shown on its peak expiratory diameter (IVCDe). 21 mm has been promoted as a standard maximus for IVC diameter by the latest American Society of Echocardiologists. Conversely, in hypotensive cases or in shock patient a diameter of less than 9 mm predicts serious intravascular loss of volume. Experienced radiologists will however recognize that 'normal' intravascular diameters differ widely, and they can have greater IVC than this without overwhelming volume and diameter without being drained by intravascular volume. For eg, despite a comparatively high IVC, volume will clinically be depleted in patients with chronic congestive heart failure. Patients who are taller and physical fit will have larger IVC. Despite the lack of agreement on the "normal" expiry diameter of IVC, there is clear evidence of increased volume expansion in the IVCDe patient, while reduced volume exposure in the IVCDe patient results.

During the respiratory cycle, the diameter of IVC varies by increasing in hypovolaemic condition and decreasing in Hypervolaemic situation. The IVC Collapse index (IVC-CI) measured using the following equation is the parameter for this difference:

$$Caval\ Index = \frac{\max(IVC) - \min\ (\mathrm{IVC})}{\max(IVC)} X\ 100$$

IVCD-max is the maximum IVC diameter, measured in expiration, IVCD-min is the minimum IVC diameter, measured during inspiration.

Even though there is no cut off value for the normal IVC collapsibility index, for normal healthy subjects IVC-CI is normally between 25% and 75%. An isolated IVC-CI is better used when it has a severe therapeutic benefit. When using an IVC-CI to determine a specific response to therapy, serial values would ensure progress against the target.

The use of IVC-CI is confounding in case of a quickly insufficient IVC (43). For example, the IVC-CI is very hypovolaemic in a 3 mm diameter, which collapses to 2 mm, despite a mere 33 percent IVC-CI. The IVCDe and the slit-like structure are more apparent in this situation.

2.3 Effect of Mechanical Ventilation

With positive pressure ventilation, the IVC parameters differ in several respects. It raises IVC diameter by impairing the venous return to the chest and compromise the strength of the IVC-CI assessment by reversing normal pressure changes throughout the air cycle (44). Studies show that the IVC-CI in ventilated persons has been significantly smaller than in the situation where the patient is withdrawn, which suggests that a fluid receptive shock may be an example of any IVC-CI > 10-20% (45). However, the extent of the influence of positive ventilation is not overcome. Instead, the collapse of IVC shows severely hypovolaemia in the positive-pressure ventilation condition almost always.

2.4 Empirical Literature

(46) shows that cyclic differences in pleural pressure, which are passed to the right atrial pressure in a stable subject breathing normally, induce cyclic changes in venous return, with inspirational acceleration, creating an inspirational decrease in the diameter of approximately IVC. However, when the vessel is dilated, this cyclic shift in the diameter of the vena cava is eliminated because, while there is some inspiring increase in venous return, the vessel

actually stays on the horizontal portion of its relationship between pressure and diameter. If there is heart tamponade or extreme right ventricular collapse, this is the case (47).

Marik et al. (17) address how complex pressure and stroke volume changes were created as useful instruments to assess the volume response in patients experiencing mechanical ventilation. Particularly in critically ill patients, complex changes in arterial waveform-driven variable predict fluid reaction successfully. This treatment was however limited to mechanically ventilated patients.

It's a tough decision to decide the sufficient amount of fluid resuscitation to be provided to a critically ill patient (48). Normal preload sensitivity measurement techniques, such as central venous pressure (CVP) and pulmonary artery occlusion pressure (PAOP), are inaccurate in deciding whether a patient needs volume resuscitation (49). (48) suggest diagnostic ultrasound in the form of an echocardiography of respiratory variance of SV and PLR for the detection of preload sensitivity, as an alternate means of evaluating whether a patient is preloaded.

(50) performed an ultrasonographic analysis of the upper and lower vena cava in a manually ventilated patient with hypotension. Trans-essophageal echocardiography reveals a partial collapse of the SVC at each inflation and a major increase in IVC diameter in subcostal echocardiography. Hypotension was reversed and the variations in vena cava diameter were lost after a significant increase in the cardiac index blood flow. Venous cava dilation caused by elevated volume and/or right atrial pressure prevents involuntary changes in the breathing process. Therefore, only a normal or low volume status can be observed in the mechanically ventilated patient when the IVC diameter is cyclically affected. About 90 % of patients with circulatory dysfunction are unable to respond with fluid due to the lack of variance of an IVC diameter of a manually ventilated patient. [51].

A recent study (52) has suggested an ultrasound procedure to determine the variation in diameter of the lower vena cava (IVC) in ventilated and hemodynamically unhealthy patients. In stable patients, changes in intrathoracic pressure are transferred to the IVC, lowering the diameter of the vessel by 50 percent, while the inspiration mechanism induces a rise in pleural pressure in mechanically ventilated patients that decreases venous return. The changes in vessel diameter, with an inspirational rise and an expiratory decrease, are also reversed. Major differences in inspiration allow patients who are likely to respond to fluid replacement therapy to be distinguished. The ultrasound is performed by positioning the m-mode cursor 3 cm from the right atrium to create a time-motion record of the diameter of the vein in the sagittal view of the inferior vena cava at the subxiphoid stage. The researchers proposed that the patient be sedated, ventilated (volume 8-10 ml / kg), at 16 cycles / second respiratory rate, and with an inclination of 0 °. Those with an IVC diameter variance of > 12 per cent are hemodynamically unstable ventilator patients who respond to fluid replacement therapy.

CHAPTER THREE

3. METHODOLOGY

3.1 Study Design

This study used a prospective observational, study design of convenience sample of adult patients admitted to the ICU who received fluid therapy.

3.2. Study Location

The study was conducted in the main ICU in KNH. This is the largest teaching, referral and research hospital in Kenya. It is situated in the capital city of Nairobi along hospital road in upper hill. It has a bed capacity of 1800 and receives patients from within and outside Nairobi, as well as from east and central Africa. KNH has one main critical care unit with a bed capacity of 31. It also has 5 other subsidiary ICUs namely NICU, PICU, medical ICU, neurological ICU and cardiology with an additional total bed capacity of 20. The main ICU admits all patients who require intensive therapy except neonates who go to NICU.

3.3 Study Population

Patients admitted to ICU KNH undergoing intravenous fluid administration were part of the sample population during the study.

3.3.1 Inclusion Criteria

- Patients admitted in the critical care unit who are receiving fluid administration
- Patients or relatives who consent to inclusion in the study after understanding thorough explanation of the data collected

3.3.2 Exclusion Criteria

- Patients admitted in the critical care unit who are on vasopressors
- Patients or patient’s families/relatives who do not consent to be included in the study

3.4 Sample Size

Sample size is estimated using the formula as recommended by Fisher's et al., (1991)

$$n = z^2pq/d^2$$

Where

n = Desired sample size (when population is greater than 10,000)

z = Standard Normal Deviation which is equal to 1.96 corresponding to 95% confidence interval

p = Prevalence of the issue under study, 50%

q = 1-p

d = confidence limit of the prevalence (p) at 95% confidence interval 1-0.95 = 0.05

Degree of accuracy desired for the study is hence set at 0.05.

Substituting the figures above in the formula.

Thus n = 1.96^2 x 0.5 x 0.5

$(0.05)^2$

n = 384

Since the target population is less than 10,000 the sample size was adjusted using the formula.

$$nf = \frac{n}{1 + (\frac{n-1}{N})}$$

where

nf is Desired sample size (when the population is less than 10,000).

n is sample size (when population more than 10,000) calculated 384.

N is Number of monthly estimated patients 104, admitted at the KNH ICU at any given time

Thus

$$nf = \frac{304}{1 + (\frac{304-1}{104})}$$

Thus, approximate minimum sample size was **78** study subjects

3.5 Sampling method

The patients were recruited consecutively in the study. The researcher when available in the ICU actively looked for eligible patients or contacted by the clinician or the nurse on duty upon arrival of the eligible patients. The study was explained to the patient or his/her surrogate and consent obtained.

3.6 Data Collection

The author, who is an expert radiologist using the ultrasound machine with curvilinear probe, conducted the bedside ultrasound. Ultrasound evaluation was done on patients in the supine position using B-mode. The probe was positioned in the sub-xiphoid portion of the transverse plane to image the IVC and aorta in a cross-section directly above the vertebral column. It demonstrated the appearance of the IVC in a circular or completely flat with minimum respiratory and cardiac difference and the various grades of both extremes. The maximum anteroposterior (AP) internal diameter of the IVC was determined during expiration. To assess the intravascular volume status, the absolute size was taken at the peak diameter during the expiratory phase. The placement of the probe was chosen based on where the observer believes was likely to achieve the best insight. A consultant radiologist re-assessed the video loops saved by the researcher to determine inter-rater reliability.

3.7 Pre-testing and Piloting

The study instrument was pre-tested at department of radiology at university of nairobi. The pre-test gave useful guidance to the investigator on the suitability of all the areas needed for the analysis. Omissions were identified and need for addition of some items for adequate information gathering in the study was done.

3.8 Data Analysis

Using SPSS version 23 (SPSS Inc, Chicago, USA), the recorded data was arranged, tabulated, and statistically analysed. The paired Student *t* test was used to compare between hemodynamic data before and after a bolus of fluid.

The independent Student t-test analyzes all parametric results. Chi-squared testing will analyze all non-parametric data. The percentage changes in weight as well as changes in the features of the IVC and the Caval Index between the ultrasound examinations for fluid control can be measured. To measure the diagnostic importance of the IVC diameter and features, the Caval Index and the doctor's judgment for forecasting substantial fluid status according to the gold standard, percentage weight shift after fluid control, a receiver operating characteristic (ROC) curve will be used.

In this analysis, the inter-rater reliability would be tested between the ultrasound measurements conducted by the prescribing physician and those conducted using a 2-way mixed effects model by the expert radiologist. In order to determine the degree of reliability, the interclass correlation coefficients (ICCs) and their 95 percent confidence interval (CI) will be determined. A P meaning, if < 0.055, was deemed statistically significant.

A. Inferior vena cava (IVC) is normally 1.5 to 2.5 cm in diameter (measured 3 cm from right atrium)
    1. IVC <1 cm in Trauma is associated with a high likelihood of Hemorrhage requiring Blood Transfusion
    2. IVC <1.5 cm suggests volume depletion
    3. IVC >2.5 cm suggests volume overload

B. Inferior vena cava (IVC) normally collapses more than 50% with inspiration or sniffing
    1. Consider measuring in M-Mode
    2. Caval Index = (IVC-exp diameter - IVC insp diameter) / (IVC-exp diameter) * 100
        a. Collapse <50% suggests volume overload
        b. Caval Index >50% suggests fluid responsiveness

To determine the inferior vena cava diameter and respiratory variability in assessing fluid status of patients admitted at the Kenyatta National Hospital ICU, The Bland-Altman will be used to assess the relationship between the inferior vena cava diameter and respiratory variability in the fluid status of patients.

3.9 Ethical Considerations

1) The patient's names will not appear anywhere in the data collections forms in order to maintain confidentiality. Instead the patient's data will be coded using unique serial numbers. For referral purposes only the patients IP/ OP number will be recorded. No

additional examinations will be done on a patient other than the one requested by the primary physician.

2) Permission will be sought from the Ethical and Research Committee of Kenyatta National Hospital and University of Nairobi to carry out the study. Once the study is approved by the committee, research will begin.

3) The copies of the study will be given to Kenyatta National Hospital and University of Nairobi for future reference and to facilitate possible improvement in patient management

CHAPTER FOUR DATA RESULTS AND ANALYSIS

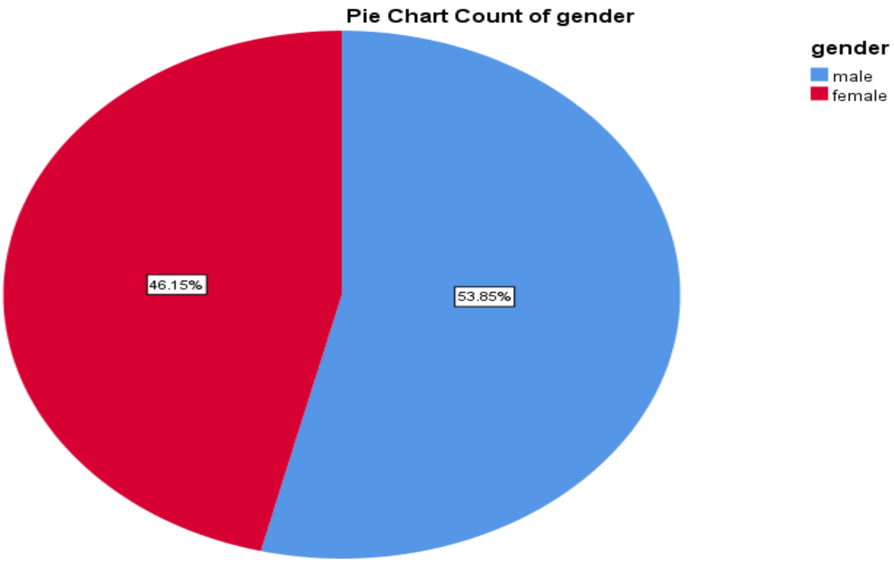
4.1 Epidemiology

This study researched on 78 adults admitted in KNH in the ICU ward who are receiving intravenous fluid administration over the period of study. The aim of the study been to investigate the clinical utility of ultrasound of the IVC in assessing patients in ICU for fluid responsiveness. Measurements of the IVC diameter before and after fluid bolus and the collapsibility index was taken. Analysis was done using t-test for all parametric results and Chi-square in all non -parametric study.

4.2 Sociodemographic characteristics

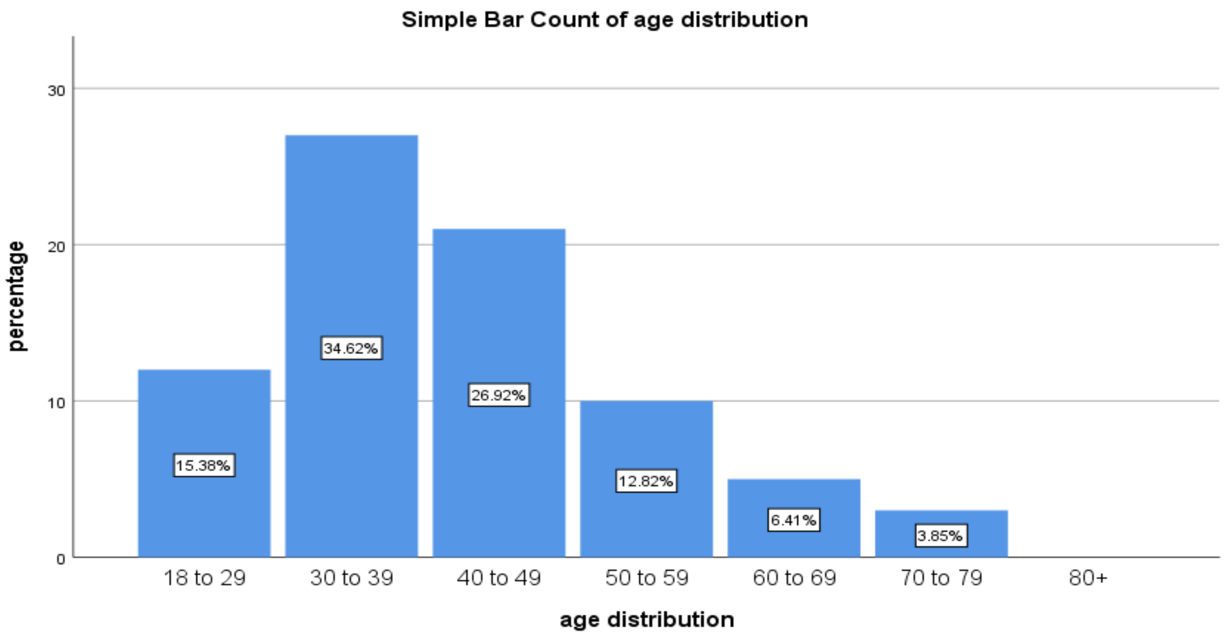
The gender of the participant was indicated to be 42 for male representing 53.85% while the female participants were 36 representing 46.15% of the entire population of adults in ICU. (Figure 4.1).

Figure 4.1 Gender



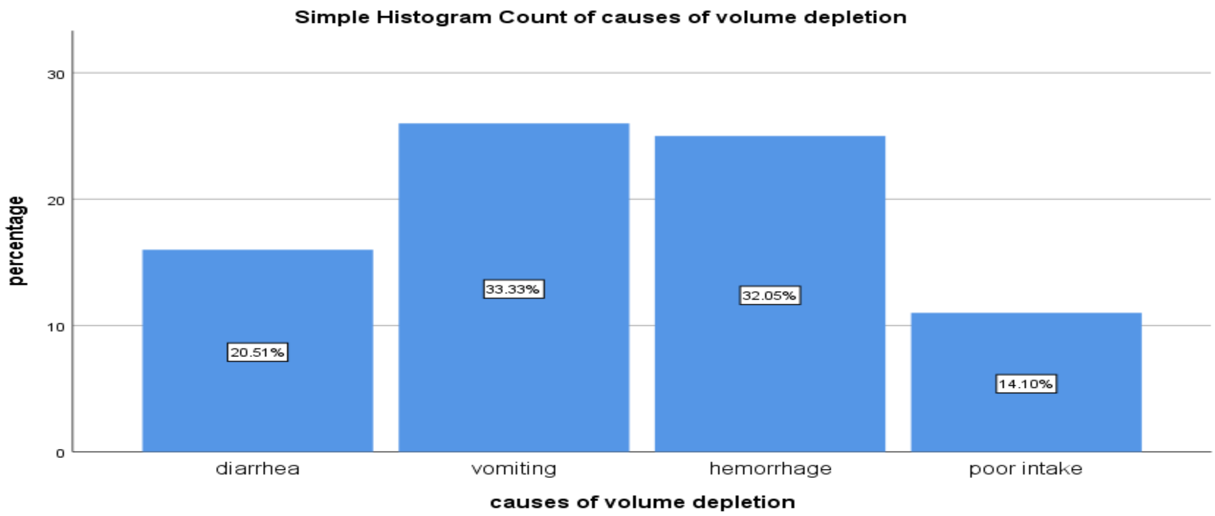
The age indicated that majority of the patients were between the age of 30 to 39 indicated by a percentage of 34.62% and the lowest age were respondents above 80 years age represented by 1.28%. Patients between the age of 18 to 29 years, 40 to 49 years, 50 to 59 years, 60 to 69 years and 70 to 79 years were represented by 15.38%, 26.92%, 12.82%, 6.41% and 3.85% respectively, (Figure 4.2).

Figure 4.2 Age distribution



The causes of volume depletion on the patients was indicated to be diarrhea, vomiting, hemorrhage and poor intake indicated by 20.51%, 33.33%, 32.05% and 14.10% respectively. This shows that majority of the respondents fluid depletion is caused by vomiting and hemorrhage, (Figure 4.3).

Figure 4.3 Causes of volume depletion



The physical examination tested on the patients was physical examination hypotension, dry mucus membranes and decreased skin turgor indicated by a percentage of 62.82%, 25.64% and 11.54% respectively. Majority physical examination tested was hypotension, (Figure 4.4).

Figure 4.4 Physical examination

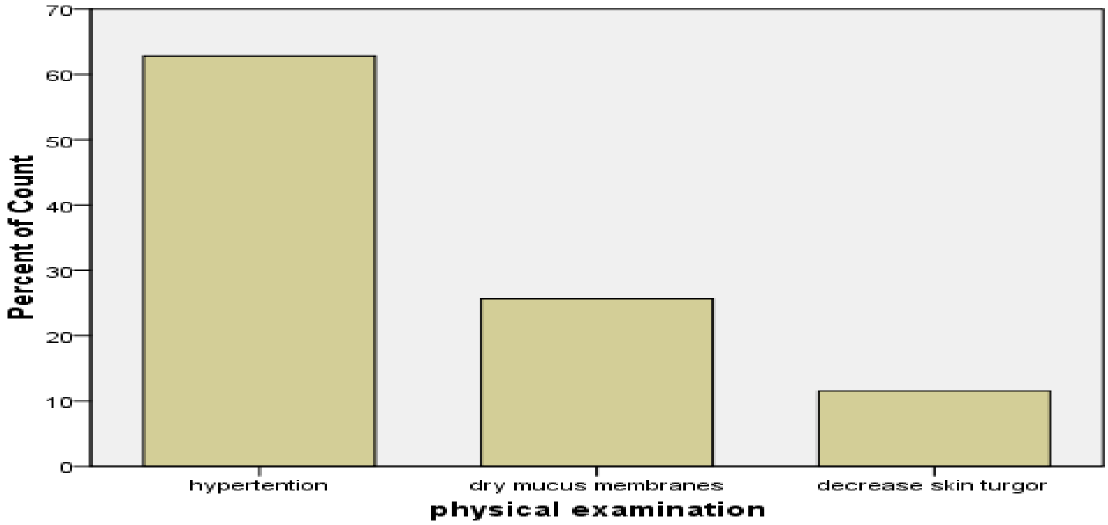


Table 4:1 IVC Diameter

	Frequency (n=79)	Percentage
IVC diameter		
<1.5	63	79.7
1.5 – 2.5	16	20.3

Majority of the patients, represented by 63, had an interior vena cave that was less than 1.5 cm which indicate a percentage of 79.7%. Those with an IVC diameter of 1.5 to 2.5 cm were 16, which represented 20.3% of the patients. (Table 4.1).

Figure 4.5 Relationship between IVC diameter (cm) pre-hydration by IVC (cm) after 500ml of fluid

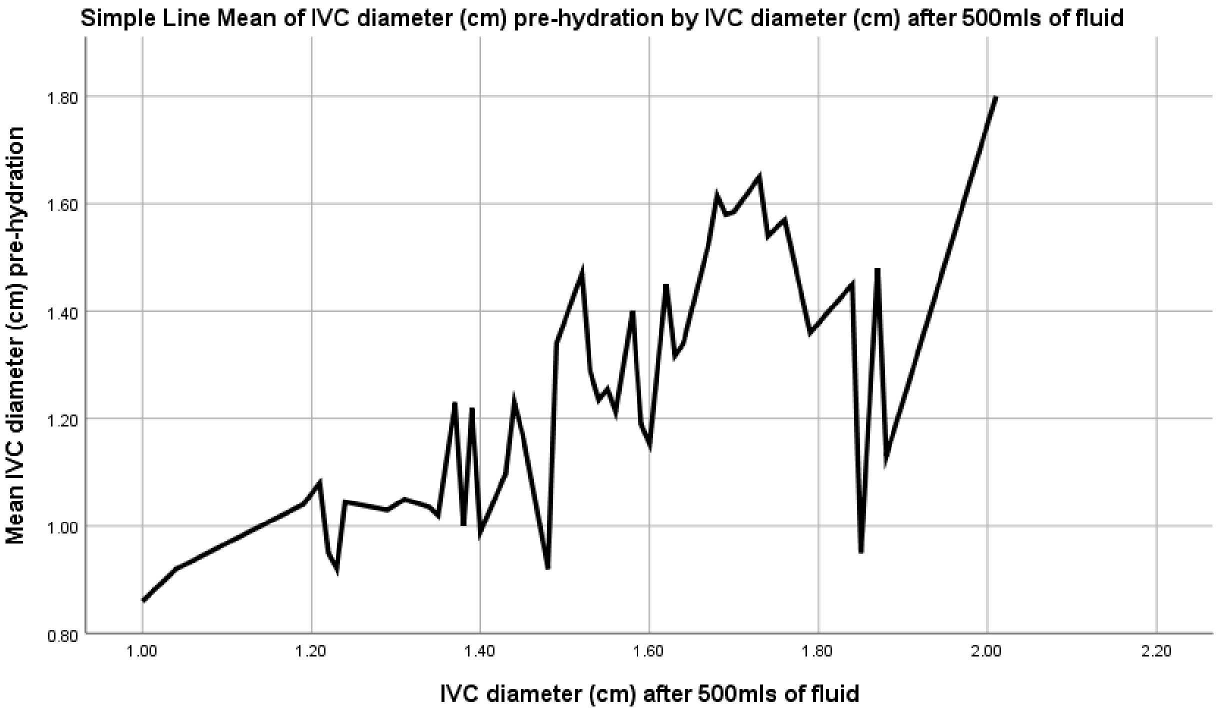


Figure 4.5 indicated the relationship between the IVC diameters during pre-hydration and after 500mls of fluid. The highest centimeter of Diameter is indicated to be 1.80cm during pre-hydration and 2.1 cm after 500mls fluid. The lowest diameter after 500mls diameter is indicated by 1.00cm while during pre-hydration is indicated by 0.83cm. This is an indication that fluid increases the IVC diameter. It is concluded that fluid intake have a positive impact on the patients health.

4.3 Description of the findings

4.3.1 Inferior vena cava diameter and respiratory variability in assessing fluid status of patients.

The IVC diameter and respiratory variability was conducted to assess fluid status of patients admitted at Kenyatta National hospital ICU. This was important in in determining the relationship between the inferior vena cava diameters according to the fluid status of the patient.

Table 4.2 Descriptive statistics

	N	Mean	Std. Deviation	Variance

IVC diameter (cm) pre-hydration	79	1.2522	.25611	.066
IVC diameter (cm) after 500mls of fluid	79	1.5308	.19862	.039
Mean difference		-0.28		

The descriptive statistics indicates that the diameter of IVC is indicated by the mean of 1.25 and 1.53 and a standard deviation of 0.26 and 0.19 for IVC diameter (cm) when the patient is pre-hydrated and when the patients has 500mls fluid respectively. When the fluid has been administered to the patients the mean is higher compared to when the patient is pre-hydrated indicating that consumption of fluid leads to an increase in IVC diameter. The mean difference was indicated to -0.28 which indicates that there is a difference in the IVC diameter between when the patient is pre-hydrated and when the patient has consumed 500mls of fluid. This is an indication that fluid intake affects the diameter of the Interior Vena Cava.

Table 4.3 Relationship between IVC diameters and IVC diameter (cm) pre-hydration

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.854[a]	.730	.726	.09843

a. Predictors: (Constant), IVC diameter (cm) pre-hydration

Table 4.3 indicates the relationship between IVC diameters and IVC diameter (cm) pre-hydration where the R was 0.854. This means that when a patient is pre- hydrated it affects the IVC diameter with 85.4%. The adjusted R indicates that there is a strong relationship between the two variable, (0.726) since 0.726 is close to 1.

Table 4.4 Significance of IVC diameter (cm) pre-hydration with IVC diameters

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-.125	.056		-2.253	.027
	IVC diameter (cm) pre-hydration	.628	.044	.854	14.421	.000

a. Dependent Variable: IVC collapsibility in inspiration (min diameter on inspiration)

The significance was tested using t-test statistics where the relationship between IVC diameters and IVC diameter (cm) pre-hydration indicated a t-test of 14.421. In 95% level of confidence the model has a negative significance. This is explained by the fact that 14.421 >

0.05 at a standard error of 0.044, stating that pre-hydration has no significance on the diameters of IVC.

Table 4.5 Relationship between IVC diameters and IVC diameter (cm) after 500mls of fluid

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.432[a]	.186	.176	.17079

a. Predictors: (Constant), IVC diameter (cm) after 500mls of fluid

The relationship indicates that IVC diameter (cm) is affected by 500mls of fluid intake by 43.2% (R=0.432). The error estimate was 0.17079. The Adjusted R squared shows that the model has no close relationship since 0.176 is not close to 1. This can be explained that if there is no fluid responsiveness the diameter of the interior vena cava will not tend to increase.

Table 4.6 Significance of IVC diameter (cm) after 500mls after fluid with IVC diameters

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	T	Sig.
1	(Constant)	.060	.083		.724	.471
	IVC diameter (cm) after 500mls of fluid	-.206	.071	-.218	-2.920	.005

a. Dependent Variable: IVC collapsibility in inspiration (min diameter on inspiration)

The t-test analysis shows a positive significant relationship. Table 4.5 indicates that at 95% level of interval the model is significant since -0.218<0.05 (t-test<0.05). This is explained that when a patient takes 500mls fluid it affects the diameters of the IVC (cm).

4.3.2 Respiratory variability in IVC diameter in analyzing fluid responsiveness of ICU patients

4.3.2.1Distensibility index and collapsibility index

Dispensability Index is computed by finding the difference between the maximum diameter on inspiration and minimum diameter on expiration then it divided by minimum diameter on expiration.

Table 4.6 Dispensability index

<50%	18	22.8
>50%	61	77.2

Dispensability of inferior vena cava (dIVC), was used as an indicator of fluid responsiveness in ventilated patients. Table 4.1 shows that majority of the respondents, represented by 61, had dispensability index that was more than 50%. This was 77.2% of the respondents. For those with dispensability index of less than 50% were 18 indicating 22.8% of the population.

Table 4.7 Collapsibility and dispensability index.

	N	Minimum	Maximum	Mean	Std. Deviation
IVC dispensability index	79	.03	2.71	.5267	.51431
IVC collapsibility index	79	-2.14	.35	-.4253	.35890
Valid N (listwise)	79				

Table 4.7 indicates the IVC dispensability index which was determined by maximum diameter on inspiration minus the minimum diameter on expiration divided by minimum diameter on expiration. The mean was represented by 0.5267 and the standard deviation was 0.51431.

Table 4.7 shows the IVC collapsibility index which was determined by maximum diameter on expiration minus minimum diameter on inspiration divided by maximum diameter on expiration. The mean was represented by -0.4253 and the standard deviation was indicated by 0.359.

4.3.2.2 Use of POC ultrasound of the inferior vena cava diameter in fluid management

Ultrasound of the IVC diameter is determined by the distensibility of IVC as an indicator of fluid responsiveness in ventilated patients.

4.4 Bland-Altman Analysis

Bland-Altman analysis was used to determine the relationship between two quantitative measurement using limit of agreement which were mean and standard difference between two measurements.

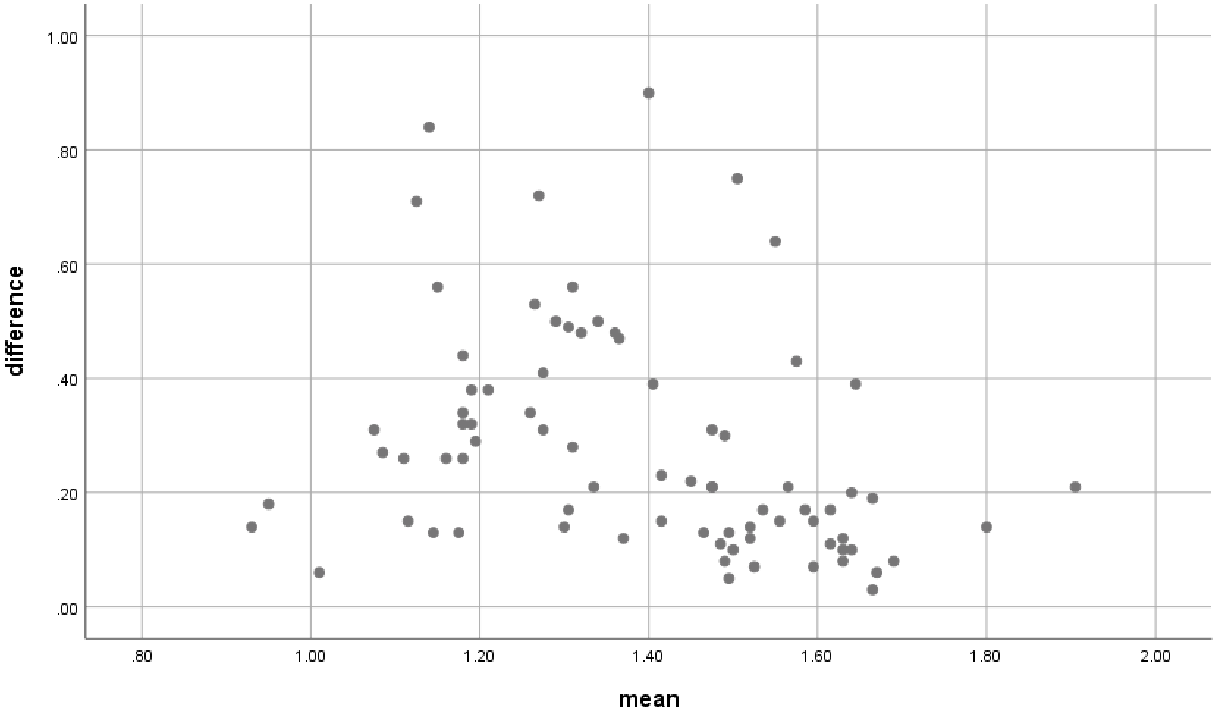
Table 4.7 T-test on difference and Mean

One-Sample Test difference between before fluid and after fluid

	Test Value = 0					
					95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)	Mean Difference	Lower	Upper
Difference	12.587	78	.000	.27861	.2345	.3227
Mean	59.750	78	.000	1.39146	1.3451	1.4378

Table 4.7 indicates the t-test between IVC during pre-hydration and after 500mls fluid intake. The mean difference is 0.278. Since it is not zero it means that the on average the IVC diameter after 500mls fluid measures 0.28 mm more than the IVC diameter during pre-hydration. The t-test statistics is greater than mean difference thus the model is significant.

Figure 4.6 Bland-Altman graphical method



The B&A graphical plot was used to plot the difference scores of two measurements against the mean for each subject. The difference between the IVC diameter (cm) after 500mls of fluid and IVC diameter (cm) pre-hydration. Figure 4.6 indicates that the deference (Y-Axis) increases the more there is fluid intake and thus increasing the mean. This is because the data is scattered on the Bland-Altman graph. The change in IVC diameter shows ability for predicting fluid responsiveness in distinct ventilator settings.

4.5 Chi-square test analysis

The Chi-square test analysis was used to measure the relevance of the non-parametric test to test whether the null hypothesis was true. The study tested whether the age of the patient had an impact on their fluid intake.

4.5.1 Chi-test on age analysis

Table 4.9 Age and volume depletion

	causes of volume depletion	Total

		diarrhea	vomiting	hemorrhage	poor intake	
age distribution	18 to 29	11	0	0	1	12
	30 to 39	5	22	0	0	27
	40 to 49	0	4	17	0	21
	50 to 59	0	0	8	2	10
	60 to 69	0	0	0	5	5
	70 to 79	0	0	0	3	3
Total		16	26	25	11	78

Table 4.9 indicates the relationship between age distribution and volume depletion. The highest number of respondents (22) are in the at the age of 30 to 39 and there depletion of fluid is vomiting, followed by those between the age of 40 to 49 who had hemorrhage (17) and 11 represented by patients between the age of 18 to 29 who their reason for depletion is diarrhea. Poor intake have a few respondents compared to the rest.

Table 4.10 Age and physical examination

		physical examination			
		hypertensions	dry mucus membranes	decrease skin turgor	Total
age distribution	18 to 29	11	0	1	12
	30 to 39	27	0	0	27
	40 to 49	11	10	0	21
	50 to 59	0	10	0	10
	60 to 69	0	0	5	5
	70 to 79	0	0	3	3
Total		49	20	9	78

When conducting physical examination majority of the respondents had hypertensions (49) where 27 were between the age 30 to 39 and 11 were between the ages of 18 to 29 and 40 to 49. When using dry mucus membrane majority of the respondents were between the age of 40 to 49 years and 50 to 59 years. When using decrease in skin turgor did not have a large number.

Table 4.11 Age distribution and gender

		gender	Total

		male	female	
age distribution	18 to 29	11	1	12
	30 to 39	27	0	27
	40 to 49	4	17	21
	50 to 59	0	10	10
	60 to 69	0	5	5
	70 to 79	0	3	3
Total		42	36	78

Majority of the respondent were men and between the age of 30 to 39 as indicated in table 4.11. Majority of the female were between the ages of 40 to 49 as indicated by 17. This is an indication that majority of the patients were male who are of a young age compares to women.

Table 12 Chi-square Test on age distribution

Chi-Square Tests							
Volume depletion	**Value**	**df**	**Asymptotic Significance (2-sided)**				
Pearson Chi-Square	154.793 a	15	0.000				
Likelihood Ratio	144.588	15	0.000				
Linear-by-Linear Association	56.276	1	0.000				
N of Valid Cases	78						
a 19 cells (79.2%) have expected count less than 5. The minimum expected count is .42.							
Physical examination	**Value**	**df**	**Asymptotic Significance (2-sided)**				
Pearson Chi-Square	117.830 a	10	0.0000				
Likelihood Ratio	102.92	10	0.0000				
Linear-by-Linear Association	48.888	1	0.0000				
N of Valid Cases	78						
a 12 cells (66.7%) have expected count less than 5. The minimum expected count is .35.							
Gender	**Value**	**df**	**Asymptotic Significance (2-sided)**				

Pearson Chi-Square	61.282a	5	0.0000				
Likelihood Ratio	80.335	5	0.0000				
Linear-by-Linear Association	43.589	1	0.000				
N of Valid Cases	78						
a 5 cells (41.7%) have expected count less than 5. The minimum expected count is 1.38.							

The chi square statistic Pearson Chi-Square where in the volume depletion the value of the chi-square statistics is 154.793 and the p-value is represented by the asymptotic significance (2-sided) column (0.000). The result is significant since this value is less than the designated alpha level (0.000<0.05). On physical examination the chi-square statistics is represented by 117.83 and the asymptotic significance (2-sided) is less than 0.05 (0.000<0.05). Therefore, the results are significant. When comparing age and gender the chi-square statistics is represented by 61.282 and the asymptotic significance (2-sided) is less than 0.05 (0.000<0.05). In this case, the p-value is smaller than the standard alpha value, so we'd reject the null hypothesis that asserts the two variables are independent of each other. To put it simply, the result is significant – the data suggests that the variables Age and volume depletion, physical examination and gender are associated with each other.

4.6 Correlation Analysis

This shows the relationship between the variables. This indicates the IVC diameter (cm) after 500mls of fluid, IVC diameter (cm) pre-hydration and IVC collapsibility in inspiration (min diameter on inspiration).

		IVC diameter (cm) after 500mls of fluid	IVC diameter (cm) pre-hydration	IVC collapsibility in inspiration (min diameter on inspiration)
IVC diameter (cm) after 500mls of fluid	Pearson Correlation	1	.652**	.432**
	Sig. (2-tailed)		.000	.000
	N	79	79	79
IVC diameter (cm) pre-hydration	Pearson Correlation	.652**	1	.854**
	Sig. (2-tailed)	.000		.000

	N	79	79	79
IVC collapsibility in inspiration (min diameter on inspiration)	Pearson Correlation	.432**	.854**	1
	Sig. (2-tailed)	.000	.000	
	N	79	79	79

**. Correlation is significant at the 0.01 level (2-tailed).

The multicollinears relationship indicates that the strongest relationship is indicated by 0.854 indicating the relationship between IVC collapsibility in inspiration and IVC diameter (cm) pre-hydration. This indicates that when a patient is pre-hydrated the IVC diameter is affected and the diameter reduces. The relationship between IVC diameter (cm) after 500mls of fluid and IVC diameter (cm) pre-hydration is indicated by 0.652. This explain that there is a relationship between diameter of IVC when a patient is pre-hydrated and with fluid. The relationship between IVC diameter (cm) after 500mls of fluid and IVC collapsibility in inspiration (min diameter on inspiration) is indicated by 0.432 which shows the weakest relationship. This is explained by when the patient consume 500mls fluid it tends to increase the IVC diameter.

4.7 Chapter Summary

This chapter presented all the research data that was collected from the Kenyatta National Hospital ICU unit. In this chapter, interpretation of the data collected from the questionnaires was done, and this was represented through the use of pie charts and tables to represent the information one is able to understand from a glance. Inferential analysis was also conducted to ensure the relationship between the parametric and non-parametric relationship between variables such as t-test analysis, p-value and chi-square analysis. The next chapter will present the discussion, conclusion, recommendations of the study and suggestions for further research.

CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The aim of the study was to investigate the clinical utility of ultrasound of the IVC in assessing patients in ICU for fluid responsiveness. This chapter therefore, was to discuss the summary of the findings. Included are summary, conclusion and recommendations represented from all the qualitative and quantitative analysis presented in chapter 4 with relation to the literature review in chapter 2.

5.2 Discussion

The social demographic analysis indicated that majority of the patients were male (53.85%) while the rest were female. The age was distributed as 18-29 years, 30-39years, 40-49years, 50-59years, 60-69years, 70-79years, and above 80 years where majority of the patients were between the age of 30 to39 years (34.62%) while the minimum number of patients was represented by patients above the age of 80 (1.28%). Majority of the patient causes of depletion was due to vomiting (33.33%) and hemorrhage (32.05%) while the minimum was due to poor intake (14.10%). The most used physical examination was hypertension (62.82%) and the minimum was disease skin turgor (11.54%). The Interior Vena Cava diameter was measured and majority of the patients had a diameter that was less than 1.5cm (79.7%) while the rest had a diameter that was greater than 1.5cm. the relationship between the diameter centimeters indicates that during fluid intake the IVC diameter is greater than during pre-hydration.

The descriptive statistics indicated that the highest Interior Vena Cava diameter was experience when the patient takes the 500mls of fluid as indicated by the mean (1.5308) compared to during pre-hydration. There was a mean difference of 0.28 showing that there is a difference before fluid intake and after intake. A t-test analysis was conducted to indicate the relationship and significance of the fluid intake on IVC diameter. The t-test statistics was indicated to have a negative relationship during pre-hydration since $t=14.421 > 0.05$. On the other hand, the t-statistics was indicated to have a positive relationship during after 500mls fluid as indicated by $t=-0.218<0.05$.The dispensability index indicated that majority (77.2%) of the patients have a dispensability index that was greater than 50%. The collapsibility index had the lowest mean of -0.4253 while the dispensability index had the highest mean indicated by 0.5267.

The t-test statistics is greater than mean difference thus the model is significant (12.58 > 0.28 and 59.75 > 1.39). The Bland-Altman indicates that the change in IVC diameter shows ability for predicting fluid responsiveness in distinct ventilator settings. The chi-square analysis indicated that the results are significant p-value is smaller than the standard alpha value (< 0.05). The analysis shows that fluid intake in the patient have a significantly positive effect on the diameter of the Interior Vena Cava.

5.3 Conclusion

Fluid intake in the body has a lot of positive significance to the human health. Previous studies indicate that an inspirational decrease in the diameter of IVC in the body is caused by inspirational acceleration caused by cyclic differences in differences in pleural pressure, which are passed to the right atrial pressure in a stable subject breathing normally. Other than increase in IVC diameter it is significant for stabilizing chronic heart failure patients on optimal pharmacological treatment and weight regulations. On previous study it was concluded that a large fluid intake is associated with decrease in thirst without any negative effect on the heart failure and physical capacity. Therefore, the more the fluid there is in the body the more the patient is able to prevent the diseases in the body.

Since there is a divergence in the mean of IVC diameter during pre-hydration and after 500mls this is an indication Using the chi-square analysis it is difficult to know how much of fluid to give patients according to their age, critical status and gender since each of the patient a difference in fluid responsiveness has. In most cases, physical examination is taken to know which method to make conclusion on. However, when patient are experiencing mechanical ventilation in critical ill patient always predict fluid reaction successfully.

5.4 Recommendation

All the patients in the ICU were analyzed on fluid responsiveness irrespective of their health conditions and their physical examination. Therefore, it is recommended that fluid responsiveness on IVC should be considered in terms of the health conditions and their diseases since different diseases have different physical reaction on medicine, treatment and fluid responsiveness. It is recommended that there should be intake of excess fluid that is more than the 500mls in order to indicate the IVC diameter capacity to expand. On the other hand different patients respond differently, according to their age, gender and health status thus this should be carried out to be sure of the actual impact of the fluid intake to the patient. It's a tough decision to decide the sufficient amount of fluid resuscitation to be provided to a critically ill patient. The conclusion therefore indicates that patients have different diseases and critical conditions therefore, their responsiveness towards fluid can be different on the Interior Vena Cava. The age of a patient may be considered since the older the patient the challenging it becomes to observe responsiveness due to weakness of the body.

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7. APPENDIX A

7.1 Questionnaire

PLEASE ANSWER THIS QUESTIONNAIRE PRIOR TO ULTRASOUND EVALUATION:
Based on the history and physical examination, this patient's volume depletion is (circle one only)

MILD MODERATE SEVERE

What is the main cause of this patient's volume depletion (haemorrhage, vomiting, diarrhoea, sepsis, etc)?
………
What elements of history or physical examination caused you to give fluids in this patient
……
……

PATIENT INFORMATION (DO NOT INCLUDE ANY PATIENT IDENTIFIERS ON THIS FORM
AGE ……………………….. SEX. M F INTUBATED? Y N

Measurements during volume resuscitation
IVC diameter to be measured 2-3cm from right atrial border
Report BP and heart rate taken simultaneously with ultrasound measurements

- Before fluid bolus

IVC diameter (on inspiration in mm) ……………………………………. BP ………….
IVC diameter (on expiration in mm) …………………………………….. HR …………

- At 500cc

IVC diameter (on inspiration in mm) …………………………….. BP …………
IVC diameter (on expiration in mm) ……………………………… HR …………

At 1000cc

IVC diameter (on inspiration in mm) …………………………….. BP …………
IVC diameter (on expiration in mm) ……………………………… HR …………

At 1500cc

IVC diameter (on inspiration in mm) …………………………….. BP …………
IVC diameter (on expiration in mm) ……………………………… HR …………

At 2000cc

IVC diameter (on inspiration in mm) …………………………….. BP …………
IVC diameter (on expiration in mm) ……………………………… HR ………...

APPENDIX B: CONSENT FORM ENGLISH VERSION

Title of the study: Ultrasound evaluation of inferior vena cava diameter to measure fluid responsiveness in dehydrated patients at the ICU Kenyatta hospital
My name is Dr. Vipul Nagnesia, a third-year resident in the department of radiology at the university of Nairobi.
I am conducting a study with the above title as part of my study program.

Aim of the study
This study aims to determine whether ultrasound measurement of IVC diameter correlates with the clinical assessment of volume status and how IVC predicts fluid responsiveness in patients requiring fluid resuscitation at the ICU Kenyatta national hospital.

Participation in this study
Adult patients admitted in the ICU at KNH with signs of hypotension and/or shock judged by attending clinician to require fluid resuscitation will be requested to enrol in this study.
Participant him/herself or the next of kin if the patient has altered mental status or unstable can give a written consent as to be enrolled in the study.
The study involves serial ultrasound measurements of the IVC diameter during fluid administration.

If you decide not to participate in the study, you/your patient care will not be affected in any way and he/she/you will still receive appropriate care, as any other patient in the ICU.

Risks
Physical risks are not involved in association with the participation in this study as ultrasound is a painless, non-irradiating, non-invasive imaging tool already in use at the bedside. Resuscitation of patients will proceed as per physician protocol and will not be impacted by research considerations.

Benefits
If you agree to participate in this study, your patient will benefit in monitoring of IVC diameter during fluid resuscitation. The results from this study will be used for developing guidelines in monitoring fluid resuscitated patients.

Confidentiality
All data collected will be treated with strict confidence and stored in locked cabinets and on encrypted computers and will not be revealed to anybody outside the research team.

Cost
You will not be required to make any payments to participate in this study and no payment will be made to you.

For further information, questions or queries, you can contact:

The principal investigator,
Dr. Vipul Nagnesia
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Email: vnagnesia@yahoo.com

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I, ………………………………………………………………………. Participant/next of keen have read/been told of the contents of this form and have understood its meaning. I agree to enrol……………………………………. in this study.

Signature of next of kin/participant …………………………………….
Signature of researcher ……………………………………..
Date ………………………

APPENDIX C: CONSENT FORM KISWAHILI VERSION

Jina langu ni Dr Vipul Nagnesia, mkazi wa mwaka wa tatu katika idara ya radiology katika chuo kikuu cha Nairobi (UONBI). Ninafanya utafiti kuangalia endapo upimaji wakipenyo cha mshipa unaorudisha damu kwenye moyo kutumia ultasaundi unaitikia vipi wingi au uchache wa kiwango cha maji mgonjwa anayowekewa kupitia dripu wakati wa kuokoa maisha kwa wagonjwa wanaofika idara ya dharura na wagonjwa mahatuti katika hospitali ya Taifa, Nairobi, Kenya.

Madhumuni ya utafiti:

Ninafanya utafiti kuangalia endapo upimaji wakipenyo cha mshipa unaorudisha damu kwenye moyo kutumia ultasaundi unaitikia vipi wingi au uchache wa kiwango cha maji mgonjwa anayowekewa kupitia dripu wakati wa kuokoa maisha kwa wagonjwa wanaofika idara ya dharura na wagonjwa mahatuti katika hospitali ya Taifa, Nairobi, Kenya.

Ushirikikatikautafiti:

Wagonjwa wazima waliolazwa katika ICU kwa KNH na ishara za hypotension na / au mshtuko uliohukumiwa kwa kuhudhuria kliniki kuhitaji kutafutwa tena kwa maji wataulizwa kujiandikisha katika utafiti huu. Muvumilie yeye au nduguye jamaa ikiwa mgonjwa amebadilika hali ya kiakili au kutokuwa na msimamo anaweza kutoa idhini iliyoandikwa kama ya kujiandikisha katika masomo.
Utafiti unajumuisha vipimo vya serial vya upimaji wa kipenyo cha IVC wakati wa utawala wa maji.
Ikiwa unaamua kutoshiriki katika utafiti, wewe / utunzaji wako wa mgonjwa hautaathiriwa kwa njia yoyote na yeye / bado utapata huduma inayofaa, kama mgonjwa mwingine yeyote katika ICU

Hatari:

Hatutarajii kuwepo na athari/hatari yeyote itokanayo naushiri kikatika utafiti huu, kwa sababu mashine ya ultrasound haiumizi, haitoimionzi haratishi na mpaka sasa inatumika katika kitengo chetu cha wagonjwa wa dharura na mahututi.
Pia matibabu yako/ya mgonjwa wako hayatatokana na ushawishi wa utafiti huu, bali yataendelea kulingana na matakwa ya dakitari wako.

Hali yeyote mbaya au ya kumsumbua mgonjwa itakayotokana na utafitihuu, itashugulikiwa maramoja na ipasavyo.
Faida za utafiti:
Kwa kushiriki katika utafiti huu, wewe au mgonjwa wako atapata faida ya kufanyiwa kipimo hichi cha ultrasoundi kuangalia mshipa huu wa damu wakati matibabu yakiendelea. Pia matokeo ya utafiti huu yatatuwezesha kuandaad ondoo za kutibu wagonjwa wanaohitaji kuwekewa maji katika siku za mbeleni.

Usiri:

Taarifa zote zitakazokusanywa katika utafiti huu zitakuwasiri, hivyo ushiriki wako hautajulikana na mtu. Taarifa hizi zitajulikana kwenye timu ya watafititu.

Malipo:

Kwa kushiriki kwenye utafitihuu, hautalipwa wala hautalipa chochote. Ukiwa na swali au tatizo lolote, unawezakuwasiliana nawafuatao:

Mtafiti mkuu

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Mimi, ____, nimesoma/ nimesomewa maelezo yote yaliyomo kwenye fomu hii nanimeelewa.

AU

Mimi, ____________________, mume/mke/baba/mama/_______ nimesoma/nimesomewa maelezo yote yaliyomo kwenye fomu hii na nimeelewa. Nakubali mgonjwa wangu ashiriki katika utafiti huu.

Sahihi y amzazi/mbadala ____________________________

Sahihi ya Mtafiti _________________________
Tarehe _______________________

x

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15th February 2021

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Dept. of Diagnostic Imaging and Rad. Medicine
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KENYATTA NATIONAL HOSPITAL APPROVED 15 FEB 2021 KNH/UoN-ERC P. O. BOX 20723 NAIROBI

Dear Dr. Nagnesia

RESEARCH PROPOSAL – EVALUATING INFERIOR VENA CAVA DIAMETER TO ASSESS FLUID RESPONSIVENESS IN I.C.U PATIENTS AT THE KENYATTA NATIONAL HOSPITAL (P618/11/2020)

This is to inform you that the KNH- UoN Ethics & Research Committee (KNH- UoN ERC) has reviewed and **approved** your above research proposal. The approval period is 15th February 2021 – 14th February 2022.

This approval is subject to compliance with the following requirements:

a. Only approved documents (informed consents, study instruments, advertising materials etc) will be used.
b. All changes (amendments, deviations, violations etc.) are submitted for review and approval by KNH-UoN ERC before implementation.
c. Death and life threatening problems and serious adverse events (SAEs) or unexpected adverse events whether related or unrelated to the study must be reported to the KNH-UoN ERC within 72 hours of notification.
d. Any changes, anticipated or otherwise that may increase the risks or affect safety or welfare of study participants and others or affect the integrity of the research must be reported to KNH- UoN ERC within 72 hours.
e. Clearance for export of biological specimens must be obtained from KNH- UoN ERC for each batch of shipment.
f. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. (*Attach a comprehensive progress report to support the renewal*).
g. Submission of an *executive summary* report within 90 days upon completion of the study. This information will form part of the data base that will be consulted in future when processing related research studies so as to minimize chances of study duplication and/ or plagiarism.

Protect to discover

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For more details consult the KNH- UoN ERC website**http://www.erc.uonbi.ac.ke**

Yours sincerely,

PROF. M.L. CHINDIA
SECRETARY, KNH-UoN ERC

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