COMPARISON OF ULTRASOUND AND OPERATIVE FINDINGS IN ABDOMINAL LESIONS AT MUHIMBILI NATIONAL HOSPITAL

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CERTIFICATION

The undersigned certifies that he has read and hereby recommend for acceptance by the University of Dar es Salaam a dissertation titled; "Accuracy of Ultrasound in diagnosing Surgical Abdominal Lesions at Dar es Salaam Hospitals" in partial fulfillment of the requirements for the degree of Master of Medicine in Surgery.

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DECLARATION

I, Maurice Mavura, declare that this dissertation is my own original work and that it has not been presented and will not be presented to any other University for a similar or any other degree award.

Candidates Signature;……………………………

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ABSTRACT

Background

Abdominal and pelvic ultrasound is widely used in investigating patients with surgical abdominal diseases and gynaecological diseases. This may be explained by its relative accessibility, affordability, and safety as compared to other sophisticated imaging modalities such as CT scan, MRI, and others. However the diagnostic value, i.e. sensitivity, specificity, accuracy, and predictive values, of this imaging technique have not yet been assessed, here in Dar es Salaam.

Objective

To compare the Ultrasound findings and Operative findings in abdominal lesions at Muhimbili National Hospital.

Method

From March 2003 through March 2004, 277 patients were studied. These were patients who under-went abdominal or pelvic ultrasound, or both, followed by either open surgical procedure or endoscopy, due to either surgical or gynaecological condition, within the study period.Ultrasound was the screening test where as surgery and endoscopy were confirmatory. The ultrasound results were compared with the operative or endoscopic findings.

Results

A total of 109(39.3%) male and 168(60.7%) female patient were studied. Accuracy, sensitivity, specificity, positive and negative predictive values were used to assess the diagnostic value of US. The range of values obtained are summarized here-under, according to each disease category;

Summary of Diagnostic Value Indicators of the Abdomino-pelvic US.

Disease Category	**Accuracy (%)**	**Sensitivity (%)**	**Specificity (%)**	**PPV (%)**	**NPV (%)**
Gynaecological Diseases	50-76	33-78	0-100	82-100	0-67
Hepatobiliary Diseases	0-80	0-90	0-60	0-82	0-75
Pancreatic Diseases	33-88	33-86	0-100	100	0-50
GI Diseases	76-100	75-100	0-100	80-100	0-100
Urological Diseases	80-100	88-100	50-100	75-100	67-100
Paediatric Diseases	25-100	0-100	0-100	0-100	0-100
Other Diseases	20-100	20-100	0-50	67-100	0-25

Conclusion

According to this study, abdominal and pelvic ultrasound is not a reliable diagnostic tool for evaluating abdominal and pelvic lesions, at MNH.

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LIST OF ABBREVIATION

AMLs	-	Acute Myeloid Leukaemias,
BhCG	-	Beta Human Chorionic Gonadotrophin Hormone,
BPH	-	Benign Prostatic Hyperplasia,
CAP	-	Carcinoma of Prostate,
CT scan	-	Computerized Tomography scan,
DVT	-	Deep Vein Thrombosis,
D+	-	Presence of Disease as Evidenced by either Open Surgery or Endoscopy,
D-	-	Absence of Disease,as Evidenced by either Open Surgery or Endoscopy.
FAST	-	Focused Assessment for the Sonographic examination of a Trauma patient,
FNA	-	Fine Needle Aspiration,
GI~	-	Gastrointestinal~,
HCC	-	Hepatocellular Carcinoma,
IUCD	-	Intra-uterine Contraceptive Device,
MNH	-	Muhimbili National Hospital,
MRI	-	Magnetic Resonance Imaging,
MUCHS	-	Muhimbili University College of Health Sciences,
NPV	-	Negative Predictive Value,
OP~	-	Operative~

OR	-	Operating Room,
PHT	-	Portal Hypertension,
PID	-	Pelvic Inflammatory Disease,
PPV	-	Positive Predictive Value,
PSA	-	Prostatic Specific Antigen,
RCC	-	Renal Cell Carcinoma ,
SICU	-	Surgical Intensive Care Unit,
T+	-	Ultrasound is positive for a disease,
T-	-	Ultrasound is negative for a disease,
TB	-	Tuberculosis
TOM	-	Tubo-ovarian Mass,
TRUS	-	Trans-rectal Ultrasonography,
TVS	-	Trans-vaginal Sonogram,
PUJ	-	Pelvi-ureteric Junction,
US	-	Ultrasound,
uTNM	-	Tumor Node Metastases staging by Ultrasound.

1. INTRODUCTION

Medical ultrasonography is an ultrasound-based imaging technique used to visualize internal organs; their size, structure, and their pathological lesions. Ultrasonography is widely used in medicine primarly in gastroenterology, cardiology, gynaecology and obstetrics, urology, and endocrinology.

Sound, literally, means perception of vibrations stimulating the ear. However, scientifically, sound may be defined as a periodic disturbances in a fluid density, or in the elastic strain of a solid matter, generated by a vibrating object. These waves (vibrations) propagate in two basic ways; longitudinal and transverse waves(1).

Ultrasound is a sound with frequency over 20,000 Hz (circles/ second). Human beings perceive sound whose frequency is below 20,000 Hz (20 KHz), hence, ultrasound is inaudible to human (1).

In surgical practice , ultrasound has a wide range of application it may be applied in diagnostic and interventional purposes. Anatomical defects in the pelvis, abdomen, infant brain, eye, thyroid and parathyroid glands, salivary glands, breast, heart, pleaura, oints , scrotum and in the vascular system may be diagnosed and intervened with aid of ultrasound(1).

It is possible to perform diagnostic or therapeutic procedures with guidance of ultrasonography (for instance biopsies) [1].

Ultrasound imaging has the following strengths:

i) It images muscle and soft tissues very well and is particularly useful in delineating between solid and fluid filled spaces;

ii) It renders "live" images, where the operator can dynamically select the most useful section for diagnosing and documenting changes, often enabling rapid diagnosis;

iii) It shows structures as well as aspects of function of organs;

iv) It has no known long-term side effect and rarely causes any discomfort to patients;

v) Equipment is widely available and comparatively flexible as examinations can be performed at bedside.

Ultrasound imaging has the following weakness;

i). Ultrasound cannot penetrate bones and perform poorly when there is air between the scanner and the organ of interest. For example, overlying gas in the gastrointestinal tract often makes ultrasound scanning of the pancreas difficult;

ii) .Even in the absence of one or air the depth of penetration of ultrasound is limited making it difficult to image structures that are far removed from the body surface especially in obese patients;

iii).The method is operator dependent hence a high level of skill and experience is needed to acquire good-quality images and make accurate diagnosis.

Medical ultrasonography was invented in 1953 at Lund University by cardiologist Inge Edler and Carl Hellmuth Hertz, the son of Gustav Ludwig Hertz, who was a graduate student at the department of nuclear physics. Edler had asked Hertz if it was possible to use radar to look into the body, but Hertz said this was impossible. However, he said it might be possible to use ultrasonography. Hertz was familiar with using ultrasonic reflectoscopes for non-destructive material testing and together they developed the idea of using this idea in medicine[2]. The first successful measurement of heart activity was made in October 29,1953 using device lent from the Ship construction company in Malmo. In December,16 the same year, the method was used to generate an echo-encephalogram (ultrasonic probe of the brain). The first Obstetric measurements were made in Scotland [2] .

Role of Ultrasound in Diagnostic Imaging.

Thanks to the medical acumen and inventive skills of early and recent pioneers in the field, ultrasound has evolved into a high-quality, reliable, and cost effective diagnostic tool. Ultrasonography has become one of the most widely used diagnostic imaging modality today. Ultrasound exams are non- invasive and generally considered safe at the power levels used for diagnostic exams [2] .

Early Pioneers

Sonar, the technique of sending sound waves through water and observing the returning echoes to characterize submerged objects, inspired early ultrasound investigators, who explored ways to apply the concept to medical diagnosis. Shortly after the close of World War II, researchers in Japan began to explore medical diagnostic capabilities of ultrasound, building the first model of ultrasonic equipment with A-mode presentation blips on an oscilloscope screen – which was followed by work in B-mode presentation of two dimensional, gray scale imaging(3) . Japan's work in ultrasound was relatively unknown in the United States and Europe until the 1950s. Then , researchers presented their findings on the use of ultrasound to detect gallstones, breast masses, and tumors to the international medical community. Japan was also the first country to apply Doppler ultrasound, an application of ultrasound that detects internal moving objects –such as blood flowing through the heart and blood vessels –for cardiovascular investigation (3).

Ultrasound pioneers working in the United States contributed many innovations and important discoveries to the field during the following decades. Researchers learned to use ultrasound to detect potential cancer and to visualize tumors in living subjects and in excised tissue. Real-time imaging, another significant diagnostic tool for physicians, resented ultrasound images directly on the system's screen at the time of scanning. The introduction of spectral Doppler and later color Doppler depicted blood flow in various colors to indicate speed of flow and direction .The United States also produced the earliest hand held "contact" scanner for clinical use, the second generation of B-Mode equipment, and prototype for the first articulated-arm hand held scanner, the origins of 2-D images(4).

Recent Pioneers

By the early 1980s, when ultrasound technology was thought to have reached its peak, the existing scanners produced satisfactory diagnostic images from returning echoes through electrical channels, but the machines could not refine the images, because computers for ultrasound imaging did not exist. When Samuel H. Maslak, who later was named "The Father of Modern Ultrasound", and Acuson Corporation developed the 128-channel Computed Sonography platform, computer technology and diagnostic ultrasound were finally used. For the first time, a software controlled image formation process provided black and white and color ultrasound images with superior resolution and clarity(4) .

Ushering in the era of high performance ultrasound systems, the 128-channel system allowed physicians to process and customize ultrasound images to maximize diagnostic information. Medical professionals were quick to label this major advance in diagnostic ultrasound imaging technology "the fourth generation of medical ultrasound" (Diagnostic Imaging, Faye C. Laing , M.D, University of San Francisco, October 1985) and the system became the " Gold Standard" for a growing list of applications, including obstetrical/gynecological, abdominal, vascular, trans-cranial , and cardiac(5).

The New Frontier

Acuson's newest technology, the Sequoia 512 ultrasound system and Sequoia C256 echocardiography system, introduced in April 1996, will again rewrite the history of ultrasound . During its development process , the world's leading ultrasound physicians evaluated Sequoia technology, predicting it will result in improvements across all clinical applications[5]. Using proprietary scientific and system architectural breakthroughs, Acuson developed a fundamentally new way to form an ultrasound echoes contain two types of information –phase and amplitude- each of which contains one half of the total acoustic information. Unlike conventional ultrasound systems, which produce images based only on the amplitude information, Coherent Image Formation uses both the phase and amplitude information to form ultrasound images based on all of the diagnostic information available [5].

This quantum leap in image formation dramatically increases spatial and temporal resolution. Users can now routinely see anatomy and physiology not seen with conventional ultrasound, which results in better tissue differentiation in the body, especially between healthy and diseased tissue. This latest advance from Acuson should increase productivity, expand capabilities and be cost effective well into the next century. For the next century, pioneers predict higher frequency transducers, second harmonic imaging , and 3-D reconstruction on the horizon of ultrasound science [5].

The earliest diagnostic application of ultrasound to abdominal disease was the work of the young George Ludwig in the late 1940s and early 1950 on detection of gall stones embedded in the muscles of animals. John Wild designed his flexible and rigid trans-rectal scopes for imaging the bowel and deeper abdominal structures in the course of his ultrasonic research in the early 1950s [6].

The early work of the Denver group under Douglass Howry's direction, took its ultrasonic picture-taking in many directions, including the abdomen. In scans taken with their "somascope" in 1951, Howry's team produced images through both normal and pathologic gall bladders; in one of the latter, the image showed clearly the biliary calculi. Their success in visualizing these freshly excised organs encouraged their belief that it would be feasible to visualize even deep-lying organs such as the kidney, liver, and spleen in the living subjects. As the project moved under the direction of Dr. Joseph Holmes, a nephrologist, the interest in abdominal areas (in addition to many others) was maintained. By the late 1950s, using their pan scanner, the Denver team was producing scans of abdominal organs through the abdominal wall [6].

In the peoples' Republic of China, Dr. Chou Yung-Chang of Shanghai began work in abdominal ultrasound in 1958 that remained isolated from Western developments.

Dr. Chou's earliest interest in ultrasound was based on its therapeutic possibilities; he hoped to break up urethral calculi with ultrasonic beams. This therapy proved ineffective but during the clinical trials Dr. Chou noted that the beams seemed effective in detecting space-occupying lesions in the liver and kidney. He also obtained echoes from the gravid uterus. Dr. Chou continued to use ultrasound as a diagnostic tool and designed equipment for that purpose [6].

In the 1960s, the clinical application of ultrasound to imaging abdominal structure and assessing abdominal diseases expanded rapidly. The use by gynaecologists of ultrasound to assess problems in the pelvis, of course, represented an extention of ultrasonic diagnosis within the abdomen, and occasionally clinicians like Donald, Thompson, and Gottesfeld extended their diagnostic work to other organ system. For example, in 1963, using a mechanical sector scanner, Ian Donald visualized conditions characteristic of liver cirrhosis, other liver diseases, and abnormalities in cardiac tissue, as well as ovarian cysts and tumors [6].

The group under Joseph Holmes at the University of Colorado Medical Center maintained a major research and clinical concentration on abdominal diseases, imaging the liver, bladder, spleen, kidney, etc, and worked at producing both better imaging and more precise diagnostic criteria [6].

2. LITERATURE REVIEW

2.1 Physics and Instrumentation

Before the application of ultrasound devices to patient evaluation is addressed, it is worthwhile to briefly review certain basic physical principles and terminology associated with ultrasonography (see Tables 1,2 and 3)[1,2,3,4,5]. Nowhere in diagnostic imaging is the understanding of wave physics more important than in ultrasound diagnostic imaging, because ultrasonography is highly operator dependent. To perform an ultrasound examination correctly, a surgeon must be able to interpret echo patterns, determine artifacts, and adjust the machine appropriately so as to obtain the best images. In diagnostic ultrasonography, the transducer or probe inter-converts electrical and acoustic energy [6]. To accomplish this inter-conversion, the transducer contains the following essential components;

1. An active element; Electrical energy is applied to the piezo-electric crystals within the transducer, and an ultrasound pulse is thereby generated via the piezoelectric effect. The pulse distorts the crystals, and an electrical signal is produced . This signal causes and ultrasound image to form on the screen via the reverse piezoelectric effect.

2. Damping or backing material; An epoxy resin absorbs the vibrations and reduces the number of cycles in a pulse, thereby improving the resolution of the ultrasound image .

3. Matching layer; This substance reduces the reflection that occurs at the transducer-tissue interface. The great difference in density (i.e. the impedance mismatch) between the soft tissue and the transducer results in reflection of the ultrasound waves. The matching material decreases this reflection and facilitates the transit of the ultrasound waves through the body and into the target organ.

Transducers are classified according to (1) the arrangement of the active elements (array) contained within the transducer and (2) the frequency of the ultrasound wave produced. Transducer arrays contain closely packed piezoelectric elements, each with its own electrical connection to the ultrasound instrument.[7] These elements can be excited individually or in groups to produce the ultrasound beam. There are four main transducer arrays; (1) the rectangular linear array, which yields a rectangular image, (2) the curved array , which yields a trapezoidal image, (3) the phased array, a small transducer in which the sound pulses are generated by activating all of the elements in the array, and (4) the annular array , a small transducer in which the elements are arranged in a circular fashion. The advantage of transducer arrays is that the ultrasound beam can be electronically steered without any moving mechanical parts (except for the annular array) and focused [7,8] . In the clinical setting, this arrangement allows the operator to adjust the focal zone so that he or she can accurately image a large organ (e.g. the liver) while still being able to obtain fine details of a lesion.

The frequency of the transducer is determined by the thickness of the piezoelectric elements within the transducer: the thinner the piezoelectric elements, the higher the frequency[7,8].

Although diagnostic ultrasonography makes use of transducer frequencies ranging from 1MHz to 20 MHz, the most commonly used frequencies for medical diagnostic imaging are those between 2.5 and 10MHz (see Table 4). Ultrasound beams of different frequencies have different characteristics; higher frequencies penetrate tissue poorly but yield excellent resolution, whereas lower frequencies penetrate well but at the cost of compromised resolution. Accordingly, transducers are generally chosen on the basis of the depth of the structure to be imaged[9]. For example, a 7.5 MHz transducer is a suitable choice for imaging a superficial organ such as the thyroid, but a 3.5MHz transducer would be preferable for imaging a deep structure such as the abdominal aorta and heart.

Ultrasound machines vary in complexity, but each has the following essential components.

1. A monitor (for displaying the ultrasound image).
2. A keyboard (for labeling the image and making adjustments to produce a quality image).
3. A transducer (for inter-converting electrical and acoustic energy).
4. An image recorder (for producing copies of the ultrasound images).

Finally, there are three scanning modes, A,B, and M; these modes evolved over several

Table 1: Ultrasound Physics Terminology Relevant to Ultrasonographic Imaging [4,5,6]

Term	Definition	Significance
Ultrasound	High-frequency (> 20kHz)mechanical radiant energy transmitted through a medium	
Frequency	Number of cycles/ sec (106cycles/sec=1MHz) Diagnostic ultrasound: 1-20 MHz	Increasing frequency improves resolution
Wavelength	Distance traveled by wave per cycle: as frequency becomes higher, wavelength becomes smaller	Wavelength is related to spatial resolution of object: shorter wavelengths yield better resolution but poorer penetration

Table 1: (continued)

Amplitude	Strength or height of wave	Amplitude and intensity are reduced (attenuated) as waves travel through tissue; time-gain compensation circuit compensates for this attenuation
Attenuation	Decrease in amplitude and intensity of wave as it travels through a medium; attenuation is affected by absorption, scattering, and reflection	
Absorption	Conversion of sound energy into heat	
Scattering	Redirection of wave as it strikes a rough or small boundary	
Reflection	Return of wave toward transducer	
Propagation Speed	Speed with which wave travels through soft tissue (1, 540 m/sec)	Propagation speed (determined by density and stiffness of medium)is greater in solids than in liquids and greater in liquids than in gases

Years[10]. A-mode (amplitude modulation), the most basic form of diagnostic ultrasonography, yields a one-dimensional image that displays the amplitude or strength of the wave along the vertical axis and the time along the horizontal axis.

Therefore, the greater the signal returning to the transducer the higher the "spike". B-mode (brightness modulation), the most commonly used today to the denser structures appear brighter (i.e. whiter, more echogenic), on the image because they reflect the ultrasound waves better. M mode relates the amplitude of the ultrasound wave to the imaging of moving structures, such as cardiac muscle.

Table 2: Essential Principles of Ultrasound

Principle	Explanation
Piezoelectric effect	Piezoelectric crystals expand and contract to interconvert electrical and mechanical energy
Pulse–echo principle	When ultrasound wave contact tissue, some of signal is reflected while some is transmitted into tissue, these waves are then reflected to crystals within transducer, generating electrical impulse comparable to strength within transducer, generating electrical impulse comparable to strength of returning wave .
Acoustic Impedance	Acoustic impedance=density of tissue x speed of sound in tissue. Strength of returning echo depends on difference in density between two structures imaged: structures of different acoustic impedance (e.g. bile and gallstone) are relatively easy to distinguish from one another, whereas those of similar acoustic impedance (e.g. spleen and kidney) are more difficult to distinguish .

Table 3: Terminology Used in Assessment of Ultrasonograms [3,108]

Term	Definition
Echogenicity	Degree to which tissue echoes ultrasonic waves (generally reflected in ultrasound image as degree of brightness).
Anechoic	Showing no internal echoes , appearing dark or black.
Isoechoic	Having appearance similar to that of surrounding tissue,
Hypoechoic	Less echoic or darker than surrounding tissue.
Hyperechoic	More echoic or whiter than surrounding tissue.
Resolution	Ability to distinguish between two different structures, spatial resolution improves as frequency increases.
Lateral	Resolution transverse to ultrasound wave, relates to width of structure.
Axial	Resolution parallel to ultrasound wave, relates to depth of structure.

Before real–time imaging became available, M-mode scanning formed the basis for Echocardiography [10,11].

As an extension of the physical examination, ultrasonography is a valuable adjunct to surgical practice in the office, the emergency department , the OR, and the SICU. Once surgeons have learned the essential principles of ultrasonography, they can readily build on this experience and extend the use of this technology to various specific aspects of surgery.

2.2. General Considerations for Diagnostic Ultrasound Examinations

INSTRUMENTATION

Before an ultrasound examination is performed, the following three steps should be observed;

1. The correct ultrasound machine and transducer should be chosen for the specific type of examination to be done. For example, if a vascular study is to be performed, the machine should have Doppler capability and, ideally, color flow capability as well.
2. The transducer should be chosen according to the structure or organ to be imaged. It must provide both sufficient depth of penetration to image the entire organ and sufficient resolution to allow the examiner to distinguish the details of lesions.
3. Although many machines have preset controls for power and gain, a standard image should be obtained to confirm that the settings are correct for the specific examination being done. For example, the FAST begins with an image of the heart so that blood can be identified and the gain controls adjusted, if necessary, to permit accurate detection of hemoperitoneum .

2.3. Patient Positioning

The patient should be positioned so that all of the images required for a particular examination can be readily obtained. The surgeon should take time to review the scanning planes and understand the orientation of the patient on the monitor screen in relation to the transducer. It is also important to follow conventional scanning protocols so that when the images are reviewed, a lesion can be accurately located and the scan can be reproduced even by another ultrasonographer. An example of such a protocol is the radial scanning technique recommended for examination of the breast.

2.4. Documentation

The machine's annotation keys are used to record the patient's name and identification number, the area of interest , and the scanning plane. Most machine have function keys that automate the recording of these data. Furthermore, the internal clock automatically labels each image with the date and time (accurate to 0.01 second). Any hard copies of the ultrasound images that may be required should be printed, saved, and reviewed. Ideally, the ultrasound images should be videotaped, because the dynamic real–time provides more information than still images, thereby increasing the confidence level associated with each observation .

2.5. Continuous Performance Improvement

As part of the performance improvement process, ultrasound images should be routinely reviewed, with special attention paid to false positive or false negative examinations. The goal of this process is to help identify any correctable factors associated with such examinations and thereby minimize or prevent their recurrence. Some studies have noted the presence of a pronounced learning curve, as a result of which the sensitivity and specificity initially achieved by new surgeon-ultrasonographers have been relatively low[12]. However, there is evidence that surgeons performance may be improved with the help of an ultrasound training course that focuses on those pitfalls of imaging that were found to be problems in the clinical setting. For example, in one study, surgeons learned both to perform Examinations correctly and to interpret positive results accurately in patients with minimal as well as pronounced ascites; as result, they were better able to distinguish relatively subtle differences within the spectrum of positive FAST result [13].

Other suggestions for improving performance are (1) to perform the ultrasound examination initially on normal tissue (as in evaluation of a breast mass) and (2) to perform the examinations on patients with known disease (e.g., a palpable breast mass, ascites, gallstones, or benign pericardial effusion). The rationale for the latter suggestion is that it should help the surgeon learn more rapidly how to recognize lesions with varying degrees of pathology.

2.6. Technical Tips

The following general technical tips should prove useful in a wide range of ultrasonographic applications: The ultrasound machine should be inspected according to the guidelines of the institution's department of biomedical engineering to ensure that it is functioning properly.

1. The patient's orientation on the monitor or screen relative to the position of the transducer should be checked by applying gel to the transducer's footprint (i.e., the part of the transducer that is in contact with the patient's skin) and then rubbing the footprint with a finger near the indicator line of the transducer. Motion on the left side of the screen indicates that the transducer is properly oriented.

2. Liberal amounts of gel should be applied to the area being examined. The gel acts as an acoustic coupler, helping to transmit the ultrasound waves and reduce their reflection. If not enough gel has been applied, the waves will not be transmitted properly, and a dark area will appear on the ultrasound image. The transducer should be manipulated with small movements (not wide sweeps), and gentle pressure should be applied initially. This second point is especially important in imaging the breast or the thyroid: the tissues are superficial, and too much pressure can easily compress them and distort the ultrasound image. The gain and time-gain compensation settings should be rechecked for each new examination. For example, after completing a breast examination, the sonographer should not begin an examination of the carotid vessels without confirming that these settings are correct.

3. Normal tissue should be examined ultrasonographically before the sonographer turns to the area of interest. For example, if the goal is to assess an abscess or DVT in one extremity, the first step should be to inspect the other extremity to see what the corresponding normal tissue looks like. This helps to sensitize the examiner to subtle pathologic changes in the abnormal tissue. The patient should be asked to take a deep breath so that the motion of the diaphragm and the organs can be observed. If the motion of these structures is impaired, inflammation or an abscess may be present. If the left upper quadrant is difficult to examine (as is sometimes the case in the FAST), a nasogastric tube should be inserted to decompress the stomach and minimize the presence of air so that it does not interfere with the transmission of the ultrasound waves.

4. Although B-mode ultrasound is usually sufficient to identify blood vessels, it sometimes is unable to distinguish the artery from the vein because of pulsations transmitted from the artery . In such cases, use of the Doppler mode, compression of the vessel (veins compress very easily), or having the patient perform the Valsalva maneuver can help differentiate arterial from venous anatomy. In addition, the vena cava is more readily identified as the patient completes inspiration.

5. A full bladder is needed for pelvic ultrasound examinations: it acts as an acoustic window, facilitating visualization of the pelvic structures. It should

not, however, be so full that it is over distended. If the bladder is not full enough, the urinary catheter can be clamped to allow it to fill; if it is too full, the catheter can be unclamped to allow it to drain. In this way, hematomas in the pelvis can be more easily detected.

3. ABDOMINAL EXAMINATION

3.1. Trauma

Ultrasound has a very important role in the management of abdominal trauma. Among diagnostic applications of US that are currently advocated is the Focused Assessment for the Sonographic examination of the Trauma patient (FAST). FAST is a rapid diagnostic test developed for the evaluation of patients with potential truncal injuries. FAST accurately detects the presence or absence of hemoperitoneum in patients with blunt trauma, it does not readily identify intraparenchymal or retroperitoneal injuries. Therefore, a computed tomographic scan of the abdomen may be needed to complement the FAST and reduce the incidence of missed injuries[14,15,16]. There is some evidence that false negative results are more common is patients with pelvic ring fractures, which suggests that CT of the abdomen is routinely indicated in such patients[17].

Historically, its development is rooted in several fundamental studies that demonstrated the high sensitivity of ultrasonography in detecting small degrees of ascites [18], splenic injury [19], and hemo-peritoneum in the hepatorenal space and the pelvis [20].

The FAST determines the presence or absence of the blood in the pericardial sac and three dependent abdominal regions, including Morison's pouch, the splenorenal recess and the pelvis. Ultrasonography may also be used in traumatic settings to detect hemothorax, sternal fracture, and pneumothorax [21,22,23].

FAST is performed during the Advanced Trauma Life Support secondary survey while the patient is in the supine position. With the thoraco-abdominal area exposed, warmed hypoallergenic, water-soluble ultrasound transmission gel is applied to the abdomen in four specific areas. A focused, limited examination for the detection of blood in these four regions is conducted in sequence as follows: (1) the pericardial area, (2) the right upper abdominal quadrant, (3) the left upper abdominal quadrant, and (4) the pouch of Douglas.

The transducer is oriented for sagittal sections and placed in the subxiphoid region. The heart is then identified, with the density of blood used as a standard. The subxiphoid approach through the longitudinal axis is taken to enable the examiner to identify the heart and to look for blood in the pericardial region. The transducer is then placed in the right midaxillary line region between the 11^{th} and 12^{th} ribs to enable the examiner to identify the liver, the kidney, and the diaphragm and to look for blood in Morison's pouch. Next, the transducer is positioned on the left posterior axillary line between the 10^{th} and 11^{th} ribs to enable the examiner to visualize the spleen and the kidney and to look for blood in the space between these organs and posterior to the spleen. The transducer is then oriented for transverse sections and placed in the midline approximately 4 cm superior to the symphysis pubis to determine whether there is blood around the full bladder.

An analysis of 1,540 injured patients undergoing FAST examinations performed by surgeon-ultrasonographers reached the following conclusion[13].

1. Ultrasonography should be the initial diagnostic adjunct for the evaluation of patient with precordial wounds and blunt truncal injuries because it is rapid and accurate and augments the surgeon's diagnostic capabilities.

2. Surgeon-performed FAST is most accurate when used for the evaluation of patients with precordial or transthoracic wounds and a possible hemopericardium and for the evaluation of hypotensive patients with blunt torso trauma.

3. Because of the high sensitivity and specificity of ultrasonography when it is used for the evaluation of patients with precordial or transthoracic wounds and hypotensive patients with blunt torso trauma, immediate operative intervention is justified in these patients when the ultrasound examination is positive.

3.2. Non-trauma

In the acute non-traumatic setting, surgeons are currently using ultrasonography for the following purposes;

1. Assessment for multiple loculations and drainage of a soft tissue abscess [22].
2. Early diagnosis of wound dehiscence through visualization of the fascial defect
3. Detection of a foreign body in soft tissue [23,24,25].
4. Evaluation of a patient with abdominal pain (e.g. from gallstones) [26,27,28].
5. Confirmation of the reduction of an incarcerated hernia through identification of the fascial defect and observation of the reduction occurring with real–time imaging [29].
6. Identification of an abdominal aortic aneurysm in a patient who presents with back pain and hypotension. Intramural calcification and intra-luminal thrombus are common findings.

If the aortic aneurysm ruptures into the peritoneal cavity, the FAST can detect thepresence of hemoperitoneum.

Here-under I wish to describe clinical application of US in different abdominal non-trauma diseases according to system that is affected.

Table 4: Clinical Application of Selected Transducer Frequencies

Frequency	Applications
2.5 –3.5 MHz	Renal Aortic General abdominal
5.0 MHz	Transvaginal Pediatric abdominal Testicular
7.5 MHz	Vascular Foreign body in soft tissue Thyroid

3.2.1. Gastrointestinal Tract

Patients with suspected or palpable abdominal masses are normally subjected to ultrasound examination, with the aim of confirming the presence of a mass and also detect the organ of origin of the mass. It has been shown to have a sensitivity of 90% in detecting the organ of origin of the mass [30].

With the exception of the diagnosis of pyloric stenosis in infancy, ultrasound does not have a primary role in the investigation of the gastrointestinal tract. However tumors of the gastrointestinal tract will often be obvious on ultrasound, although it may be difficult to differentiate these from inflammatory masses such as diverticular masses [31].

Ultrasound has, however, a sensitivity of more than 80 percent and specificity of 95 percent in the diagnosis of acute appendicitis without perforation and it has been advocated that is should be used routinely in an attempt to reduce the negative appendicectomy rate, to patients with equivocal clinical findings and young women, in whom it will exclude a gynaecological cause for the pain [32].

3.2.2. Hepatobiliary Tract

In examination of hepatobiliary system, ultrasound has a sensitivity of 97,82,96,67 percent in identify pancreatic masses, choledocholithiasis, cholangio carcinoma and chronic pancreatitis respectively [33,34]. It has replaced the oral cholecystogram for detection of gallstone, not so much because of its greater sensitivity but rather because it enables examination of other structures at the sometime. There is little difference in the detection of gall bladder pathology [35].

Ultrasound has a major role of investigating for a diffuse liver diseases and localized liver masses. It can differentiate between solid and cystic lesions, and if there is any doubt about the nature of a mass, guided aspiration may be performed to determine whether the lesion is benign or a malignant tumor or whether it is an abscess or cyst.

Intra-operative ultrasound is currently the most sensitive method of detecting liver tumors. Forty percent of the lesion detected by this method are not palpable at surgery[36] Take care to evaluate the entire liver completely since it is not difficult to overlook a small hepatic mass.

Small US appearance of HCC (Hepatocellular carcinoma) is variable. Note that the quality HCCs can be homogeneously hyperechoic and can mimic hemangioma. This can result when a large proportion of fat is present in the tumor [37]. Small HCCs also can appear hypoechoic with larger HCCs frequently mixed in echogenicity [38].

Good quality US with careful evaluation of the entire liver can be a screening examination for HCC in patients at risk in combination with serum AFP evaluation. However, sensitivity of US for the detection of lesions in a cirrhotic liver is limited. Vascular invasion can be evaluated adequately using color Doppler imaging with conventional gray-scale US. Look for tumor thrombus in hepatic and portal veins aswell as in the inferior vena cava. Portal venous invasion is more common in HCC but hepatic vein invasion is more specific for HCC. Preoperative assessment with ultrasound has a sensitivity of about ultrasound has a sensitivity of about 60 percent to 70 percent in the detection of liver tumors [38]. It is 80-90% accurate in liver abscess and capable of delineating liver lesions as small as 2cm in diameter [38].

3.2.3. Urinary Tract

US demonstrates the shape, size, and echogenicity of the kidneys and the nature of mass lesions. It also demonstrates renal tract dilatation. It is more sensitive and more specific, than urography , in the detection of renal mass lesion other than tumors of renal pelvis. It also determines whether the mass is solid or cyctic. Tumors of the urinary bladder are better detected by transabdominal ultrasound than urography. Trans abdominal US has a sensitivity of 61 to 72 percent, in detecting tumors of the urinary bladder. The combination of the transabdominal and transrectal ultrasound increases the sensitivity to 95 percent [39].

On sonograms, RCC can be isoechoic, hypoechoic, or hyperechoic relative to the remainder of the renal parenchyma. Smaller lesions with less necrosis are more likely to be hyperechoic and may be confused with AMLs. Isoechoic tumors are detected only by distortion of the renal contour, focal enlargement of a portion of the kidney, or distortion of the central sinus fat [40].

For the workup in RCC, US is used primarily to differentiate solid masses from simple cysts and to visualize the internal architecture of lesions more effectively than can be accomplished by using CT or MRI [40] .

The degree of confidence in tumor detection is increased as lesions increase in size. Larger lesions usually are more heterogeneous and more often hypoechoic. In reported series, a detection rate of 85% was seen in lesions larger than 3 cm. A detection rate of less than 60% was seen in lesions smaller than 2 cm. The confidence also increases if lesions are solid, lobulated, or well differentiated from the normal parenchyma and if they have poor through transmission. The false-positive results are rare because US is seldom the sole imaging modality used prior to intervention[40].

The Role of US in Obstruction of Pelvi-ureteric Junction

Ultrasound has a significant role in investigating patients with obstruction of the uretero-pelvic junction by demonstrating hydronephrosis and the cause of obstruction

The Role of US in Carcinoma of Prostate

TRUS was evaluated to determine if it could be used for CAP screening. However, lack of specificity made this difficult. CAP lesions appear hypoechoic, hyperechoic, or isoechoic . Therefore, TRUS is used to direct the physician to suggestive areas in the prostate or to perform systematic biopsies [41].

Prostate volume is assessed during the TRUS examination. The volume of the prostate gland can be used to determine treatment options. Perineal prostatectomies are easier when the gland is less than 50 g. Similarly, brachytherapy is easier when the gland less than 50 g; in large glands, the anterolateral portion of the gland is behind the pubic arch, and these areas cannot be reached by the perineal brachytherapy needles. Hormonal downsizing is useful in such a case, and TRUS is used to monitor gland size. Measuring prostate volume is also useful in large BPH glands to help decide if transurethral resection or an open procedure is appropriate for prostatectomy. TRUS can help identify extraprostatic CAP in advanced-stage T3 cases[41].

4. PELVIC ULTRASONOGRAPHY

The two major ways of conducting pelvic ultrasonography are the transabdominal and endovaginal ultrasonography. The transabdominal ultrasonography uses a lower frequency and can penetrate further, with a large field of view. In addition, pelvic kidneys can be visualized.[40] .

Endovaginal ultrasound can help in a detailed morphologic examination of pelvic structures. This requires a hand-held probe to be inserted into the vagina. It is relatively noninvasive and is well-tolerated in reproductive-aged women and post–reproductive-aged women who are still engaging in intercourse. It does not require a full bladder. Endovaginal scanning uses a high-frequency transducer and enables optimal imaging of organs close to the probe, including the endometrium, myometrium, cul-de-sac, and ovaries, which can be seen in detail(42). Thus, fibroids, ovaries, or cysts located high in the pelvis may be out of the focal range of an endovaginal probe.

Transabdominal ultrasound is better than endovaginal ultrasound for evaluating large masses and allows assessment of other intra-abdominal structures such as the kidneys, liver, and ascites. It uses a low frequency and is performed to view large fibroids and ovaries that are high in the pelvis and to determine the shape and size of the bladder, uterus, vagina, and cervix. In such situations a full bladder provides a sonographic window for evaluation of the uterus and adnexa. A full bladder has a teardrop-shaped appearance on the longitudinal view and is rectangular on the transverse view where as the uterus(longitudinal orientation) is oval and more echogenic than the bladder. The endometrial stripe is an echogenic (bright) line in the central uterus(42).

4.1. Indications of Pelvic Ultrasound

- Evaluation of vaginal bleeding in early pregnancy. This indication is well outlined in ectopic pregnancy. It may also be used in subchorionic hemorrhage (implantation bleeding), a common cause of spotting.
- Evaluation of pelvic pain. Ultrasonography can be used to evaluate pelvic pain, and entities such as ovarian cysts, tubo-ovarian mass.

- Evaluation of a pelvic mass e.g. abscess, uterine fibroids, or even an infected pelvic kidney [42].

- Localization of an intrauterine device or foreign body. An intrauterine device produces a characteristic acoustic artifact (shadow), which is helpful to the physician sonographer [42].

- Evaluation of trauma. Views of the pelvis are used at ultrasonographic examination to evaluate for free fluid or clotted blood, which can be present in the pouch of Douglas (cul-de-sac).

4.2. The Role of US in Endometrial Cancer.

Transvaginal sonography is advocated as the imaging modality of choice for screening for endometrial cancer [43]. TVS is superior to CT and approaches MRI in its ability to provide information regarding myometrial, cervical and, perhaps, parametrial invasion by endometrial carcinoma. US has significantly lower sensitivity than CT in detecting enlarged abdominal and pelvic lymph nodes (particularly in the obese patient) and in depicting intraperitoneal, omental, and mesenteric metastases. CT also is superior to US in assessing pelvic sidewall extension and adjacent organ invasion[43].

No US feature can differentiate reliably between malignant and benign endometrial pathology in the absence of identifiable myometrial invasion. The reported overall accuracy of US in detecting myometrial invasion and distinguishing between superficial and deep myometrial invasion by endometrial carcinoma ranges from 69-90%. The reported sensitivity and specificity of US evaluation of the depth of myometrial invasion are 50-100% and 65-100%, respectively. The reported sensitivity and specificity of US evaluation of cervical invasion by endometrial carcinoma are 66.7-80% and 95.2-100%, respectively. However, US findings of endometrial cancer are not specific and can be simulated by ;adenomatous hyperplasia; polyp(s); tamoxifen-related endometrial changes; degenerating submucosal leiomyoma; endometrial extension of cervical cancer[44] .

4.3. The Role of US in Uterine Fibroids.

US is the imaging modality of choice in the detection and evaluation of uterine fibroids.The most frequent US appearance is that of a concentric, solid, hypoechoic mass. This appearance results from the prevailing muscle, which is observed at histologic examination. These solid masses absorb sound waves and, therefore, cause a variable amount of acoustic shadowing.[45].

Fibroids may vary in their degree of echogenicity; they can be either heterogeneous or hyperechoic, depending on the amount of fibrous tissue and/or calcification. Fibroids may have anechoic components resulting from necrosis. Most fibroids are intramural, that is, located in the myometrium, however, they can be submucosal or subserosal as well. If fibroids are small and isoechoic relative to the uterus, the only US sign may be a bulge in the uterine contour.

Fibroids in the lower uterine segment may obstruct the uterine canal, causing fluid to accumulate in the endometrial canal[45]. The echogenic endometrial stripe may be displaced by a fibroid. Calcifications are hyperechoic, with sharp acoustic shadowing. Diffuse leiomyomatosis appears as an enlarged uterus with abnormal echogenicity. US has a sensitivity of 60%, a specificity of 99%, and an accuracy of 87% in diagnosing uterine fibroids[45].

4.4. The Role of US in Ovarian Masses.

Ultrasound is,also, the primary imaging tool for a patient considered to have an ovarian cyst . Findings can help define morphologic characteristics of ovarian cysts. Simple cysts are unilocular and have a uniformly thin wall surrounding a single cavity that contains no internal echoes. These cysts have a very low malignant potential.

Most commonly, they are functional follicular or luteal cysts or, less commonly, serous cystadenomas or inclusion cysts[46] .

Complex cysts may have more than one compartment (multilocular), thickening of the wall, projections sticking into the lumen or on the surface, or abnormalities within the cyst contents. Malignant cysts usually fall within this category, as do many benign neoplastic cysts [46]. However,Ultrasound images may not be helpful for differentiating hydrosalpinx, paraovarian, and tubal cysts from ovarian cysts [46].

Doppler flow studies can help identify blood flow within a cyst wall and adjacent areas, including tumor surface, septa, solid parts within the tumor, and peritumorous ovarian stroma. The principle is that new vessels within tumors have lower resistance to blood flow because they lack developed smooth muscle in the walls. This can be quantitated into a resistive or pulsatility index [47] . Determination of the presence or absence of any blood flow within certain cysts may be helpful in diagnosis. For instance, hemorrhagic cysts may contain fine internal septations that characteristically do not demonstrate blood flow on Doppler images [47] .

4.5. The Role of US in Ectopic Pregnancy.

US probably is the most important tool in diagnosing an extra-uterine pregnancy. More frequently, it is used to confirm an intrauterine pregnancy. Visualization of an intrauterine sac, with or without fetal cardiac activity, often is adequate to exclude ectopic pregnancy. The exception to this is in the case of heterotropic pregnancies, which occur from 1 in 4000 to 1 in 30,000 spontaneous pregnancies. Screening the adnexia by US is mandatory despite visualization of an intrauterine pregnancy in patients undergoing ovarian stimulation and assisted reproduction because they have a 10-fold increased risk of heterotropic pregnancy [47].

Transvaginal US, with its greater resolution, can be used to visualize an intrauterine pregnancy by 24 days post-ovulation, or 38 days after last menstrual period, which is about 1 week earlier than transabdominal US. The gestational sac, which is a sonographic term and not an anatomic term, is the first structure that is recognizable on transvaginal US. It has a thick echogenic rim surrounding a sonolucent center corresponding to the trophoblastic decidual reaction surrounding the chorionic sac. Structures that represent a developing embryo cannot be recognized until a later time[48].

A pseudosac is a collection of fluid within the endometrial cavity created by bleeding from the decidualized endometrium often associated with an extrauterine pregnancy and should not be mistaken for a normal early intrauterine pregnancy. The true gestational sac is located eccentrically within the uterus beneath the endometrial surface, whereas the pseudosac fills the endometrial cavity [48].

The yolk sac is the first visible structure within the gestational sac, and it resembles a distinct circular structure with a bright echogenic rim and a sonolucent center. It can first be recognized 3 weeks post-conception, about 5 weeks after last menstrual period. The embryo is recognized first as a thickening along the edge of the yolk sac, and embryonic cardiac motion can be observed 3.5-4 weeks postconception, about 5.5-6 weeks after the last menstrual period[48]. The value of US is highlighted further in its ability to demonstrate free fluid in the cul-de-sac.

While free fluid could represent hemoperitoneum, it is not specific for ruptured ectopic pregnancy. Free fluid on US can represent physiological peritoneal fluid or blood from retrograde menstruation and unruptured ectopic pregnancies. Furthermore, US can be used to detect the presence of other pathological conditions that may display the signs and symptoms of ectopic Pregnancy[49].

4.6. The Role of US in Pelvic Inflammatory Diseases.

Abdominal sonography may not be useful in the diagnosis of PID. It has a low sensitivity (81%) and specificity (78%) with mild or atypical PID. It can be used to document an adnexial mass (TOM) or demonstrate fluid-filled fallopian tubes[50] .

5. PROBLEM STATEMENT

Ultrasound technology, like other advanced technology, is new to most countries in developing world . Expertise on clinical application of Ultrasound is also low due to limited number of people who would otherwise be conversant enough to interpret Ultrasound findings like qualified Doctors, Nurses and Radiologists. Not only that but also unavailability of appropriate probes for particular sonographic assessments.

Poor socio- economic status in the developing world countries, on the other hand, contributes very significantly in above mentioned factors. As a result, this interferes with management of different surgical conditions. Many times there have been occasions where ultrasound findings have misled surgeons and patients who would otherwise need no surgery were operated.

In Tanzania, the usefulness of Ultrasound in management of different surgical conditions has not yet been evaluated. This factor prompted the investigator decide to assess the accuracy of ultrasound in Dar es salaam Hospitals.

6. RATIONALE OF THE STUDY

Ultrasound is continuing to be one of the most available and most affordable imaging techniques in Tanzania. Surgeons and gynaecologists are currently regarding Ultrasonography as an important technique in confirming diagnoses and plan the management of patients. This is chiefly because other sophisticated imaging techniques such as the Computerized Tomography, Magnetic Resonance Imaging and others are either relatively unaffordable or inaccessible. surgeons will have to depend upon the widely available ultrasonography for possibly many years to come till the socio–economic status of Tanzania improves . Hence, it is of utmost importance to evaluate the accuracy of ultrasound in our settings.

7. OBJECTIVES

7.1. MAIN OBJECTIVE

To compare the Ultrasound and Operative findings in abdominal lesions.

7.2. SPECIFIC OBJECTIVES

1. To determine the sensitivity of Ultrasound in diagnosing abdominal surgical conditions,
2. To determine the specificity of Ultrasound in diagnosing abdominal surgical conditions,
3. To determine the positive predictive value of Ultrasound in diagnosing abdominal surgical conditions,

4. To determine the negative predictive value of Ultrasound in diagnosing abdominal surgical conditions.

8. METHODOLOGY

8.1. Study Area.

The study was done at the Surgical and Gynaecological wards of the MNH. MNH is a largest consultant hospital and a University teaching Hospital in Tanzania. It serves as a tertiary Hospital. Patients are attended to without restrictions whether they have been referred from peripheral Health facilities or they are self referrals.

The Hospital provides both the out-patient and in-patient Surgical and Gynaecological services including emergency and elective surgical operations, in addition to medical, pediatric, and other health services.

The Hospital has a Department of Radiology where several radiological services, including plain X-ray and contrast studies e.g. barium studies, intravenous urography; ultrasound; CT can are provided. So far the ultrasound that can be done is trans-abdominal and the radiological services are only diagnostic. There are no interventional services available at present, probably due to lack of facilities and expertise.

The Hospital has seven operating rooms where about 30-50 operations, both emergency and elective are done daily. The surgical procedures that are done include , both the open surgical operations and endoscopic procedures. Majority of endoscopic procedures are diagnostic, however, trans-urethral resection of the prostate and trans-urethral resection of bladder tumors are used for therapeutic purposes.There is only one blood bank for all departments.

The staff in the surgical and gynaecological departments include; consultants, specialists, residents, registrars, intern doctors, as well as nurses.

8.2. Study Design.

This was a prospective study which started in March 2003 and was completed in March 2004, a period of one year.

Cases that were studied included all patients who underwent pelvic and/or abdominal ultrasound between March 2003 and March 2004 followed by either endoscopy or open surgery within that period.

The ultrasound results were accepted from any Hospital located within Dar es Salaam, where as the endoscopy and surgery were performed at the MNH.

The ultrasound findings were compared to the operative findings, hence, ultrasound was a tested diagnostic tool where as endoscopy and surgery were the "Gold Standard" tests.

8.3. Study Population.

The study included patients, at all age groups, who underwent abdominal or pelvic surgical procedures, which were either endoscopic or open procedures, after undergoing abdominal or pelvic ultrasonography or both, due to the same disease condition.

8.4. Patient Selection.

Inclusion Criteria;

- All patients who under-went abdominal or pelvic ultrasonography followed by either an endoscopic or open surgical procedure, due to either surgical or gynaecological disease, during the study period.

Exclusion Criteria;

- Patients who refused to be included in the study,Patients who under-went endoscopy or surgery but the ultrasound results were not available,
- Patients who under-went ultrasound and surgery before the beginning of the study period.
- Patients who did not undergo ultrasonography within 24 hours prior to emergency surgical operation,
- Ultrasonography that was done out-side Dar es salaam region.

For patients who underwent ultrasonography more than once, the most recent results were the ones considered.

8.5. Definition of Terms.

True Positive Value.

A true positive value is a number of cases to which ultrasound findings, and operative findings are all corresponding to one another, i.e. they about point to one particular disease condition.

False Positive Value.

A false positive value is a number of cases to which ultrasound findings point to a particular disease, but operative findings are negative to a disease.

True Negative Value.

A true negative value is a number of cases to which both the ultrasound and operative findings are negative to a disease.

False Negative Value.

A false negative value is a number of cases to which operative findings are positive for a particular disease condition, but the ultrasound findings are negative to the disease.

Sensitivity.

Sensitivity is the percentage of all patients with disease who have a positive test.

$$\text{Sensitivity} = \frac{\text{True Positive x 100 \%}}{\text{(True Positive + False Negative)}}.$$

Specificity.

Specificity is the percentage of all patients without disease who have a negative test.

$$\text{Specificity} = \frac{\text{True negative x 100\%}}{\text{(True Negative + False Positive)}}$$

Accuracy

An accuracy of a test refers to a proportion of all cases with correct diagnosis.

$$\text{Accuracy} = \frac{\text{(True Positive + True Negatives) x 100 \%}}{\text{Total}}$$

Positive Predictive Value.

Refers to percentage of persons with positive test results who actually have the disease i.e. Probability that the disease is actually present if the test positive.

$$\text{Positive Predictive Value} = \frac{\text{True Positives x 100\%}}{\text{(True positives + False positive)}}.$$

Negative Predictive Value.

Measures the probability of the disease being actually absent if the test for that disease is negative .

$$\text{Negative Predictive Value} = \frac{\text{True Negative x 100 \%}}{\text{(True Negative + False Negatives)}}$$

8.6 . Sample Size.

Calculation of the sample size was based on the formula by Kirkwood.

$$N = \frac{Z^2P(1-P)}{d^2}$$

Where :

N = Sample size .

Z = Percentage of normal distribution corresponding to level of significance. If significance level is 5% , then will be equal to 1.96.

P = Sensitivity of Ultrasound in detecting abdominal masses and the organ of origin the value is 90%.

D = Margin of error on P. Whose value is taken to be 5%.

$$N = \frac{(1.96)^2 \times 0.9\,(1-0.2)}{(0.05)^2}$$

$$= \frac{3.8416 \times 0.9 \times 0.1}{0.0025}$$

$$= 138.24$$

Hence, At least 138 patients were to be recruited into the study.

8.7 Research Tools.

Tools which were used in this study included the questionnaires, ultrasound facilities, and surgical facilities.

8.8 Plan for Data Collection.

Questionnaires were filled by the principal investigator.

The questionnaires were used in data collection. They consisted of closed ended questions. They addressed the socio-demographic characteristics; provisional diagnosis; ultrasound findings; and findings at the operation and the respective dates of each procedure in order to ensure that each case followed an accepted sequence of events, i.e. clinical diagnosis, followed by US examination, and finally, an operative procedure.

8.9. Data Processing and Analysis

The principal investigator did a maximum of 6 interviews per day, and his name was written in each questionnaire. There was a daily quality check to ensure completeness of recorded answers.

This was done at the MNH by reading through all the questionnaires. Data was analyzed using EPI info 6 computer program by the principal investigator with the help of a computer technician and results were summarized in a tabular form.

The diagnoses appearing in the tables are post-operative. They are not histologically proven.

9. ETHICAL CONSIDERATION

Ethical clearance was sought from the Ethical clearance committee of MUCHS. The whole exercise was conducted after obtaining consent from the patients or guardians. All relevant information about the study was given to the patients or guardians and they were given freedom to ask questions about the study. After they have understood the purpose of the study to the patients or guardians, they were given freedom to either give a signed consent for being included in the study or disagree.

Also approval by the College Research and Publication Committee of MUCHS was sought. Surgeons and radiologists were informed about the study.

10. LIMITATIONS OF THE STUDY

Some of the cases were attended by junior doctors and underwent ultrasound examination before being reviewed by senior doctors. This may, in one way or another, affect the accuracy of the clinical diagnosis, as the junior doctors might not be having enough clinical skills that are necessary in arriving at a more correct diagnoses. Some of the US results only indicated the US findings and no US diagnosis.

Comparison of the US findings and the post operative diagnoses required a sound knowledge in both surgery, gynaecology, and ultrasound. This might have led to misinterpretation of some of the findings. The post operative diagnoses, also, were not noted down in most of the operative notes.

Thorough recording of operative notes was not satisfactory in some of the cases and this necessitated a verbal enquiry on the details of the surgical procedures. This again was very difficult as most surgeons couldn't remember some of the operative findings.

The study may have a selection bias due to the following reasons;

- Only patients who underwent endoscopy or surgery were analyzed and those who did not undergo these procedures were not included in the study.
- Some patients who either had negative US findings or were seriously sick were not analyzed.

- Only patients that were operated at the MNH were analyzed although US results were accepted from all Dar es Salaam Hospitals. Those patients who were operated in other Hospitals, who are significant in number, were not analyzed.

The study is assessing the diagnostic value of US in a heterogeneous group of diseases. This made reference data unavailable as most of the studies that were done in the past were analyzing specific disease categories. Not only that but also the number of cases in each group of diseases that were studied was small. This may make the comparison of figures obtained in the study and those obtained in other studies unreliable. Not only that but also the values obtained in this study may not reflect the true values if the study were done to a homogenious group of diseases.

The sample was predominantly female, the fact that may arise the possibility of bias to "specific women diseases".

11. RESULTS

For a period one year (March 2003 to March 2004) two hundred and seventy seven patients were studied. These were the patients who underwent both ultrasound of the abdomen and/or pelvic Examination and open or endoscopic surgical procedures, both due to the same disease condition.

A total of 109 (39.3%) male patients and 168 (60.7%) female patients were studied, making a ratio of male to female ratio of 1:1.54.

A total of 78 (28%) patients presented with surgical emergency conditions, females being 41 (14.8%) and males 37 (13.4%).

One hundred and ninety nine (72%) patients presented with non-emergency conditions, females being 127 45.8%) and males 72 (26%). The ratio of emergency to non-emergency conditions was 1:2.6.

Table 5: Distribution of Study Population by Age and Sex.

AGE	MALE		FEMALE		TOTAL	
Years	*Number*	*%*	*Number*	*%*	*Number*	*%*
< 11	19	6.9	11	4.0	30	10.9
12-19	5	1.8	11	4.0	16	5.8
20-39	38	13.7	60	21.6	98	35.3
40-59	27	9.7	56	20.3	83	30.0
60	20	7.2	30	10.8	50	18.0
Total	**109**	**39.3**	**168**	**60.7**	**277**	**100.0**

Table 6: Frequency Distribution of Gynaecological Conditions.

POST OP DIAGNOSIS	FREQUENCY	PERCENTAGE (%)
Uterine Fibroid	23	37.7
Ovarian Masses	14	23.0
Ectopic Pregnancy	13	21.3
Foreign Body (IUCD)	4	6.6
PID	3	5.0
Endometrial Carcinoma	4	6.4
Total	**61**	**100.0**

Table 7: Distribution of Hepatobiliary and Pancreatic Diseases by Sex.

POST OP DIAGNOSIS	Male		Female		Total	
	Number	*%*	*Number*	*%*	*Number*	*%*
Calculous Cholestasis	2	7.4	8	220.6	10	37.0
Pancreatic Carcinoma	5	18.5	2	7.5	7	26.0
Pancreatic Pseudocysts	5	18.5	2	7.4	7	25.9
Pancreatitis	3	11.1	0	0	3	17.1
TOTAL	**15**	**55.5**	**12**	**44.5**	7	**100.0**

Table 8: Distribution of Gastrointestinal Diseases by Sex.

POST OP DIAGNOSIS	MALE		FEMALE		TOTAL	
	Number	*%*	*Number*	*%*	*Number*	*%*
Acute Appendicitis	8	25.8	4	12.0	12	38.7
Gastric Cancer, metastatic	4	12.9	2	6.5	6	19.4
Colorectal Cancer, non-metastatic	5	16.1	3	9.7	8	25.8
Appendicular Mass	2	6.5	1	3.2	3	6.4
Appendicular Abscess	2	6.4	0	0	2	6.1
TOTAL	**21**	**67.8**	**10**	**32.2**	**31**	**100**

Table 9: Distribution of Urological Conditions by Sex.

POST OP DIAGNOSIS	MALE		FEMALE		TOTAL	
	Number	*%*	*Number*	*%*	*Number*	*%*
U/Bladder,Carcinoma	8	28.7	4	14.3	12	43.0
Urolithiasis	4	14.3	2	7.1	6	12.4
Renal Cell,Carcinoma	3	10.7	2	7.1	5	17.8
Prostate,Carcinoma	3	10.7	0	0	3	10.7
PUJ Obstruction	0	0	2	7.1	2	7.1
TOTAL	**34**	**64.4**	**10**	**55.0**	**28**	**100.0**

Table 10: Distribution of Paediatric Surgical Conditions by Sex.

POST OP DIAGNOSIS	MALE		FEMALE		TOTAL	
	Number	*%*	*Number*	*%*	*Number*	*%*
Acute appendicitis	1	4.1	3	12.5	4	16.6
PUJ Obstruction	2	8.3	4	17.0	6	25.3
Neuroblastoma	1	4.1	2	8.3	3	12.4
Willim's Tumors	3	12.5	1	4.1	4	10.0
Iliopsoas abscess	3	12.5	0	0	3	12.5
Undescended testis	3	12.5	0	0	3	12.5
Choledochal Cysts	0	0	1	4.1	1	4.1
TOTAL	**13**	**54.0**	**11**	**40.0**	**24**	**100.0**

Table 11: Distribution of Other Surgical Conditions by Sex.

POST OP DIAGNOSIS	MALE		FEMALE		TOTAL	
	Number	*%*	*Number*	*%*	*Number*	*%*
Ruptured Spleen	3	16.7	2	11.1	5	27.8
Hypersplenism due to PHT.	5	27.8	0	0	5	27.8
Intestinal Obstruction	2	11.1	1	5.5	3	10.6
Peritonitis	1	5.5	2	11.1	3	10.6
Abdominal TB	0	0	2	11.1	2	11.1
TOTAL	**11**	**61.2**	**7**	**38.8**	**18**	**100.0**

Table 12: Diagnostic Value of US in Specific Diseases

Post OP Diagnosis	Accuracy (%)	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Uterine Fibroid	75.7	78.3	71.4	81.8	66.7
Ovarian Mass	75.0	71.4	80.0	83.3	66.7
Ectopic Pregnancy	72.7	69.2	77.8	81.8	63.6
Uterine Foreign Body	75.0	75.0	0	100	0
PID	50.0	33.3	100	100	33.3
Endometrial Carcinoma	75.0	75.0	0	100	0
Calculous Cholecystitis	80.0	90.0	60.0	81.8	75.0
Choledochal cyst	0.0	0	0	0	0
Pancreatic Carcinoma	77.8	71.4	100	100	50.0
Pancreatic Pseudocyst	87.5	85.7	100	100	50.0
Pancreatitis	33.3	33.3	0	100	0
Acute Appendicitis	75.8	75.0	76.9	80.0	71.4
GI metastases	85.7	85.7	85.7	92.3	75.0
Appendicular Mass	100	100	100	100	100
AppendicularAbscess	100	100	0	100	0
Carcinoma of U/Bladder	100	100	100	100	100
Urolithiasis	88.8	100	66.7	85.7	100
Renal Tumors	100	100	100	100	100
Carcinoma of Prostate	80.0	100	50.0	75.0	100
PUJ	90.0	87.5	100	100	66.7
Neuroblastoma	25.0	0	100	0	25.0
Iliopsoas Abscess	100	100	100	100	100
Undescended Testis	33.3	33.3	0	100	0
Ruptured Spleen	42.9	40.0	50.0	66.7	25.0
PHT	20.0	20.0	0	100	0
Intestinal Obstruction	75.0	100	0	75.0	0
Peritonitis	100	100	0	100	0
Abdominal Tuberculosis	100	100	0	100	0

12. DISCUSSION

The study population had ages ranging from 4-94 years. The majority (35.3%) belonged to the age group 20-39 years; female patients constituting about 21.6% and male patients 13.7% of the study population. The minority belonged to the age group above 60 years; female constituting about 10.8% and male patients 7.2%.

The mean and median ages of the study population were 40.23 and 37.00 years respectively.

The 'Gold Standard tests in this study were open surgery and endoscopy where as the tested diagnostic instrument was the Ultrasound.

Two hundred and seventy seven patients were studied. Among them 254(91.7%) underwent open surgery and 23(8.3%) underwent endoscopy. The diagnostic value of US was assessed in terms of accuracy, sensitivity, specificity, positive and negative predictive values. These values were obtained following a comparison between the findings by the 'Gold Standard' tests and findings by the US.

Individual Disease Conditions;

Gynaecological Diseases;

Uterine fibroid (38%) was the commonest gynaecological condition encountered in this

Study. The least common gynaecological disease was PID which donstituted about 5%. The accuracy of US in diagnosing gynaecological conditions ranged from 50-76%.

Where as the sensitivity ranged from 33-78%; specificity, 0-100%; positive predictive value and negative predictive value ranged from 82-100% and 0-67% respectively.

A total of 23 patients were diagnosed to have uterine fibroid disease. In this disease condition US was found to have the highest sensitivity of all the gynaecological condition,78%.This value is even higher than a sensitivity of 60%,a value obtained in Western studies. However, this may be explained by the fact that patients seeking medical attention at the MNH already have huge fibroids that are easy to detect with US. The diagnostic value of US may further be improved by the use of transvaginal ultrasound.

A total of 13 patients of patients with ectopic pregnancy were studied. The sensitivity of US to ectopic pregnancy was 69%.The diagnostic value of ultrasound in diagnosing ectopic pregnancy may be improved by the use of TVS, and improved even further by the use of the Color-flow Doppler US.

The use of color-flow doppler US, compared with transvaginal US alone, increases the diagnostic sensitivity from 71-87% for ectopic pregnancy, from 24-59% for failed intrauterine pregnancy, and from 90-99% for viable intrauterine pregnancy[47]. The addition of color-flow Doppler US may expedite earlier diagnosis and eliminate delays caused by using levels of beta hCG for diagnosis. Furthermore, color-flow Doppler US can potentially be used to identify involuting ectopic pregnancies that may be candidates for expectant management[47]

Hepatobiliary Diseases

Eleven patients belonged to this disease group. There were 10 patients with calculous cholecystitis and one patient with a choledochal cyst.

Calculous cholecystitis was diagnosed by US with an accuracy of 80%, sensitivity of 90%, and specificity of 60%. The positive and negative predicyive values were 82% and 75% respectively.

The choledochal cyst could not be detected with US.

The diagnostic value of US is probably lower,as compared with values of US in western studies, due to poor skills of our sonographers.

Pancreatic Diseases

There were 17 patients in this disease category. Diseases that were encountered, in descending order of frequency, were; pancreatic carcinoma(26%), pancreatic pseudocyst(25.9%), and pancreatitis(11,1%).

The accuracy of US in diagnosing these diseases ranged from 33-78%.The sensitivity ranged from 33-71%; specificity, 0-100%; positive and negative predictive values, 100% and 0-100%, respectively [31].

The sensitivity of abdominal ultrasound found in western studies in diagnosing pancreatic masses is 95%[31]. Other diagnostic value indicators were not indicated in this study.

The values in this study are relatively low most likely due to gas-filled bowels and stomach which over-lie the pancreas, and lack of endoscopic ultrasound which is more sensitive in identifying even small pancreatic tumors [31].

Pancreatic pseudocysts appear as anechoic structures associated with acoustic enhancement on ultrasound examination. They are well defined and round or oval, and they are contained within a smooth wall[31] During the early phase of their development, pseudocysts can appear more complex, with varying degrees of internal echoes. Usually this appearance results from the presence of necrotic pancreatic and peripancreatic debris and is more common in pseudocysts that form following an acute necrotizing pancreatitis than in others. The pseudocysts may appear more complex in other two instances; when haemorrhage occurs into the cyst or when infection complicates the clinical course [31].

Sensitivity rates of ultrasound in the detection of pseudocyst of the pancreas are 75-90%, therefore US is a slight inferior choice compared to CT, which has sensitivity of 90-100% [31].

US has several limitations compared to CT in the diagnosis of a pseudocyst. The presence of overlying bowel gas decreases the sensitivity of US; US is highly operator dependent compared with CT; US is unable to provide more information regarding the surrounding viscera and vasculature [31].

Gastrointestinal Diseases

There were 35 patients who were diagnosed to have GI diseases. The commonest GI disease encountered was acute appendicitis(45.7%). Other diseases were GI malignancies(40%), appendicular mass(8.6%), and appendicular abscess (5.7%) .

US was found to have an accuracy of ranging from 76-100%; sensitivity ranging from 75-100%; specificity, 0-77%; positive and negative predictive values ranging from 80-100% and 0-100% respectively.

The role of ultrasound in malignant tumors of the gastrointestinal tract was to identify features of distant metastases such as liver metastases, ascites, lymph node enlargement and so on.

Ultrasound has, however , a sensitivity of more than 80 percent and specificity of 95 percent in the diagnosis of acute appendicitis without perforation and it has been advocated that it should be used routinely in an attempt to reduce the negative appendicectomy rate, to patients with equivocal clinical findings and young women, in whom it will exclude a gynaecological cause for the pain [(32)]. The diagnostic value may become further worsened if the appendix is retrocaecal, due to the gas in the caecum.

The role of ultrasound, however, in acute appendicitis has increased dramatically from1986, after the introduction of graded compression US by Puylaert[(32)]. The graded compression US allows successful examination of a patient who may have peritoneal irritation and sensitivity.

During the compression, maximal tenderness of abdominal point can provide an important clue, which is often useful in focusing the US examination on the correct area in a patient with suggested appendicitis. Puylaert also described the use of high-frequency linear transducer by applying gentle but firm pressure in the right lower quadrant to displace the intervening bowel gas and to decrease the distance between the transducer (5 MHz) and the appendix, thereby improving image quality. The postero-lateral approach has markedly improved the sensitivity of ultrasound in evaluation of a retrocaecal appendix [(32)].

Major US findings of acute appendicitis include; aperistaltic, non-compressible, blind ended, sausage-shaped structure arising from the base of the caecum; distinct appendiceal wall layers; outer diameter greater than 6 mm; “target” appearance; appendicolith; periappendiceal fluid collection; and echogenic prominent pericaecal fat[32] .

Urological Diseases

Thirty eight patients were included in the study. Twenty eight (74%) patients were adults and 10 (26%) were children.

Carcinoma of the urinary bladder was the commonest disease that was encountered .It constituted about 31.6% of all urological diseases.

The accuracy of US in detecting urology lesions ranged from 80-100%.The sensitivity ranged from 88-100%; specificity, 50-100%; positive and negative predictive values, 75-100% and 67-100% respectively.

Tumors of urinary bladder are better detected by trans-abdominal whose sensitivity is 61 to 72 percent. The combination of the trans-abdominal and trans-rectal ultrasound increases the sensitivity to 95 percent [39].The classical appearance of the transitional cell carcinoma, is an irregular soft tissue structure of low to intermediate echo texture projecting into the bladder lumen from a fixed mural site. Lesions are often branched

The attachment to the bladder wall may be either sessile or stalk-like. This appearance is indistinguishable sonographically from other neoplasms such as squamous cell carcinoma or direct extension into the bladder from prostate, colon, or gynaecological malignancies. Carcinoma in situ and squamous metaplasia are generally undetectable by ultrasound but may be seen as focal bladder thickening[39] .

In this study the sensitivity of abdominal US to carcinoma of urinary bladder was found to be 100%.This value is higher because our patients seek medical attention when the disease if far advanced and, hence, the tumors are too big to be missed with US.

The study revealed that renal masses were picked with US with a sensitivity of 100%.This value is on the higher side, probably because we encounter renal tumors that are too big to be missed with US.

Renal cysts may be picked with accuracy of 95-98%. Of all solid masses picked by ultrasound, 85% represent RCC; 10% represent other malignances, e.g. renal sarcoma, lymphoma, or metastases [40]. The solid renal masses are considered malignant until proven other wise.

Paediatric Surgical Diseases

A total of 24 children were studied. The commonest condition encountered in this group was acute appendicitis (16.6%).The least common was choledochal cyst

(4.1%).The GI and urology diseases that were encountered in this group of patients have been analyzed together with diseases of adults under the respective categories of diseases.

However, diseases that occurred to children only included the neuroblastoma(12.4%), nephroblastoma(16.6%), and undescended testis(12.5%).

The paediatric diseases were picked with US with an accuracy that ranged from 25-100%;sensitivity that ranged from 0-100%; specificity,0-100%; positive and negative predictive values ranging from 0-100% respectively.

Other Surgical Conditions

The commonest conditions that were encountered in this group of diseases was ruptured Spleen (17.8%) and hypersplenism (27,8%) where the least common condition was abdominal tuberculosis(11.1%).

In this study, the sensitivity of US in detecting a ruptured spleen was found to be 40%. This value is too low to make US a reliable investigation tool in evaluating patients with a ruptured spleen, at MNH.

Abdominal US has a role in the management of abdominal tuberculosis. In this study, US was found to have an accuracy of 100%, sensitivity of 100%, specificity of 0%, positive and negative predictive values of 100% and 0%,respectively.

Sonographic features of abdominal tuberculosis include ascites, mesenteric thickness of 15mm or more and increase in mesenteric echogenicity (from fat deposition) combined with mesenteric lymphadenopathy. However, these features may also be seen on sonograms in patients with Crohn's disease. Therefore, US findings are less specific in western population.

Lymphoma is another disease which has to be differentiated with abdominal tuberculosis as it may also present with abdominal lymphadenopathy. However, mesenteric lymphnodes are involved more often in disseminated TB(80%) and in non-disseminated TB(52%) than in patients with lymphoma.

13. CONCLUSION

The diagnostic value of Ultrasound that was assessed in this study is much lower than that seen in the Western countries, hence, abdominal and pelvic Ultrasound is not a reliable diagnostic tool in detecting abdominal and pelvic lesions at MNH.

14. RECOMMENDATIONS

With this regard, I wish to recommend that;

- Ultrasound skills of our radiologists and surgeon-sonographers should be improved by giving them opportunity to attend seminars and conferences concerning ultrasound, so that they can keep pace with new techniques of performing sonographic examination and also learn from one another.

- The Government should equip the National Hospital with Ultrasound probes that are most suitable for a particular examination. This will definitely optimize the diagnostic value of ultrasound and, hence, improve the quality of health care provision particularly in the surgical and gynaecological departments.

- The diagnostic vale of abdominal ultrasound in abdominal injuries may be improved by employing FAST. This will enable the sonographers to diagnose truncal injuries, such as splenic injuries, more rapidly and minimize the use of more expensive diagnostic facilities such as CT scan. This will, in-turn, enable the surgeons to plan and institute treatment to patients without delay and hence reduce morbidity and mortality to the trauma victims.