"A CROSS SECTIONAL STUDY TO EVALUATE THE SENSITIVITY, SPECIFICITY AND PREDICTIVE VALUE OF ULTRASONOGRAPHY IN DIAGNOSING NON TRAUMATIC ACUTE ABDOMEN."

By

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Dissertation

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M.S. (GENERAL SURGERY)

Under the Guidance of

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DECLARATION BY THE CANDIDATE

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ABSTRACT

Background and objectives:

Acute abdomen designates symptoms and signs of intra abdominal disease. It usually account for 5-10% of all emergency admissions and requires a rapid, accurate diagnostic work up is required for the institution of appropriate management. This study aims at evaluating the sensitivity, specificity and predictive values of ultrasound in diagnosing non traumatic acute abdomen.

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Methods:

The present study was conducted in the Department of Surgery, KLES Dr. Prabhakar Kore Hospital and Medical Research Centre, Belgaum on patients presenting with acute abdominal pain meeting the inclusion criteria during the period of January 2008 to December 2008. The ultrasound findings of 65 patients operated for acute abdominal symptoms were compared to histopathologcal or operative findings. The accuracy of ultrasound is assessed statistically by calculating positive predictive values and sensitivity of each of the abdominal conditions.

Results:

Ultrasound has a poor sensitivity (65%) but a very high predictive value (92.85%) in diagnosing acute appendicitis. Ultrasound provided corroborative evidence in case of bowel perforation (sensitivity 85%) and intestinal

obstruction. (sensitivity 60%). It is fairly accurate in detecting biliary pathology with a sensitivity of 80% for acute cholecystitis. Ultrasonography has a combined sensitivity of 72.02% and a specificity of 66.7% in all the acute abdominal conditions.

Conclusions:

Ultrasound is a useful imaging modality in diagnosing acute abdominal conditions which need surgical attention. It continues to be a first line investigation to evaluate acute abdomen and can be considered as an extension of clinical examination.

Key words: Acute abdomen, ultrasonography

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INTRODUCTION

Acute abdomen designates symptoms and signs of intra abdominal disease usually treated best by surgical operation. Acute abdomen encompasses a wide range of surgical, medical and gynaecological conditions. They usually account for 5-10% of all emergency admissions. [1, 2.] The causes of abdominal pain can range from benign self limiting conditions to acute life threatening disorders. Many diseases, some of which do not require surgical management, produce abdominal pain, so any case of acute abdomen must be evaluated methodically and also needs rapid and accurate diagnostic work-up.[3]

Ultrasonography is often a commonly asked investigation by a surgeon in a case of acute abdomen. Ultrasound is also a commonly available diagnostic tool. It provides a rapid, safe, cost effective and repeatable evaluation of liver, gall bladder, bile ducts, spleen, pancreas, appendix, kidneys, ovaries, adnexa and uterus. [1] It can also detect intra abdominal fluid. But, it is operator dependent and is incapable of detecting certain conditions. It has an estimated 70% to 98% sensitivity in diagnosing acute abdominal conditions. [4,5,6]

Clinical examination in the case of acute abdomen though indispensible is sometimes unreliable, making imaging modalities necessary. An early and accurate diagnosis is needed for the institution of prompt and appropriate management in order to limit morbidity and mortality.

In an era of evidence based medicine understanding the value of ultrasonography as an adjunct to the clinical diagnosis before surgery is of utmost importance. [7] Various studies have shown different values of sensitivity of ultrasound, hence the need for the study to evaluate the role of ultrasound in diagnosing those acute abdominal conditions which require surgical intervention.

OBJECTIVES

This study aims at finding out sensitivity, specificity and predictive value of ultrasound, in diagnosing non-traumatic acute abdominal conditions.

To compare the diagnosis made by ultrasound with clinical diagnosis and in select situations with other modalities of investigation.

REVIEW OF LITERATURE

Acute disease within the abdomen is common in many patients with acute abdominal symptoms present every day to doctors working in the community. Within a Western population of half a million people, between five and ten patients are admitted to a surgical ward each day with acute abdominal pain. [8]

Julian Britton defines it as "the illness which starts suddenly and most patients present to a hospital within seven or ten days of the onset of symptoms" [8]

Jones S. R. describes the term acute abdomen as "symptoms and signs of intra-abdominal disease usually treated best by surgical operation". [1]

The onset of abdominal pain is a common condition that demands an expedient diagnosis and treatment plan. If a patient presents in the emergency room with severe abdominal pain the clinician must have a defined pathway outlined in order to make a differential diagnosis. It becomes important to not only narrow the diagnosis to one particular choice but also to determine if the patient is a surgical candidate. The general rule for acute abdominal pain is that which appears in a previously healthy individual and lasts for at least six hours and may require surgical intervention. Emergent problems such as appendicitis, perforated ulcer, intestinal obstruction or other pathology may require immediate surgical intervention. An overview of the aetiology, clinical signs and symptoms, and diseases that fall under the "acute abdomen" and their sonologic findings are presented here. [1, 3, 9]

The most common presentation of the acute abdomen is pain. Abdominal pain can be difficult to interpret unless an understanding of the developmental anatomy of the abdominal cavity and the viscera is applied. Pain can be classified into three types [3, 10]

Visceral pain

It is diffuse, difficult to localize and is referred to the cutaneous dermatomes (e.g. small bowel pain presenting as T10 level peri umbilical pain). Nausea and vomiting may also be due to visceral pain through activation of the motor and autonomic reflexes.

Somatic pain

It arises from the abdominal wall or parietal peritoneum and is usually sharp, intense and accurately localizable to the site of pathology. A good example of visceral pain becoming somatic is appendicitis. Initially, only the appendix is inflamed and pain is classically peri-umbilical. However, as the inflammation increases, the peritoneum becomes involved and the pain is localized to the right iliac fossa.

Referred pain

It is the pain resulting from irritation of an abdominal organ not felt in the viscus, but in a somatic structure that may be at a considerable distance from it. Pain is usually referred to a structure that developed from the same embryonic segment as the organ of the pain. This is why irritation of the diaphragm can produce shoulder tip pain, as both are innervated by the C4/5

Pathophysiology [3,1,11]

Common pathological sequences can occur in different causes of an acute abdomen. These include the following.

Luminal obstruction

Obstruction may be of the gut, biliary tree or the kidney. There are a variety of causes that can be divided into luminal, mural and extramural.

Presenting features include

- Abdominal colic that is referred to the dermatomes supplying the part of the tube proximal to the obstruction. The frequency and duration of pain is related to the rate of peristalsis of the blocked structure

- Vomiting which is prominent feature of gastric outlet obstruction and small bowel obstruction. If the ileocaecal valve is competent, patients with large bowel obstruction may not vomit but have an increased risk of perforation.

- Abdominal distension is more pronounced in patients with large bowel obstruction. It is often associated with absolute constipation.

Importantly, patients with high obstruction (e.g. in the small bowel) will often present with vomiting and may continue to pass stool. Those with large bowel obstruction commonly develop early constipation, with vomiting as a late feature. Passing faeces should not rule out obstruction, as this can occur with partial obstruction.

On suspicion of intestinal obstruction, history of previous surgery or symptoms suggestive of gastro-intestinal malignancy should be sought. The hernia orifices should be examined and abdominal tenderness investigated. Increasing tenderness in intestinal obstruction can be a sign of imminent or actual perforation of a viscus. If untreated, adynamic ileus, strangulation and perforation can occur.

Inflammation

The appendix, gall bladder, small and large bowel (inflammatory bowel disease, diverticulitis), pancreas, urinary system and pelvic organs are the usual sources of inflammation within the abdomen. Vomiting may be a vagal response to the pain. In most instances the inflammation is secondary to infection (with or without luminal obstruction) or ischaemia. Again, pain may initially be diffuse and visceral, before becoming localized as the peritoneum becomes inflamed. Inflammation can be self limiting and can be treated with antibiotics in some circumstances. However in some cases, gangrene and perforation may occur if left untreated. This can lead to peritonitis.

Peritonitis

The classic signs of peritonitis, of guarding, rigidity and rebound tenderness are often present. Abdominal distension and absent bowel sounds may also occur as the condition progresses. However, these signs may be reduced in the elderly or the immunocompromised patients (e.g. those taking steroids or having chemotherapy)

There are many causes of peritonitis. Irritation of the peritoneum can be caused by bowel contents, bile, urine, pus and blood. Therefore, any perforated viscus may cause peritonitis. An erect x-ray is often useful because a perforated bowel (e.g. peptic ulcer or diverticulum) will show gas beneath the diaphragm in 70% of the cases. Rigler's sign may also be seen on the left side of the abdomen, with outline of the stomach bubble, or on supine plain films of the abdomen. Free intraperitoneal gas and fluid can also be demonstrated on CT.

Patients with peritonitis are often septic, with or without evidence of end-organ hypoperfusion and /or hypotension (septic shock). Therefore, resuscitation and input from the critical care team is required. Pre-operative diagnosis of the cause of peritonitis is often helpful, but this should not delay a laparotomy, which is the definitive treatment.

Ischaemia and infarction

Infarction of the abdominal organs can be classified as arterial or venous. Causes can be divided into intraluminal (e.g. emboli or thrombosis) or extra luminal (e.g. volvulus, intussusceptions, hernia, tumours and aortic dissection). The index of suspicion should be high in those with vascular disease and in those with atrial fibrillation.

The condition is difficult to diagnose, but delay can prove fatal. The classic presentation is abdominal pain that is out of proportion to the physical findings. This can vary in intensity, site and characteristics. Associated symptoms include anorexia, vomiting and diarrhoea or GI bleed. Patients may be systemically unwell due to increase in concentrations of proinflammatory cytokines, bacterial translocation and anaerobic metabolites entering the circulation. Arterial lactate concentration is usually above 2 mmol/l and intramural gas may be demonstrated on CT. Resuscitation and prompt laparotomy is often required.

Non-specific abdominal pain

Non-specific abdominal pain is a diagnosis of exclusion. In 40% of patients the cause of abdominal pain is not found. Often patients require admission to hospital for 24-48 hrs to allow observation and investigation. Many are young female patients. Occasionally these patients are readmitted with recurrent abdominal pain. It is important to remember that abdominal pain can be real and distressing for the patient, despite the fact that no obvious cause can be found.

Each patient should be investigated thoroughly. Causes of non-specific abdominal pain include viral infections, parasitic infestations, gastroenteritis, mesenteric adenitis, ovulatory pain, torsion of the appendices epiploicae of the colon and irritable bowel syndrome. The pain may settle spontaneously, but investigation by CT, ultrasound (per abdominal and trans-vaginal) and even laparoscopy may be required.

Aetiology of the acute abdomen [1,8,9,11]

The main component in the patient with acute abdomen is usually abdominal pain. The increased pain makes it difficult for the clinician to adequately examine the patient to be certain of an intra abdominal lesion which may present and cause the symptoms. The diagnosis of the origin of the pain may be difficult to assess because of the sympathetic nervous chain and transmitted signals from the related muscles to the nerve centers. Knowledge of muscular anatomy may help the clinical differential diagnosis as the muscles may be directly or indirectly irritated by the inflammatory process. For example a subphrenic or hepatic abscess may radiate to the diaphragm and shoulder area. A patient with appendicitis may present with pain around the umbilicus. A gastric ulcer may rupture and fluid impinges on the diaphragm, which may irritate the phrenic nerve and cause radiating pain to the shoulder.

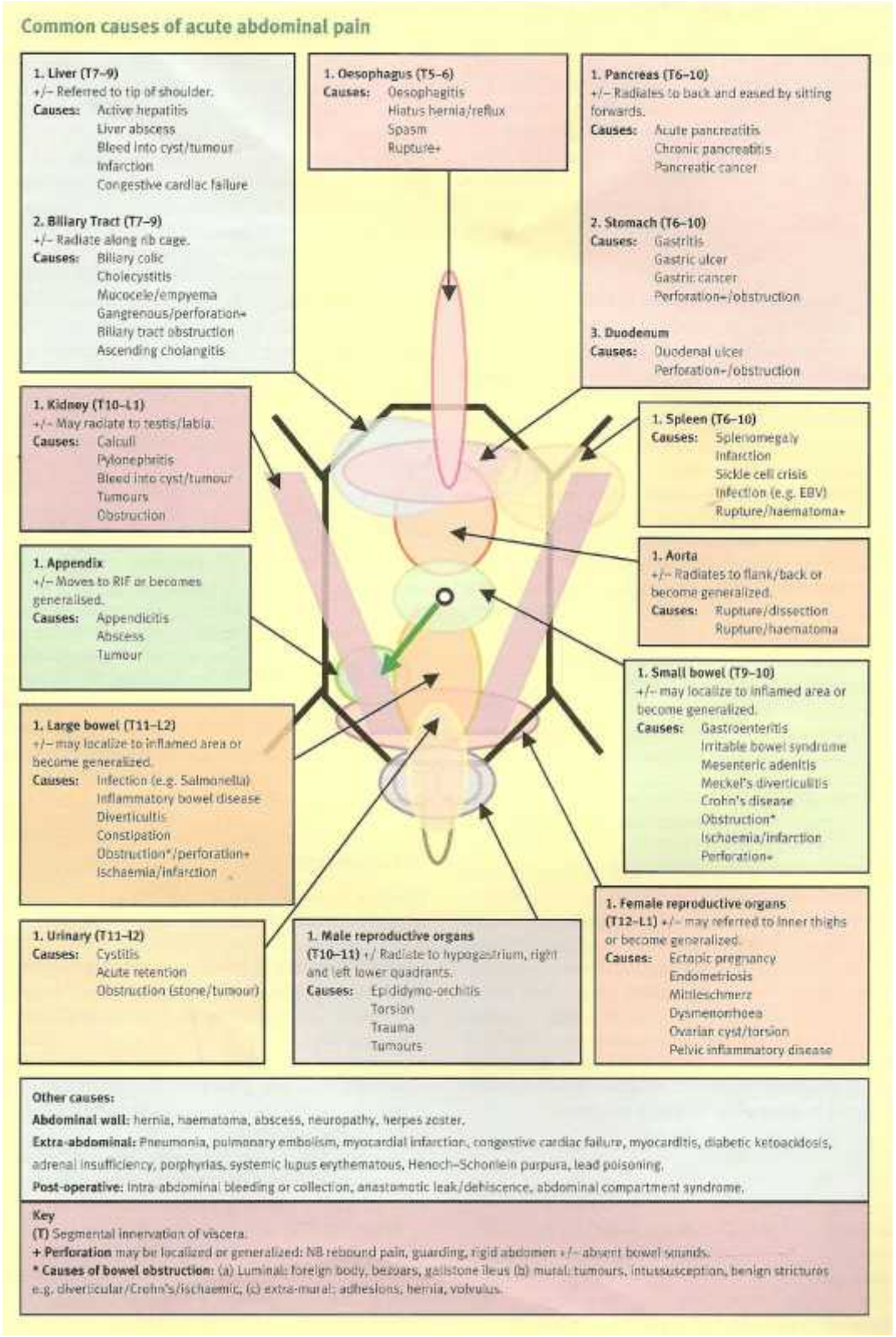


Figure 1: Common causes of acute abdominal pain [3]

Central abdominal pain

- Intestinal colic
- Acute appendicitis
- Obstruction of small intestine
- Meckel's diverticulitis
- Mesenteric thrombosis

Right hypochondriac pain

- Acute cholecystitis
- Liver abscess
- Acute hepatitis
- Hydatid cyst of liver
- Leaking duodenal ulcer

Left hypochondriac pain

- Perforated gastric ulcer
- Rupture of inflamed diverticulum
- Splenic abscess
- Spontaneous rupture of spleen
- Left subphrenic abscess
- Leakage of splenic artery aneurysm

Right iliac pain

- Acute appendicitis
- Meckel's diverticulitis
- Ureteric colic
- Pelvic inflammatory disease
- Torsion of right ovarian cyst
- Ectopic pregnancy

Left iliac pain

- Ureteric colic
- Sigmoid diverticulitis
- Salpingo oophoritis
- Torsion of left ovarian cyst

Lumbar pain

- Ureteric colic
- Hydronephrosis
- Pyelonephritis
- Perinephric abscess

Several factors are important to know to help define the cause of acute abdomen. The age of the patient helps to define the nature of the disease. A child may appear with acute intussusceptions, whereas appendicitis is more common in the younger adolescent. An obstruction of the large intestine is more common in an elderly patient. Acute pancreatitis or perforated ulcer is more often seen in adult patient. Cholecystitis usually in a middle aged female.

The present condition considers many factors: the exact time of onset, whether the pain is gradual or acute, and the specific character of the pain. The clinician should note if the pain shifted over time. The presence of fever may indicate an infectious process. Nausea and vomiting should be documented as to the time it occurred in relation to pain (before, same time or after the pain) and how often the vomiting occurred. Perforation of a gastric or duodenal ulcer or acute pancreatitis may cause the patient to faint if the pain is intense enough. On the other hand, many cases of intestinal obstruction pain may gradually increase in intensity.

Significant past history would include history of similar attacks of pain, previous diseases or conditions that may have caused surgical intervention. The patient's loss of appetite or symptoms of indigestion should be noted. Jaundice, weight loss and fatigue may include gastrointestinal or gall bladder disease.

It is the responsibility of the sonographer to understand the patients past history, clinical signs and symptoms, and to find out if the patient has had previous diagnostic examinations prior to performing the songraphic procedure.

This approach will enable the sonographer to look specifically for the differential diagnosis of acute abdomen.

Imaging the acute abdomen

Clinical examination is the fold standard in making a fairly accurate diagnosis. Investigative modalities help confirm the clinical suspicion.[12]

The imaging modalities available are

- Plain radiograph – chest and abdomen / contrast radiograph
- Ultrasonography
- CT and MRI
- Others – radionucleotide imaging

Plain x-ray abdomen

Advantages – Simple and easy to perform. It is valuable in certain situations like intestinal obstruction and hollow viscus perforation.

Disadvantages – Findings are sometimes nonspecific and indeterminate.

According to a recent study the use of conventional radiography has been surpassed; this examination has only a possible role in the setting of bowel obstruction. [13, 14]

Generally erect abdomen and chest radiographs are taken, but in case the patient is moribund a lateral decubitus film can also be taken. A supine abdominal film is also helpful.

Findings of significance:

Air under diaphragm is usually found in case of hollow viscus perforation. Presence of pyopneumoperitoneum is generally detected by the presence of air and fluid levels. In supine films Pneumoperitoneum is generally made out in the form of oval or football shaped collection of gas just beneath the anterior abdominal wall. Abnormal calcifications are generally seen in case of ureteric calculi, appendicoliths, intrapancreatic calculi or calcific aneurysms. 10% of gall bladder calculi are also radio opaque. Air in the biliary tree suggests biliary –enteric fistula. Ground glass appearance is seen in peritonitis and gross ascitis. The colon cut off sign and sentinel loop are suggestive of acute pancreatitis. Plain x-ray is of greatest value in the evaluation of mechanical bowel obstruction. X-rays can differentiate between high, mid and low small bowel obstruction and also colonic obstruction. The dilated loops are generally seen as air-fluid levels. In an adult two air-fluid levels are considered physiological. In a plain x-ray jejunum is characterized by its valvulae conniventes that completely pass across the width of the bowel and are regularly spaced giving a concertina appearance. Ileum is described as featureless. Caecum is shown by a rounded gas shadow in the right iliac fossa. Large bowel except for the caecum show haustral folds which are spaced irregularly and the indentations are not placed opposite one another. [4, 15]

Since this study is about ultrasound, the basics of ultrasound and the sonological findings in various acute abdominal conditions will be dealt in detail

Ultrasound

History [16]

1985 – Discovery of x-rays by Roentgen

First step towards making anatomical image with ultrasound by Dussik brothers

1914-1918 – SONAR - sound waves were used for the underwater detection of submarines and airplanes manly due to works of Paul Langevin.

1949 – The beta scanner was developed by Wild and Reid. This was considered the forerunner of modern imaging procedure

1964 – The first commercial beta scanner Diasonograph was developed by Donald and Brown and marketed by Smith Industries, Glasgow.

Diagnostic medical ultrasound may have a brief history, but its roots as seen above date back to the early nineteenth century. Over the past 40 years, ultrasound has become an important diagnostic modality.

Principles of Ultrasound [16]

Ultrasound is the sound that has a frequency above the range of human hearing, which is about 20,000 cycles per second or 20 KHz. Like sound waves they require a medium to be propagated (i.e. they cannot travel in vacuum) and produce echoes when they hit a surface. The amount of echoes produced depends on the acoustic impedance of the medium, which varies from substance to substance. The echoes are converted to light waves which are displayed on the screen. If acoustic impedance is very low like in air, all waves are absorbed and none are reflected, producing a poor image. If acoustic impedance is very high like in bone, then all waves are reflected leading to blurring of the image.

Production of Ultrasound [16]

Ultrasound is produced by a device called a transducer. Transducer is a substance that converts one form of energy to another. Ultrasound transducers are made of lead zincronate titanate. When electrical energy is applied to this it vibrates at a high frequency to produce ultrasonic waves. This is called Piezo-electric effect. The same transducer also receives the echoes and converts it into electrical energy. This is known as Reverse Piezo-electric effect. This electrical energy is recorded and is displayed on the screen in the visual form.

Frequency: It is the number of cycles per second.

106 cycles/second = 1 MHz

Diagnostic ultrasound ranges from one to thirty MHz

Essential Principles of Physics [16, 17]

Principle I

Piezoelectric effect

Piezoelectric crystals expand and contract to interconvert electrical and mechanical energy.

Principle II

Pulse - Echo principle

When an ultrasound wave contacts a tissue, some of the signal is reflected back and some is transmitted into the tissue. These waves are then reflected back to the crystals within the transducer, generating an electrical impulse comparable to the strength of the returning wave.

Principle III

Acoustic impedance

Acoustic impedance = Density of tissue x speed of sound in the tissue.

The strength of the returning echo depends on the difference in density between the two structures imaged. Structures of different acoustic impedance (gall bladder and gallstone) are easier to distinguish from each other than those of similar acoustic impedance (liver and kidney).

Fig 2. Ultrasound machine

Fig 3. Curvilinear transducer

Different transducers are required for different structures. Generally transducers are selected based on three features

- Frequency
- Focal zone
- Face diameter

Frequency – Lower the frequency, higher the penetration. Hence to scan a superficial structure like thyroid we require a high frequency transducer

Focal zone – It is the distance from the transducer the beam is the narrowest after which it spreads to cover a wide area. So, if a wide area of a superficial structure is to be visualized then a high frequency transducer with narrow focal zone should be used.

Face diameter – This includes the diameter of the transducer head. For a smaller area like intercostals space transducer with a smaller face diameter is required.

Typical frequencies for various ultrasound applications [16]	
Transducer	**Application**
2.25 MHz	Deep abdominal structures, obese patients, renal arteries
3.5 MHz	General abdominal, obstetrics
5.0 MHz	Neonates, paediatric patients, peripheral vessels
7.5 MHz	Cerebrovascular, breast, testicle.
10 MHz	Ocular imaging, vein mapping, superficial soft tissue.

Modes in Ultrasound

A-mode: Returning echoes are displayed as spikes. It is not used nowadays for routine work

B-mode: Returning echoes are displayed as a series of bright dots. Brightness represents the amplitude of the echo.

M-mode: Like B-mode representation is by bright dots. But, unlike B-mode echoes from moving structures like heart, aorta, and diaphragm are also received. M-mode is especially used in echocardiography.

Beta scan: It is a computerized aggregation of beta mode displays to produce a two dimensional image of an object over a screen. It is a static image.

Real time ultrasound: Here multiple images are produced over a very short period. So within the movement of the transducer a different cross section is produced. This provides for easy and convenient visualization.

Doppler ultrasound: It is based on the change in frequency of sound emitted by a moving source. The Doppler system has two transducers. One works as a transmitter and the other as a receiver. When both work simultaneously, then the frequencies of the initial signals of transducers are algebraically subtracted and this falls within the audible range.

Knowledge of the principles of ultrasound physics and instrumentation allows the surgeon to maintain proper ultrasound techniques and obtain the best possible image. Furthermore, when these principles are understood, artefacts and pitfalls of imaging are avoided.

Abdominal Ultrasound

Imaging protocol for abdomen [16]

1) General protocols:

   - History and clinical examination and ensuring proper preparation if needed. E.g.: Empty stomach, Full bladder, etc.
   - Explaining the procedure to the patient.
   - Proper knowledge about the machine.

2) The transducer is first placed below the xiphoid process. Aorta and the IVC are best seen in this position

3) The pancreas is scanned first as during the course of scan the patient may be asked to breathe in and breathe out causing gaseous distension of the stomach making the visualization of the pancreas difficult

4) The transducer is moved along the right costal margin to visualize the liver and the gall bladder.

5) The transducer is moved along the left costal margin and patient is put in the right lateral position for pathology in left kidney or the spleen is suspected.

6) Bowel is identified by its peristaltic movement.

7) Lastly the pelvis and urinary bladder are scanned.

Ultrasound findings in various acute abdominal conditions:

Acute appendicitis:

Frequently, the patient experiences a recent history of indigestion or gastritis a few days prior to the attack of appendicitis. Bowel habits may be irregular, with either constipation or diarrhoea, especially in adolescents. A patient who presents with acute appendicitis may have intense pain that may begin in the umbilical area and move towards the right iliac fossa with eventual extension throughout the abdomen. Nausea, vomiting and fever are usually

present in the early stages of the attack, with subsequent loss of appetite. The degree of nausea and the frequency of vomiting depend on the amount of distension of the inflamed appendix and reflex nervous susceptibility of the patient.

The critical element causing inflammation of the appendix is bacterial invasion. The usual bacteria are colon bacilli and streptococci, two organisms which are commonly found in the intestinal tract.

Fever may initially be absent, but usually develops within a 24 hour period followed with elevated white blood cell count with neutrophilia, which probably means that peritonitis has already begun. Extreme local tenderness, rigidity, or distension of the abdomen is usually experienced. When the appendix is acutely inflamed gaseous distension of the caecum may be present. This localized distension is due to the excessive formation of gases by the bacterial decomposition of caecum and appendix.

Symptoms and signs of acute appendicitis

- Pain, periumbilical with extension into right iliac region
- Nausea and vomiting; Loss of appetite
- Change in bowel habits
- Local deep tenderness, more at the McBurney's point
- Rebound tenderness
- Others like Rovsing's sign and Copes test

Many diagnostic aids are used to improve the accuracy of diagnosis of acute appendicitis, but no one method is of proven superiority. [18]

Common conditions that may simulate acute appendicitis include but are not limited to cholecystitis or perforated gall bladder, inflamed duodenal ulcer, perinephric abscess, renal infection, Meckel's diverticulitis, intestinal obstruction, ectopic pregnancy, ovarian torsion or ureteric colic.

Sonographic findings in acute appendicitis

Ultrasound in case of suspected appendicitis is done not to diagnose appendicitis but to rule out other problems like ureteric calculus, ovarian cyst etc.

Ultrasound is also useful in picking up complications of appendicitis like appendicular mass, appendicular abscess etc.

Graded compression is used in evaluation of patients with right iliac fossa pain. Gentle progressive pressure is applied at the site of maximum tenderness using the ultrasound probe. This helps to displace the fat and the bowel.[19]

Normal appendix – sausage like structure

- Diameter <7mm
- Easily compressible
- Concentrically layered
- Mobile

Inflamed appendix

- Non compressible
- Non concentric
- Restricted mobility
- Faecolith may be detected in 30% of cases
- Hyperaemia in the wall of the appendix at colour Doppler ultrasound is a sensitive indicator for inflammation [20, 21]

Reasons for false positive cases:

Secondary thickening of the appendix occurs in cases of perforated peptic ulcer, Crohn's disease. Caecal carcinoma. Combination of a large appendix with relatively mild symptoms should alert the possibility of a caecal carcinoma.

Reasons for false negative cases:

Air filled dilated bowel loops because of associated ileus hampers visualization. Only the tip of the appendix may be inflamed. The proximal part may be visualized on ultrasound and reported as normal. The associated lymph nodal enlargement maybe so prominent, that an erroneous diagnosis of mesenteric lymphadenitis may be made.

Detecting complications of appendicitis: [22, 23]

- Perforation: Presence of a large amount of free fluid in the surrounding region; prominent paracaecal fat and thickening of the mesentery.

- Phlegmon: Large mass of non compressible fat around the appendix interspersed with echo poor streaks

- Abscess: Circumscribed paraappendicular fluid collection. Air may be present within the fluid collection and surrounding bowel may be thickened

Bowel Obstruction

This can be due to a whole variety of causes. Obstruction may be dynamic or adynamic. [24]

Clinical features

- Colicky abdominal pain
- Abdominal distension
- Vomiting
- Constipation / Obstipation
- Visible peristalsis
- Shock
- Passage of blood or mucus per rectum
- Occasional fever
- Peritonitis (later stage)

Ultrasound in bowel obstruction

Conventionally the role of ultrasound in suspected bowel obstruction has been very limited. But in recent years sonography is being used for the diagnosis of bowel obstruction and found to be quite sensitive. Recent articles claim sensitivity of ultrasound to be higher than that of plain x-ray of the abdomen. [25, 26]

Sonographic findings

Obstruction: Fluid filled dilated small bowel proximal to the collapsed small bowel; Presence of peristaltic activity in the entire dilated proximal bowel (observed as to and fro movements).

Strangulation: Presence of an akinetic bowel loop. Presence of peristaltic activity in the dilated small bowel proximal to the akinetic loop. Rapid accumulation of peritoneal fluid after the onset of obstruction.

Paralytic ileus: Absence of distinct point of transition between the dilated proximal bowel and collapsed small bowel. Impaired peristaltic activity in the entire bowel.

Acute Cholecystitis

Inflammation of the gall bladder is more common in middle aged fertile, obese females (four F's: female, fertile, fat and forty). The inflammation may be acute, sub acute or chronic. The acute form is bacterial with pre existing gall stones a common finding. The bacteria may reach the gall bladder via the blood

stream or from the intestine by the common bile duct and cystic ducts or from the ulcerated duodenum either directly or by the portal vein. The inflammation begins with the gall bladder as it attacks the mucus membrane lining the interior and gradually working its way outwards until cellular resistance either stops it or until it perforates the wall of the gall bladder to cause peritonitis. Complications may occur at the site of perforation.

The symptoms of acute cholecystitis vary in each patient, therefore in making a diagnosis; the clinician must divide the symptoms into two primary groups: those in which there is no obstruction in the cystic duct, and those in which the cystic duct is obstructed by a small gallstone or by a kink in the duct.

Primary symptoms and signs of acute cholecystitis

- Right upper quadrant pain
- Vomiting, nausea, loss of appetite
- Abdominal tenderness and muscular rigidity
- Distension of right colon
- Positive Murphy's sign

No obstruction in the cystic duct. The bacteria attack the mucous membrane, which responds by excreting an excessive amount of thick mucus that distends the gallbladder until the distension causes pain (which may be felt in the epigastrium). This pain is the first symptom and may cause a positive Murphy's sign when the gallbladder area is palpated. Nausea, vomiting or a complete loss

of appetite may follow this pain. The distended gall bladder may be palpated as a mass in the right upper quadrant. As the patient stands, the distended gallbladder becomes unable to expel the thick mucus through the cystic duct, which causes further distension and pain radiating to the epigastrium. This causes the patient to lie down and the gravity effect helps the distended gallbladder to empty gradually through the cystic duct and pain is relieved. In the next few hours, the bacteria may irritate areas surrounding the gall bladder as they transmigrate across the gall bladder wall. Acute cholecystitis with perforation is very painful as the infection enters into the peritoneal cavity.

Obstruction of the cystic duct. The most common cause of obstruction of the cystic duct is from a small gallstone that occludes the lumen of the duct. If the stone passes through the cystic duct, into the common duct and eventually into the duodenum, the biliary colic will subside. However, if the stone remains in the cystic duct, inflammation leading to a sub acute infection of the gall bladder may result with resultant peritonitis. The inflammation and infection may lead to pus formation within the gall bladder known as empyema. The inflamed gall bladder may sometimes rupture and lead to biliary peritonitis or if localized a pericholecystic abscess.

Ultrasound in gall bladder problems

Ultrasound has been found to be a very sensitive and specific investigation in the evaluation of gall bladder calculi and its complications. Ultrasound is the investigation of choice in these situations. [27]

Acute cholecystitis

There are a range of ultrasound findings which suggest acute cholecystitis[28, 29, 30]

Major signs:

Stones in the gall bladder seen as hyper echoic shadows

Oedema of the gall bladder wall. This is different from thickening of the gall bladder wall that is seen in variety of conditions – hypoalbuminemia, ascitis, acute viral infection etc. In oedema due to acute cholecystitis there is poor echo halo around due to inflammatory exudates.

Ultrasonic Murphy's sign: this is the presence of tenderness maximal over the ultrasonologically located gall bladder.

Gas in the gall bladder is the hallmark of emphysematous cholecystitis. It is important to identify this because of the high association of gangrene and perforation.

Minor signs:

Pericholecystic fluid collection. This is usually due to localized peritonitis or leaks from the gall bladder

Thickening of the gall bladder wall

Intra luminal changes

Enlargement of the gall bladder.

Complications:

Gangrenous cholecystitis/ perforation of the gall bladder

There will be marked irregularity and asymmetrical thickening of the gall bladder which reflect ulceration, necrosis and haemorrhage. There will be intraluminal membranes representing desquamated mucosa.

Empyema gall bladder: the typical finding is thickened wall and sludge within the gall bladder (seen as low level echoes)

Acalculous cholecystitis

Diagnosis is difficult because of the lack of stones and the inability to demonstrate Murphy's sign in comatose patients. Other findings are more or less similar to calculous cholecystitis.

Biliary-enteric fistula: This is generally made out by detection of gas in the biliary tree

Choledocholithiasis: is made out by detection of stones in the CBD. The CBD will be dilated (>8mm). This may be associated with multiple hypoechoic areas in the liver which suggest cholangitic abscess.

Hollow viscus perforation

This is commonly due to - Perforated duodenal ulcer

- Perforated gastric ulcer
- Perforation of ileum usually in Enteric fever

Clinical features include

- Severe abdominal pain, quite often generalized
- Presence of signs of peritonitis; Rebound tenderness, guarding, rigidity, free fluid etc
- Poor general condition in late cases

Ultrasound in hollow viscus perforation [31, 32, 33, 34]

Though ultrasound is not considered essential when there is air under the diaphragm, it certainly does provide corroborative evidence in cases of hollow viscus perforation like:

1. Presence of free fluid within the abdomen sometimes with internal echoes
2. Inflammatory mass in upper abdomen
3. Thickening of the gall bladder wall
4. Renal rind sign – this is increased width and hyperechogenecity of the right anterior extra renal tissue
5. When there is abdominal free air, a striking prehepatic hyperechogenicity with acoustic shadow that varies with postural changes is seen.
6. Thickening and increased vascularity of the omentum
7. Reduced peristalsis of the intestines.

Mesenteric Ischemia with Bowel Gangrene

When a patient presents with acute abdominal pain and distension, mesenteric ischemia should be considered. An acute blockage of the mesenteric arteries or veins by an embolus, thrombus or tumour invasion may be difficult to separate that of intestinal strangulation. If mesenteric thrombosis is the cause, the extent of bowel involvement and distension of the abdomen is usually greater than with other causes.

Sonographic findings in mesenteric ischemia and thrombosis: Specific imaging of the area of bowel ischemia is difficult to perform with real-time sonography. However Doppler ultrasound may be useful to evaluate the celiac and superior mesenteric arterial vessels in the upper abdomen. If ischemia is present, the sonographer may see retrograde perfusion of the hepatic artery through superior mesenteric artery. The peak systolic velocity greater than 160 cm/sec in the celiac trunk indicates more than fifty percent stenosis during the fasting state. [35, 36, 37]

CT scan in imaging the Acute Abdomen

The advent of CT scan has provided opportunity for the objective assessment of the acute abdomen. CT scan provides excellent cross sectional detail which may be useful not only for diagnosis but also to plan treatment like percutaneous aspiration. [38]

The main advantage CT scan has is that it is not affected by overlying bone, gas or adipose tissue, all of which can influence sonographic examination.

Conditions which are better detected on CT than on sonography [13]

Retrocaecal appendicitis

Acute pancreatitis

Aortic dissection

Retroperitoneal gastrointestinal perforation

Closed loop obstruction

In cases of suspected mesenteric ischemia CT scan may detect gas within the mesenteric venous system far earlier than ultrasound or x-ray. Bowel gangrene too is detected earlier on CT. [36]

In cases of suspected appendicitis CT has a higher sensitivity and specificity than ultrasound. CT helps to differentiate a periappendicular phlegmon from an abscess. [39]

CT is better for diagnosing other conditions like caecal diverticulitis, mesenteric adenitis and omental infarction, all of which can mimic appendicitis. The main drawback of CT is the exposure to radiation, cost and the availability. According to a recent study CT scanning results in superior diagnostic precision in patients with acute abdominal pain and is recommended early in the routine diagnostic evaluation. [12, 40]

MRI in the imaging of acute abdomen [13, 41]

Ionizing radiation is, undoubtedly, a major drawback of CT scan and the high contrast resolution of MRI is an advantage over CT for this reason. MRI has surpassed CT in the imaging of pelvic, hepatobiliary and pancreatic pathologies. Despite its apparent advantages, MRI has not yet played any significant role in imaging of the acute abdomen. The scientific evidence for MRI in the assessment of the acute abdomen is not extensive. It does not encompass all relevant conditions and some studies are small series with methodological weaknesses. Nevertheless, those data that are available are encouraging.

One of these studies, a series of 118 patients of whom 11 had acute appendicitis, showed MRI to have a sensitivity of 90 per cent, a specificity of 98 per cent, a positive predictive value of 81 per cent and a negative predictive value of 99 per cent. Good results have also been reported for MRI in sigmoid diverticulitis. MR images are useful in terms of other important findings; free fluid, abscesses and bowel obstruction are readily appreciated. MR-cholangiography is superior to US and CT in visualizing the biliary system.

The exact role of MRI for acute abdomen in general needs to be understood. Nevertheless, currently available results indicate that MRI is an accurate diagnostic tool for those conditions that have been studied.

There is abundant literature available studying the various aspects of imaging in acute abdomen

One particular interesting article is by Davies et al.[5] This study was done to assess whether all the patients who present with acute abdominal pain should routinely undergo an emergency ultrasound scan. 152 patients with acute abdomen were evaluated initially by a surgical registrar who formulated the plan of management. It was decided whether to ask for an emergency ultrasound, routine ultrasound or not ask any ultrasound. All patients later underwent sonological examination. The study showed that the overall management plan changed only in 11% of the cases. In most conditions the initial clinical assessment had the same sensitivity, specificity and positive predictive value. The authors have concluded that as quite often the immediate management does not change with ultrasound, diverting resources to provide urgent ultrasonologic examination is not necessary.

The other study is by Carmody et al. [42.] In this study, experienced clinicians were asked to examine patient with acute abdomen and list the primary diagnosis and also the three likely differential diagnoses. The patient was then subjected to a sonologic examination and based on the ultimate diagnosis the scan was qualified as uniquely diagnostic, confirmed primary diagnosis, confirmed differential diagnosis, no value and misleading. These were 18.7, 34.7, 12, 32, and 2.6% of patients in five groups respectively.

Surgeon performed ultrasound: In a study in England, surgeons performed ultrasound in 205 cases of acute abdomen and provided information regarding diagnosis in 138 cases (67.3%). In 16 cases (7.8%) initial clinical diagnosis changed after ultrasound. Subsequently scans were performed by consultant radiologist who found that 109 (78.4%) of the findings were correct.[43] In another review article the value of ultrasonography in the acute non-trauma setting lies in the identification of pathology as in gallstones, excluding pathology by identifying normal organs and intra-abdominal fluid collection. The ultrasonography extends the surgeon's diagnostic armamentarium and has become an integral part of the general surgeon's practice. [17] Ultrasound improved the correct diagnostic rate from 70% to 83% and has been recommended as a part of routine surgical investigation to be mastered and used by surgeons. [6]

Appendicitis:

The pitfall of a clinical examination has been well demonstrated by Schweric. [44] In this study treating surgeons have been asked to divide their patients with clinical suspicion of appendicitis into three categories: high, equivocal and low. Even in the high suspicion group 35% did not have appendicitis. 5% of patients in the low suspicion group had appendicitis. Sonology changed the line of management in 26% of the cases. The authors later concluded asking for a low threshold for sonologic examination in cases of suspected appendicitis

There have been innumerable studies quoting various sensitivity and specificity for ultrasound in acute appendicitis. In one article Puylaert [19] has used graded compression technique for diagnosing acute appendicitis. This and other studies have quoted sensitivity between 75-90%, specificity between 86-100%, positive predictive value of 91-94% and negative predictive value of 89-94% [45, 18, 46]

Newer imaging modalities like CT scan had higher sensitivity and accuracy over ultrasound in evaluation of patients with right iliac fossa pain. In various studies CT had sensitivity between 90-100%, specificity between 83-97%, accuracy of 93-98% and positive predictive value of 94-97% [45, 47,48]

In other conditions like caecal diverticulitis, mesenteric adenitis, omental infarction CT was found to have better sensitivity and specificity compared to ultrasound. [49]

In one study by Lim et al [20] the authors have demonstrated increased blood flow to the inflamed appendix using a duplex scan. This method supposedly had a higher sensitivity.

Acute cholecystitis and complications: In one particular study [28] authors have studied 52 patients with right upper quadrant pain. 22 had cholecystitis on ultrasound, 17 of which was confirmed on biopsy. Sensitivity was 94% and specificity was 85%. In chronic cholecystitis sensitivity was 71% and specificity was 97%. The newer modalities like HIDA scan have higher sensitivity but because of their limited availability they cannot be used regularly.

Hollow viscus perforation: As many as 35% of perforated peptic ulcers and 70% of lower GI perforations may not have visible air under the diaphragm.[15] In one particular study [32], 22 patients who had signs of hollow viscus perforation but normal chest x-rays were studied. Among these 17 had extraluminal localised area of high echogenecity in the gastrohepatic recess, 12 had sub hepatic peritoneal fluid, and four had free fluid. The authors have concluded that ultrasound can provide clues when x-rays are negative. In some studies ultrasonography was found to be more sensitive than plain radiography in the diagnosis of pneumoperitoneum [50, 51]

Intestinal obstruction: There have not been many studies evaluating the role of sonography for the diagnosis of intestinal obstruction. In one particular study from Wisconsin [52] the authors have studies 50 cases comparing plain x-ray abdomen and sonology in cases of intestinal obstruction. The final diagnosis was made on laparotomy. Sonography demonstrated bowel obstruction by showing fluid filled dilated bowel loops proximal to collapsed bowel in 22 patients with one false positive and three false negative examinations. X-rays showed bowel obstruction in 32 patients with nine false positive and one false negative examination. The authors have concluded that sonography is as sensitive but more specific than plain x-rays in the diagnosis of intestinal obstruction.

Mesenteric ischemia and bowel gangrene: Various studies have quoted a sensitivity of 70-80% for abdominal ultrasound in cases of mesenteric vascular occlusion. CT scan has a sensitivity of 90%. Abdominal duplex imaging matches CT scan in sensitivity. Abdominal aortography and selective mesenteric angiography has been considered the gold standard by most authors. [43, 36, 35]

Ultrasound was a valuable investigation in patients with suspected biliary pathology and in evaluating abdominal masses. Patients with localised abdominal pain and tenderness are more likely to have a positive finding on ultrasound examination than are those with diffuse abdominal pain and tenderness. A positive diagnosis on ultrasound was more likely in patients with a combination of abdominal pain and raised blood counts or liver function tests. [53]

In a study conducted hospital to assess the role of sonography in the decision making process at a hospital with advanced imaging capabilities (university hospital) versus a hospital with limited imaging capabilities (rural hospital) management after sonography changed in only 14% of cases, compared to 27% at the rural hospital. Additional tests were more frequently added at the urban hospital (30%) than at the rural hospital (18%), but had no influence on the decision making process. [54]

METHODOLOGY

The present study was conducted in the Department of Surgery, KLES Dr. Prabhakar Kore Hospital and Medical Research Centre, Belgaum on patients presenting with history of acute abdominal pain in a one year period from January 2008 to December 2008.

Study design:

A Cross Sectional Study

Study period:

The present study was conducted between the time period of 1st January 2008 to 31st December 2008.

Method of collection of data

Source of Data

Patients presenting with an acute abdomen, to the Department of Surgery, KLES, Dr. Prabhakar Kore Hospital and Medical Research Centre, Belgaum.

Sample size:

65 study subjects.

Sampling procedure

The sample size was calculated considering the following formula

The sample size was estimated considering an expected sensitivity of the ultrasound as 90% with a confidence interval of 7.5. The expected sensitivity thus ranged from 82.5 to 97.5 with the width of confidence being 15. The sample size was calculated using the formula

$$n = \frac{4Z\alpha^2 p(100-p)}{d^2}$$

where

$Z\alpha = 1.96$ is a constant

$p = 90$ is the expected proportion.

(expected combined sensitivity of the ultrasound)

$d = 15$ is the width of confidence.

α error is taken as 0.05

Selection criteria

Inclusion criteria:

- All patients with abdominal pain more than 6 hours and less than 3 days duration.

Exclusion criteria:

- Patients less than 14 years of age and more than 60 yrs of age
- Pregnancy.
- History of trauma to the abdomen - blunt or penetrating.
- Patients who are included in the study but are managed conservatively are to be excluded.
- Patients who had already undergone laparotomy in a outside hospital for the same or related problem
- Patients who are already enrolled in another study conducted in the hospital during the same time period.

All the patients attending KLES Dr.Prabhakar Kore Hospital and MRC, Belgaum, to the Department of General Surgery with history of acute abdominal pain meeting the inclusion and exclusion criteria are selected into the study. A detailed history and examination is carried out with a questionnaire and the case study proforma.

Informed consent is taken from all the patients included in the study.

Ultrasonography is performed by the radiologist on duty using a 3.5MHz or 5MHz probe using the Philips ultrasound machine.

The ultrasound findings are then compared to histopathological findings or operative findings or diagnostic laparoscopic findings. The accuracy of ultrasound is assessed statistically by calculating positive predictive values and sensitivity of each of the abdominal conditions.

Statistical Methods

Data Analysis done by following table (using the results of ultrasonography and the corresponding findings at histopathology, laparotomy or diagnostic laparoscopy respectively)

Ultrasound results	**Diagnosis**		**Total**
	Disease	**Non-diseased**	
Positive	a (true +ve)	b (false +ve)	a + b
Negative	c (false -ve)	d (true -ve)	c + d
Total	a + c	b + d	a + b + c + d

Evaluation of Ultrasound:

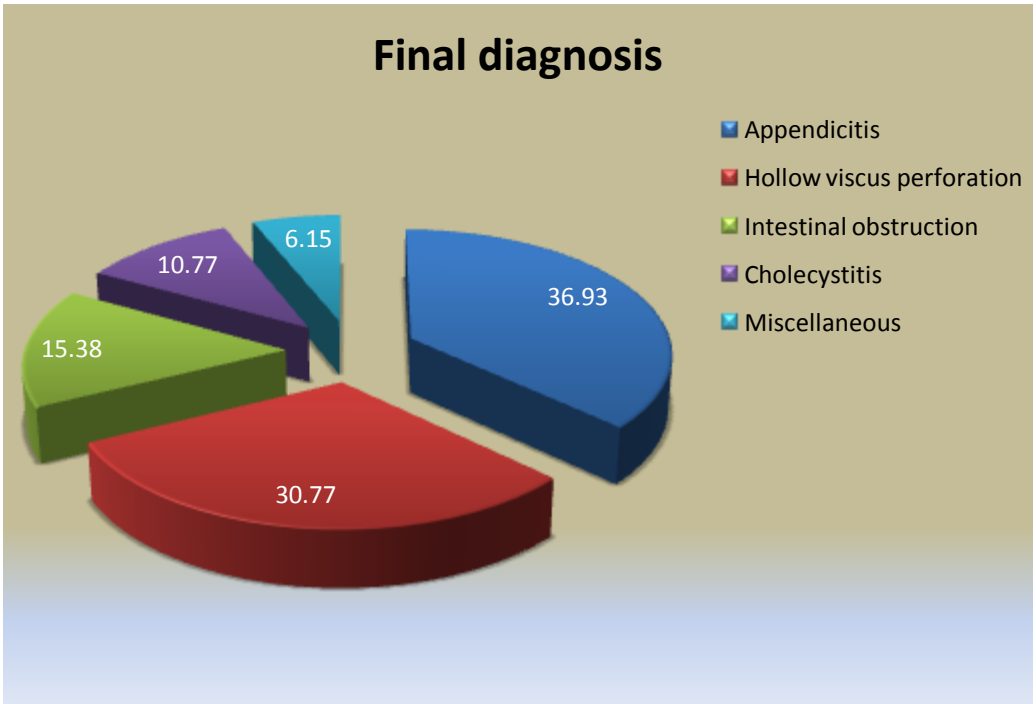
- Sensitivity = a / a + c X 100
- Specificity = d / b + d X 100
- Predictive value of positive test = a / a + b X 100
- Predictive value of negative test = d / c + d X 100
- Percentage of false negatives = c / a + c X 100
- Percentage of false positive = b / b + d X 100

RESULTS

Among the sixty five patients included in the study, **36** were male and **29** were female; with a male to female ratio of **1:0.8**. The age range was between 14 to 60 years as shown in table 1.

TABLE 1 : GENERAL PATIENT DATA	
Total number of patients in the study	**65**
Males	36
Females	29
Age range	14 to 60 yrs

TABLE 2 : FINAL DIAGNOSIS:			
1.	Appendicitis and its complications	24	(36.93%)
2.	Hollow viscus perforation	20	(30.77%)
3.	Intestinal obstruction	10	(15.38%)
4.	Cholecystitis and complications	07	(10.77%)
5.	Miscellaneous causes (Meckel's diverticulitis, Pelvic abscess, Mesenteric ischaemia, Ectopic pregnancy)	04	(6.15%)
	Total	65	



Graph 1: The causes of acute abdomen in this study; Figures indicate percentage of cases

ULTRASOUND IN ACUTE APPENDICITIS:

The total number of cases with right lower abdominal pain was 25. Out of these cases the final diagnosis was as follows.

- Appendicitis – 19
- Appendicular mass – 2
- Appendicular perforation – 3
- Meckel's diverticulitis - 1

Clinical diagnosis of appendicitis as primary diagnosis made in 18 patients and appendicitis as was considered a differential diagnosis in the remaining seven cases. Among the 18 cases where clinical diagnosis was acute appendicitis ultrasound provided direct or indirect evidence to confirm 10 cases. The remaining seven cases in which appendicitis was not considered as primary diagnosis four cases were diagnosed to be appendicitis by ultrasound.

Thus ultrasound findings confirmed the initial clinical diagnosis of appendicitis in 10 patients; was diagnostic in 4 cases where appendicitis was not the primary diagnosis and non diagnostic or failed to diagnose 11 cases.

Histopathology – was reported as follows

- Acute appendicitis – 20
- Chronic appendicitis – 4
- Meckel's diverticulitis – 1

Table: 3. Comparison of ultrasonographic and histopathological findings in acute appendicitis

Ultrasound	Histopathology		
	Acute appendicitis	Chronic appendicitis and other	
Positive	13	1	14
Negative	7	4	11
	20	5	25

Based on the above 2x2 table these values were computed

Sensitivity of ultrasound – 65% Specificity of ultrasound – 80%

Positive predictive value – 92.85% Negative predictive value – 36%

False negative percent - 35% False positive percent – 20%

Table 4: Comparison of clinical diagnosis with histopathology in appendicitis

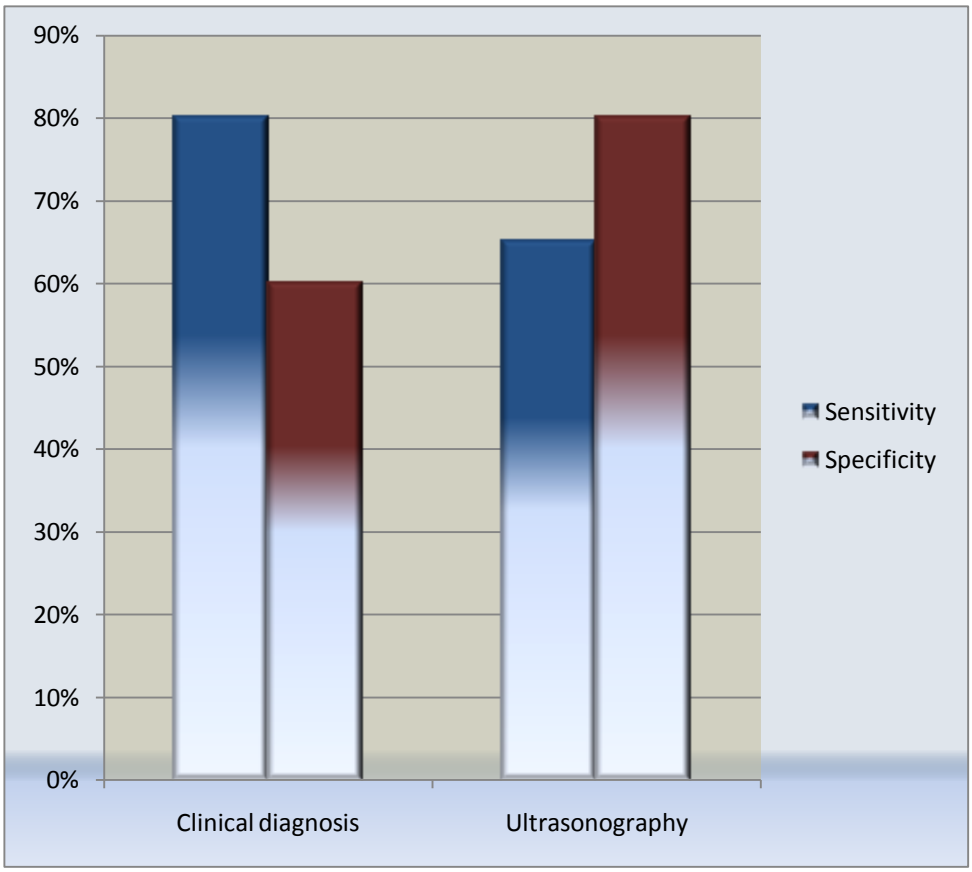
Clinical examination	Histopathology		
	Acute appendicitis	Chronic appendicitis and other	
Positive	16	2	18
Negative	4	3	7
	20	5	25

Sensitivity of clinical examination – 80%

Specificity of clinical examination – 60%

Table 5: Diagnosis of complications of appendicitis

	Cases	By clinical exam	By ultrasound
Mass	2	1	2
Perforation	3	0	3



Graph 2: Comparison of sensitivity and specificity values of clinical diagnosis and ultrasonography in acute appendicitis

HOLLOW VISCUS PERFORATION

21 cases were suspected clinically to have a hollow viscus perforation among which a pelvic abscess was misdiagnosed

- Gastro-duodenal perforation – 13 (65%)
- Ileal perforation – 7 (35%)
- Pelvic abscess - 1

18 cases had chest or erect abdominal radiograph showing gas under diaphragm, among which 12 were Gastro-duodenal perforations and 6 were Ileal perforations

Ultrasound showed positive findings in 17 cases

Free fluid with or without internal echoes – 17

Pneumoperitoneum on USG – 0

Table 6: Break up of cases with plain radiograph and ultrasonography findings in hollow viscus perforation

X-ray	**USG**	**No. of cases**
Negative	Positive	2
Positive	Negative	3
Positive	Positive	15
Negative	Negative	0

Table 7: Comparison of plain radiograph and laparotomy findings in hollow viscus perforation

Radiograph	Laparotomy		
	Perforation	No perforation	
Positive	18	0	18
Negative	2	1	3
	20	1	21

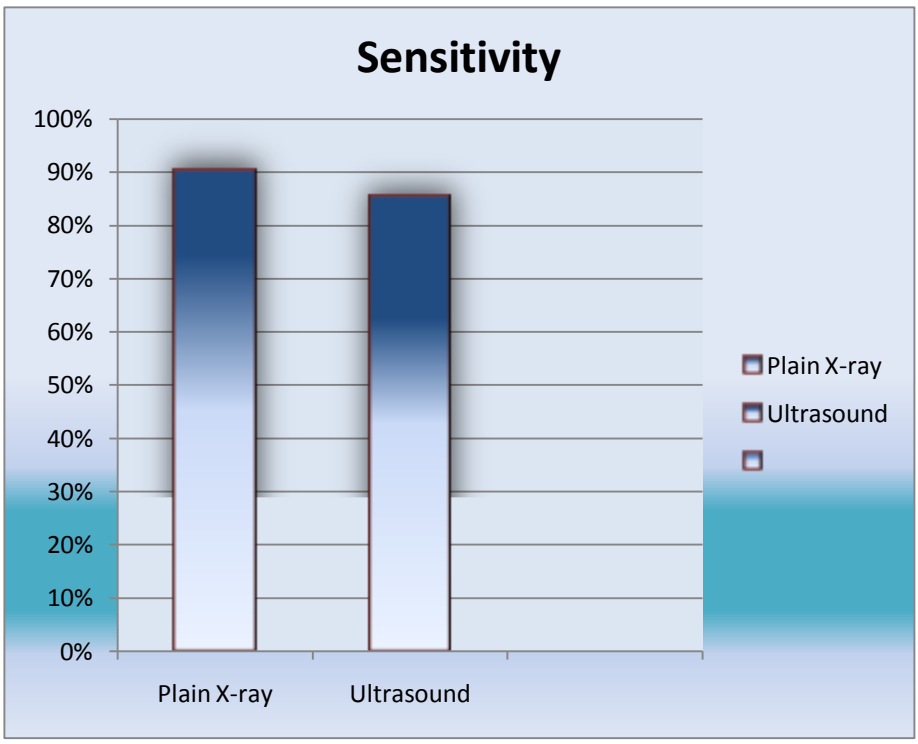
Sensitivity of radiograph – 90%

Table 8: Comparison of ultrasound and laparotomy findings in hollow viscus perforation

Ultrasound	Laparotomy		
	Perforation	No perforation	
Positive	17	0	15
Negative	3	1	4
	20	1	21

Sensitivity of ultrasound – 85% Positive predictive value – 100%

Ultrasound thus confirmed the diagnosis in 17 cases; was not diagnostic in 3 cases. One case of pelvic abscess was diagnosed by ultrasound.



Graph 3: Comparison of sensitivity of plain radiograph and ultrasonography in hollow viscus perforation

INTESTINAL OBSTRUCTION

11 cases with the clinical suspicion of bowel obstruction were included in the study. Among these 11 cases six cases were small bowel obstruction (three due to post-operative adhesions, two peritoneal bands and one jejunojejunal intussusception because of an intramural lesion). Out of the four cases of large bowel obstruction, three were because of colonic growths and the remaining one was sigmoid volvulus. One case of mesenteric ischemia was wrongly diagnosed as obstruction.

Out of 11 cases clinical diagnosis was made in 8 cases

Plain x-ray showed

- Dilated bowel loops with air fluid levels in 7 cases
- Only dilated bowel loops in 2 cases

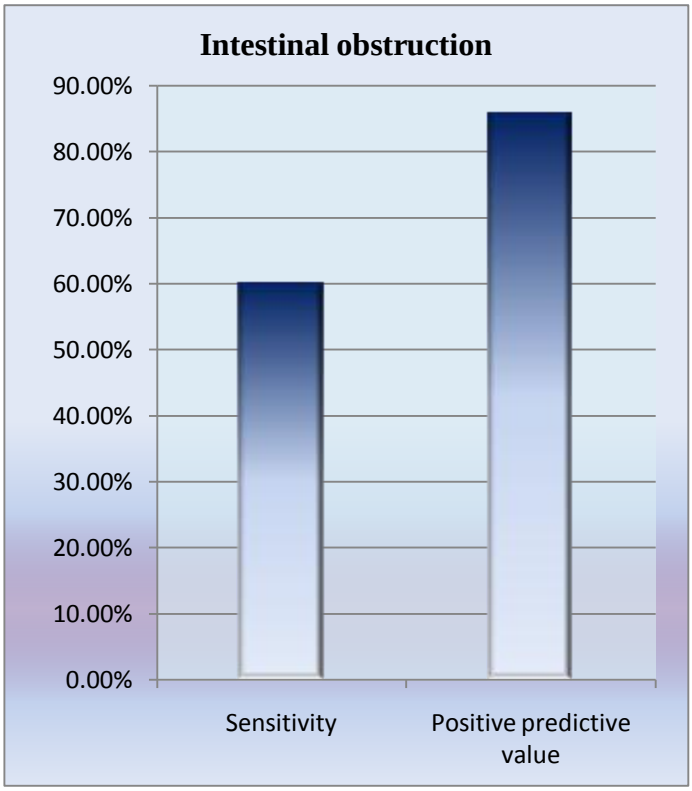
Ultrasound findings

- Dilated bowel loops – 7
- Free fluid – 2
- Normal scan – 2

Table 9: Comparison of ultrasound and laparotomy findings in bowel obstruction

Ultrasound	Laparotomy		
	Obstruction	No obstruction	
Positive	6	1	7
Negative	4	0	4
	10	1	11

Sensitivity of ultrasound – 60% Positive predictive value – 85.71%



Graph 4: Sensitivity and positive predictive value of ultrasound in Intestinal obstruction

Ultrasound confirmed primary diagnosis of obstruction in 6 cases; was not diagnostic in 4 cases. One case of mesenteric ischaemia wrongly diagnosed by ultrasound was diagnosed on CT.

CHOLECYSTITIS

Seven cases of acute cholecystitis and its complications were included in the study. Among these, acute cholecystitis was diagnosed in 5 patients. One patient had empyema gall bladder and one patient had gall bladder perforation. Both these cases were diagnosed operatively.

Clinical diagnosis of cholecystitis was made in 5 cases and cholecystitis was considered a differential diagnosis in 2 cases

Ultrasound was

- Diagnostic in 1 case
- Confirmed primary diagnosis in 3 cases
- Misleading in 1 case

Histopathology

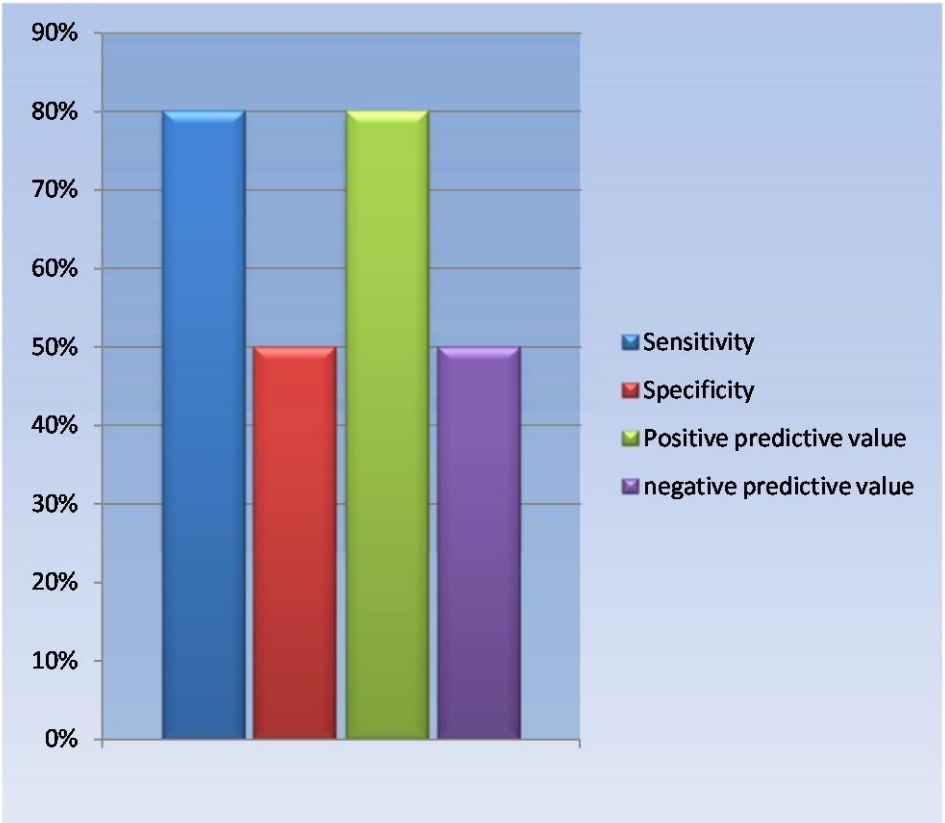
- Acute cholecystitis (including complications) in 5 cases
- Chronic calculous cholecystitis in 2 cases

Table 10: Comparison of ultrasound and histopathological findings in acute cholecystitis and its complications

Ultrasound	Histopathology		
	Acute Cholecystitis	No acute cholecystitis	
Positive	4	1	5
Negative	1	1	2
	5	2	7

Sensitivity of ultrasound – 80% Specificity of ultrasound – 50%

Positive predictive value – 80% Negative predictive value – 50%



Graph 5: Sensitivity, Specificity and predictive values of ultrasonography in diagnosing acute cholecystitis and its complications

ULTRASOUND IN OTHER ABDOMINAL CONDITIONS

Pelvic abscess -1 case

Meckel's diverticulitis – 1 case

Mesenteric ischaemia – 1 case

Ectopic pregnancy (tubal pregnancy) – 1 case

Of these conditions ultrasound could easily pick up the case of pelvic abscess and ectopic pregnancy. But, the mesenteric ischaemia with bowel gangrene was diagnosed on CT scan and Meckel's diverticulitis on surgery.

Combining all the ultrasound findings and histopathology/ operative findings to compute the aggregate sensitivity and specificity in all the cases of acute abdominal conditions the following 2x2 table was formed

Table 11: Comparison of ultrasound, with histopathology or operative findings, in all the cases of acute abdomen.

Ultrasound	Histopathology / Operative findings		
	Positive	Negative	
Positive	40	3	43
Negative	15	6	21
	55	9	64

Sensitivity of ultrasound – 72.72% Specificity of ultrasound – 66.67%

Positive predictive value – 93.02% Negative predictive value – 28.57%

DISCUSSION

Acute appendicitis and its complications

As the results show clinical examination alone has a high sensitivity in diagnosing appendicitis, the major drawback was the tendency to overdiagnose all the cases of right iliac fossa pain as appendicitis as evidenced by other studies.[18, 22, 55] As the number of false positive clinical diagnosis was less in this study, it was not possible to conclude that surgery can be done on the basis of clinical impression alone.

Ultrasound had a low sensitivity of 65% in diagnosing appendicitis in this study as compared to other studies.[6, 45, 46] The fact that ultrasound did help in four out of the seven cases of clinically doubtful or unsuspected cases of appendicitis was a point in favour of doing routine ultrasound though it was found to have a lower sensitivity.

The other striking feature was the high positive predictive value of ultrasound. Appendicitis was quite often missed on the ultrasound, but whenever detected it has always been true even when laboratory investigations have not been in favour. This was consistent with the studies reviewed. [6, 18, 45]

Many surgeons diagnose appendicitis based on the total leucocyte count. Though the sensitivity of this investigation is much higher than that of ultrasound the specificity remains to be studied. The sensitivity of ultrasound is higher in case of an appendicular mass or abscess, though in this study the numbers are quite small to draw conclusions.

Hollow viscus perforation

Traditionally ultrasound has been considered to be of very limited value in cases of hollow viscus perforations.

The sensitivity of plain x-ray in this study has been 90% in this study which was in league with the other studies.[31, 56] Ultrasound was found to have a similar sensitivity as x-ray, but this is when indirect evidence like the presence of free fluid was taken into consideration. Although certain studies showed that the ultrasound could pick up pneumoperitoneum and was considered as sensitive as plain x-ray[50, 51] in this study pneumoperitoneum could not be identified by ultrasound. Without calculating the specificity it was not possible to conclude the superiority of one investigative modality over the other.

As seen there are few number of cases where x-ray findings have been negative and ultrasound has still detected free fluid. According to one study in the presence of clinical signs of peritonitis, an ultrasound finding of free fluid was a strong indicator of hollow viscus perforation, even in the absence of air under the diaphragm and CT could not demonstrate any additional diagnostic information.[56]

One case of pelvic abscess was misinterpreted by the radiologist as having a hollow viscus perforation

Intestinal obstruction

Intestinal obstruction is again a condition where ultrasound has not much role to play. But ultrasound did provide some evidence or the other regarding the presence of obstruction with a sensitivity as high as 85.7%. This was almost as much as high as that of the plain x-ray.[26, 52] The drawback of the ultrasound was not being able to localize the site of obstruction. Plain x-ray was better in this regard, where the small bowel and large bowel loops could be identified separately. Ultrasound also is did not provide any evidence about the cause of obstruction. Among the patients with obstruction, 5 patients underwent CT abdomen. In three of these patients the cause of obstruction was identified as colonic malignancy.

Cholecystitis and complications

Ultrasound in this study has been quite reliable in picking up gall stones though it has not detected a few cases of acute cholecystitis. [27, 28] Ultrasound has not been satisfactory in detecting the complications like empyema and perforation.

The ultrasound was found to have a combined sensitivity of 72.02% and a specificity of 66.7% in all the acute abdominal conditions, which is comparable to most other studies. [4,5,6,37,43.]

CONCLUSION

Clinical examination may have a high sensitivity in diagnosing appendicitis but its specificity still needs to be assessed. Ultrasound has a poor sensitivity but a very high predictive value in diagnosing acute appendicitis. An ultrasound diagnosis of acute appendicitis needs to be believed. Ultrasound more likely helps in diagnosing complications of appendicitis.

In cases of hollow viscus perforation ultrasound is found to have a similar sensitivity as that of plain x-ray, but this is true only when indirect evidence is considered. Here again the specificity needs to be assessed. Ultrasound can provide some corroborative evidence like the presence of free fluid in diagnosing hollow viscus perforation in cases where there is no air under the diaphragm.

In cases of intestinal obstruction, ultrasound is able to detect the presence of dilated bowel loops in a high percentage of cases but it fails to provide any clue regarding the probable site or the cause of obstruction. Ultrasound is fairly accurate in detecting gall stones and the acute changes in cases of acute cholecystitis, but it is not so accurate in detecting the complications of cholecystitis. Ultrasound assessment in cases of pelvic abscess and ectopic pregnancy is reliable.

In conclusion, ultrasound is a useful imaging modality in diagnosing acute abdominal conditions which need surgical attention. It continues to be a first line investigation to evaluate acute abdomen and can be considered as an extension of clinical examination.

SUMMARY

In this present study, 65 patients were admitted at the KLES Dr. Prabhakar Kore Hospital and Medical Research Center, Belgaum with the complaints of acute abdominal pain. The patients were evaluated and underwent surgery subsequently. The sensitivity, specificity and predictive values of ultrasound in diagnosing the condition, was compared to the operative or histopathological findings.

The results showed that ultrasound had combined sensitivity of 72.02% and a specificity of 66.7%. In acute appendicitis ultrasound had a low sensitivity but a high positive predictive value. Ultrasound also is useful in easily identifying the complications of appendicitis. Ultrasound was found to have a similar sensitivity as plain x-ray in identifying hollow viscus perforation, but only when non-specific findings were taken into consideration. The same was true in case of intestinal obstruction also. Ultrasound in this study has been quite reliable in picking up gall stones but the complications of acute cholecystitis were not satisfactorily detected.

Based on this study it was concluded that ultrasound abdomen in an acute setting has been a useful first line investigation. A positive ultrasound report of appendicitis was quite reliable while a negative report was not. Ultrasound provided corroborative evidence in case of bowel perforation and intestinal obstruction.

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ANNEXURE I

CONSENT FORM

Mr./Mrs._____we are requesting you to enroll yourself in study titled **'A Cross sectional study to evaluate the sensitivity, specificity and predictive value of Ultrasonography in non-traumatic acute abdomen'** conducted by Dr.Gautham.M, postgraduate student in M.S General Surgery under the guidance of Dr.I.V.Uppin at J.N Medical College, Belgaum.

You have been requested to participate in research because you are into the study group. During the study you will be asked some questions and you are supposed to answer to the best of your knowledge.Your participation in research is voluntary. Your decision whether or not to participate in the study will not affect your relationship with J.N.M.C. If you decide to participate you are free to withdraw at any time.

. The purpose of research is to study the accuracy of ultrasonography in diagnosing acute abdominal conditions.

PROCEDURE INVOLVED:

If you agree to be a part of this research study you would be asked relevant present, past and family history and also subjected relevant detailed clinical examination. You will also undergo ultrasonography, which will be done by the on duty radiologist.

You are hereby informed that the findings of the ultrasonography would be used for the research purposes. You are also informed that, if you undergo an operation, the operative findings or the findings of histopathological examination of tissues would be used for research purposes.

RISKS AND BENEFITS:

I have been explained by investigators, that there are no potential risks involved in this study.

ALTERNATIVES:

Taking part in the study is voluntary. Even if you decline the participation, you will get the routine line of management.

PRIVACY AND CONFIDENTIALITY:

The only people to know that you are a research subject are members of the research team. No information about you or provided by you during the research will be disclosed to others without your written permission except:

1. In emergency to protect your rights and welfare.

2. If required by law.

AUTHORIZATION TO PUBLISH RESULTS:

When the results of the research are published or discussed, in a conference, no information will be displayed that would disclose your identity.

Any information that is obtained in connection with this study and that can be identified with you will remain confidential.

FINANCIAL INCENTIVES FOR PARTICIPATION:

You will not be paid/offered any free gifts for participating in the research. You will not be reimbursed for expenses.

CONSENT FORM:

I undersigned …….. have been explained in my vernacular language about the study and my participation in the study is voluntary. If I want, I can withdraw at any time. Also I have been given enough time to clear my doubts and rights as study participant.

In case you have any questions related to the study, you can contact Dr.Gautham.M (Phone No 9886414062). In case you have any questions about my rights as a study participant, you can contact Dr V.D Patil (0831-2471350)

Signature or the Left Thumb print of Participant or legally authorized representative

Participant's Name …… Signature ……

Witness Name ……... Signature ……

Experimenter's Name …… Signature ……

Date …….

Place ……

ANNEXURE II

PROFOMA

Patient's Name: I.P. No. :

Age: Sex:

Date of Admission: Date of Discharge:

Date of operation:

Religion:

Occupation:

Address:

Presenting Complaints:

Duration of pain:

Location of pain:

Character of pain:

Radiation of pain:

Aggravating factors:

Relieving factors:

Associated symptoms:

General Physical Examination:

Pulse: B.P: Temp: RR: SpO_2:

Per Abdomen Examination:

Others:

Provisional Diagnosis on Clinical examination:

Ultrasonography findings:

Diagnosis on ultrasound:

Operative findings / Diagnostic laparoscopic findings / Histopatological findings:

Final Diagnosis:

QUESTIONNAIRE

1. Is the pain abdomen of recent origin? Yes / No

(Pain less than 3 days duration)

2. Is pain persisting for more than 6 hours? Yes / No

3. What is the site of pain?

    a. Upper middle abdomen

    b. Upper right abdomen

    c. Upper left abdomen

    d. Near the umbilicus (navel)

    e. Middle right abdomen

    f. Middle right abdomen

    g. Right lower abdomen

    h. Left lower abdomen

    i. Lower abdomen

    j. All over the abdomen

4. State the character of pain:

5. Is there any

    a. Nausea / Vomiting

    b. Abdominal distension

    c. Altered bowel habits

    d. Fever

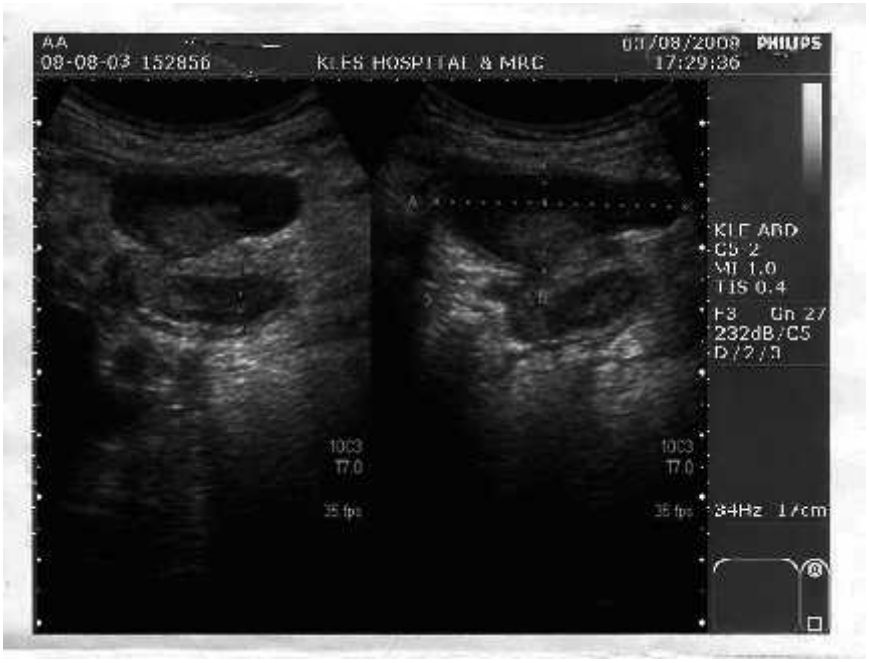
6. Did you undergo any operations in the past

If yes, when was it?

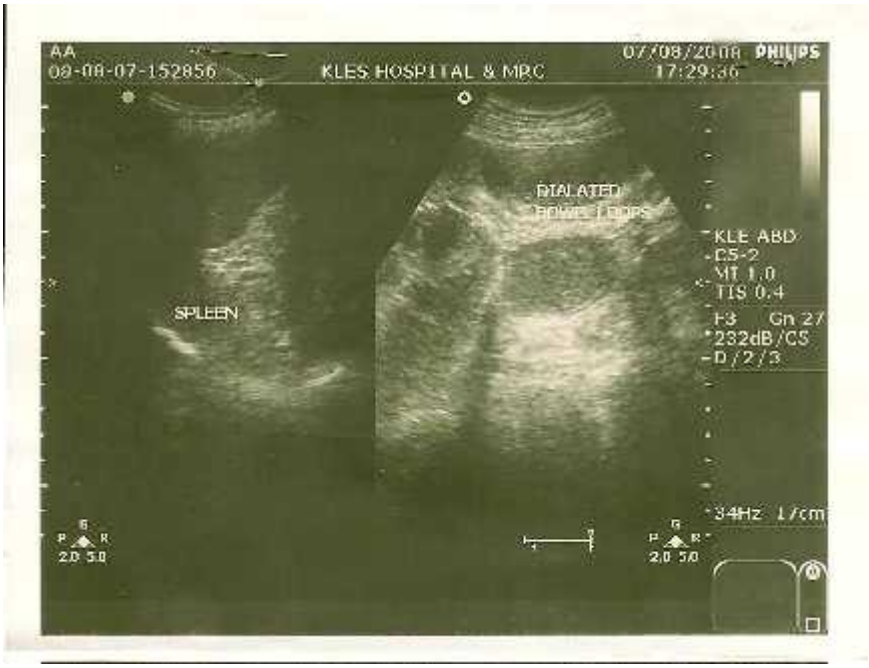
ANNEXURE III – PHOTOGRAPHS

1. **Acute appendicitis: Ultrasound film showing a tubular, non compressible, aperistaltic structure in the right iliac region.**

2. **Appendicular perforation: The aperistaltic, oedematous appendix is seen with periappendicular fluid indicating a perforation**



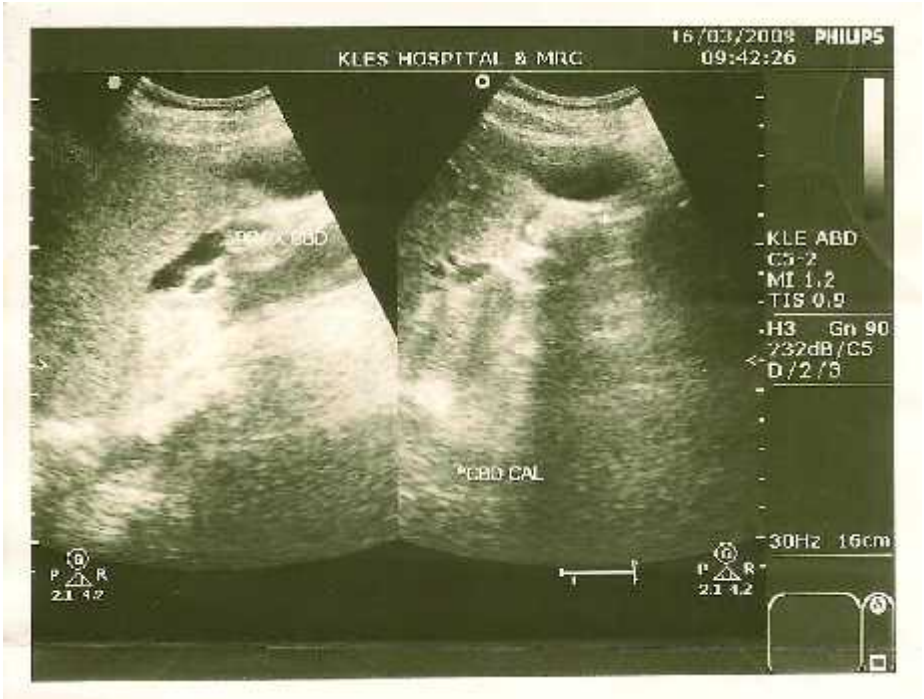
3. Multiple dilated bowel loops suggestive of intestinal obstruction



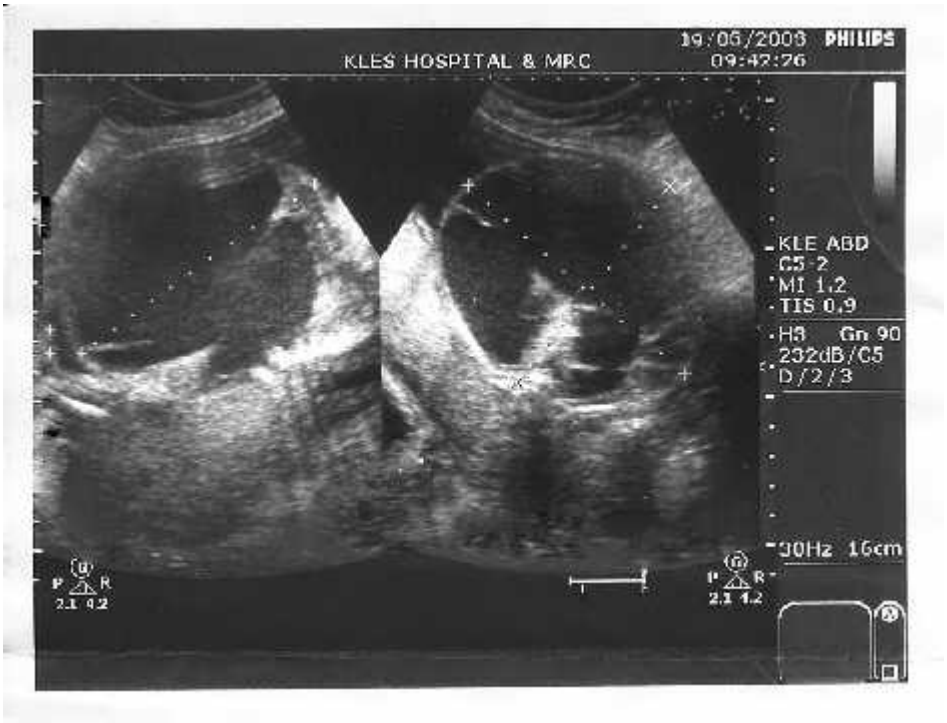
4. Acute cholecystitis: Multiple gallstones in the gall bladder with a post acoustic shadow and oedema of gall bladder wall

5. **Acute cholecystitis : Another ultrasound film showing gall bladder stone with thickened gall bladder walls and a thin rim of pericholecystic collection**

6. **Choledocholithiasis: A complication of cholelithiasis. Stone in common bile duct with shadows and dilated proximal bile duct.**



7. **Hollow viscus perforation: Moderate amount of free fluid in the peritoneal cavity with internal echoes.**



ANNEXURE III - MASTER CHART

ACUTE APPENDICITIS

Sl. No.	IP No.	Name	Age	Sex	D.0.S	TLC	Clinical	USG	Histo
1	253686	SPK	24	F	3/1/2008	I	AA	AA	AA
2	257299	SSB	35	F	4/1/2008	N	AA	N	CA
3	257358	BZP	38	F	5/1/2008	I	AA	AP	AP
4	257623	UAP	24	F	10/1/2008	I	AA	AA	AA
5	258280	SPY	18	F	12/1/2008	N	O	N	CA
6	261105	ARK	23	M	5/2/2008	I	O	N	AA
7	261509	SSD	22	M	9/2/2008	I	AM	Mass	AM
8	262749	SVH	28	M	21/2/2008	I	AA	AA	AA
9	264210	PRA	28	F	11/3/2008	N	AA	AA	AA
10	268315	SK	30	F	9/4/2008	I	AA	N	Meckels
11	269039	IYR	29	M	15/4/2008	N	O	AA	CA
12	269685	GNV	64	M	19/4/2008	I	AA	Mass	AM
13	270096	VAK	21	M	22/4/2008	I	O	N	AA
14	272149	ANP	37	F	15/5/2008	N	O	N	CA
15	273771	MMK	23	F	26/5/2008	I	AA	N	AA
16	275051	AYK	28	M	3/6/2008	I	AA	AA	AA
17	275340	BDP	16	F	3/6/2008	I	AA	AA	AA

18	275445	AMK	25	F	5/6/2008	N	AA	AA	AA
19	281185	RM	23	M	18/7/2008	I	AA	N	AA
20	287917	RHG	22	M	11/9/2008	I	O	N	AA
21	288154	NBB	20	F	12/9/2008	I	AA	AA	AA
22	288878	PSG	18	F	18/9/2008	I	AA	AA	AA
23	291157	HBJ	23	M	7/10/2008	N	AA	N	AA
24	296170	LMY	60	F	15/11/2008	I	AA	AP	AP
25	296782	ABM	17	M	20/11/2008	I	O	N	AA

HOLLOW VISCUS PERFORATION

Sl.No.	IP No.	Name	Age	Sex	D.O.S.	X-ray	USG	Final
26	257257	MSK	60	M	02/01/2008	P	FF	DUP
27	261195	RNB	55	F	06/02/2008	P	FF	DUP
28	268404	KRY	55	M	01/04/2008	N	FF	IP
29	271632	VRN	55	M	05/05/2008	P	N	GP
30	271636	LAM	42	F	05/05/2008	P	FF	DUP
31	272988	DTP	39	M	15/05/2008	P	FF	IP
32	275387	SNH	42	M	03/06/2008	P	FF	IP
33	276342	IBK	40	F	11/06/2008	P	FF	IP
34	277145	SMT	35	M	18/06/2008	N	FF	DUP

35	277265	BAP	54	M	20/06/2008	P	FF	DUP
36	279548	ABH	64	F	07/07/2008	P	N	GP
37	284882	KBM	60	F	16/08/2008	P	FF	IP
38	284917	SRM	45	M	17/08/2008	P	FF	DUP
39	287034	SSY	40	M	03/09/2008	P	FF	DUP
40	287875	SVS	28	M	10/09/2008	P	FF	DUP
41	291039	KMJ	60	M	03/10/2008	P	FF	IP
42	293894	RRB	55	F	26/10/2008	No	Pelvic abscess	Pelvic abscess
43	294940	LFP	45	M	05/11/2008	P	FF	DUP
44	297299	MBH	56	M	23/11/2008	P	FF	DUP
45	297095	SBG	43	M	26/11/2008	P	N	IP
46	300156	JVK	50	M	24/12/2008	P	FF	DUP

INTESTINAL OBSTRUCTION								
Sl.No.	IP No.	Name	Age	Sex	D.O.S	X-ray	USG	Final
47	257977	SCS	48	F	09/01/2008	AF	DB	Post op Adhesions
48	267248	CBH	52	M	31/03/2008	DB	DB	Mesenteric Ischemia
49	269968	GRH	59	F	26/04/2008	N	FF	Ca. Sigmoid
50	275139	BIS	24	M	10/06/2008	AF	DB	Peritoneal Band
51	276926	PSD	60	F	17/06/2008	AF	DB	J-J intussusception
52	279220	SBK	60	M	05/07/2008	AF	N	Ca. Colon
53	283993	VBS	20	M	08/08/2008	DB	N	Sigmoid Volvulus
54	284799	SMD	38	M	15/08/2008	AF	DB	Post op Adhesions

55	285567	GBC	58	F	22/08/2008	AF	FF	Post op Adhesions
56	299208	RMK	30	F	13/12/2008	AF	DB	Peritoneal Band
57	304345	SPR	62	M	30/12/2008	N	DB	Ca. Colon

CHOLECYSTITIS

Sl.No.	IP No.	Name	Age	Sex	D.O.S.	USG	Final
58	257285	SCK	56	F	07/01/2008	AC	CC
59	261650	DML	49	M	11/02/2008	AC	AC
60	263585	MBG	42	M	03/03/2008	AC	AC (per)
61	282341	SGK	60	F	01/08/2008	AC	AC (emp)
62	291134	KDD	52	F	07/10/2008	C	CC
63	291660	CSB	28	M	10/10/2008	C	AC
64	300579	MSM	61	M	22/12/2008	AC	AC

ECTOPIC PREGNANCY

65	291727	SSK	25	F	14/10/2008	Ectopic	Ectopic (tubal) preganacy

ANNEXURE IV

KEY TO MASTER CHART

Sl.No. –	Serial number
I.P. No. -	In-patient number
D.O.S -	Date of surgery
TLC -	Total leucocyte count
Clinical -	Clinical diagnosis
USG -	Diagnosis on ultrasound
Histo -	Histopathological diagnosis
I -	Increased
N -	Normal ultrasound or x-ray
AA -	Acute appendicitis
AP -	Appendicular perforation
AM -	Appendicular mass
CA -	Chronic appendicitis
O -	Other primary diagnosis
N -	Normal ultrasound study
P -	Hollow viscus perforation
No -	No free air on x-ray
FF -	Free fluid on ultrasound
DUP -	Duodenal ulcer perforation
GP -	Gastric perforation
IP -	Ileal perforation
AF-	Dilated bowel loops with air-fluid levels

DB -	Only dilated bowel loops on x-ray or ultrasound
AC -	Acute cholecystitis
CC -	Chronic cholecystitis
AC (per) -	Acute perforative cholecystitis
AC (emp) -	Acute cholecystitis with empyaema of gall bladder