A Dissertation on

PRE-OPERATIVE PREDICTION OF CONVERSION OF LAPAROSCOPIC CHOLECYSTECTOMY TO OPEN SURGERY : A MULTIVARIATE ANALYSIS OF PRE-OPERATIVE RISK FACTORS IN RGGGH

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BONAFIDE CERTIFICATE

Certified that this dissertation is the bonafide work of **Dr. VIJAY. K** on **"PRE-OPERATIVE PREDICTION OF CONVERSION OF LAPAROSCOPIC CHOLECYSTECTOMY TO OPEN SURGERY : A MULTIVARIATE ANALYSIS OF PRE-OPERATIVE RISK FACTORS IN RGGGH"** during his M.S. (General Surgery) course from April 2010 to April 2013 at the Madras Medical College and Rajiv Gandhi Government General Hospital, Chennai.

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CONTENTS

INTRODUCTION

Laparoscopic cholecystectomy has almost replaced open cholecystectomy as the therapeutic modality in the treatment of symptomatic gallstones. The difficult gallbladder is the most common 'difficult' laparoscopic surgery being performed by general surgeons all over the world and the potential one that places the patient at significant risk. A number of published clinical series emphasize the promising role laparoscopy is playing in treating benign gallbladder disease. In the beginning of Laparoscopic cholecystectomy, patients having acute cholecystitis, empyema, gangrenous gallbladder, cirrhotic patients, and Mirizzi syndrome were contraindication because of high risk of complications and conversion rate.

Thus with wider application of laparoscopy for technically difficult and high risk patients it was expected that the complication rates would rise as also the rate of conversion to open cholecystectomy. Although 2% to 15% of patients require conversion to open cholecystectomy for various reasons but irrespective of this morbidity and mortality statistics do still favour laparoscopic cholecystectomy over open cholecystectomy.

It is important to realize that the need for conversion to laparotomy is neither a failure nor a complication but an attempt to avoid complication and ensure patient safety. Conversion to open cholecystectomy has been associated with increased overall morbidity, surgical site and pulmonary infections, and longer hospital stays. Prediction of a difficult Laparoscopic cholecystectomy would allow the surgeon to discuss the likelihood of conversion with the patient and prepare him/her psychologically as well as planning their recovery and explaining their absence from work. Another benefit would be to allow more efficient scheduling of the operating lists and ensuring the availability of a more experienced laparoscopic surgeon for the procedure. Pre-operative prediction of a difficult laparoscopic cholecystectomy not only helps patient counselling but also helps the surgeon to prepare better for the intraoperative risk and the technical difficulties expected to be encountered. Moreover, the patient safety may further be improved by involving an experienced surgeon both preoperatively in the decision making and also during the surgery.

The ability to accurately identify an individual patient's risk for conversion based on preoperative information can result in more meaningful and accurate preoperative counseling, improved operating room scheduling and efficiency, stratification of risk for technical difficulty, and appropriate assignment of resident assistance, may improve patient safety by minimizing time to conversion, and helps to identify patients in whom a planned open cholecystectomy is indicated

My study was to predict the possibility of conversion of Laparoscopic cholecystectomy to open cholecystectomy before surgery using the clinical and ultrasonographic criteria by multivariate analysis in our Rajiv Gandhi Government General Hospital & Madras Medical College, Chennai.

AIMS OF THE STUDY

The aims of the study is,

1. To evaluate the pre-operative risk factors and to predict the difficulty of Laparoscopic cholecystectomy and the possibility of conversion to open cholecystectomy before surgery

2. To analyse the causes of conversion to open surgery

3. Multivariate analysis of pre-operative risk factors of possible conversion to open surgery

REVIEW OF LITERATURE

Historical Overview

In 1882, Langenbuch performed one of the first cholecystectomies. He was later quoted as saying "the gallbladder should be removed not because it contains stones, but because it forms stones." Surgical removal of the gallbladder thus became the gold standard for management of biliary calculus disease. Although open cholecystectomy had been performed with minimal morbidity and mortality, physicians and patients alike continued to search for alternatives to what became known as a successful but often very painful means of treating gallbladder disease. A variety of approaches were attempted with little success. With the widespread use and success of renal lithotripsy in the late 1970s, physicians began considering applying the same technology to gallstone disease. A large amount of money was spent, and many major institutions committed both resources and people to developing the technology of biliary lithotripsy. Before the technique ever became accepted, however, laparoscopic cholecystectomy was introduced and literally took the world by storm. Many have referred to the acceptance of laparoscopic cholecystectomy as a revolution because of the speed and energy with which the technique was accepted. With the introduction of laparoscopic cholecystectomy, patients were given the option of a treatment that managed their disease definitively without the morbidity of a surgical incision. This revolution has stimulated a growth in new technologies that has been unprecedented in surgical history.Who discovered laparoscopic cholecystectomy is like asking who discovered America. Ultimately, it was a matter of time, technology, and climate in the medical community that brought about laparoscopic cholecystectomy. There had been great effort to search for alternatives to open cholecystectomy. Laparoscopy as a technique had been around for more than half a century and, as of the mid-1970s, was being utilized in gynecology with great success. Many surgeons were attempting to minimize the morbidity of open cholecystectomy by utilizing a mini-lap approach. It was only a matter of time before these efforts were brought together with the introduction of laparoscopic cholecystectomy.

Credit for performing the first procedure is now given to Dr. Erich Muhe of Germany.4 In September 1985 he performed his first laparoscopic cholecystectomy, but his efforts were lost to the world. Because of local politics his efforts were rejected, and Muhe himself was persecuted for his efforts. In 1987, the French surgeon Philippe Mouret performed his first laparoscopic cholecystectomy while performing laparoscopy on one of his gynecology patients.5 Once again, this effort went for the most part unrecognized until a French surgeon from Paris encountered this patient and inquired about her surgery. Dr. Francois DuBois had been extremely interested in finding minimal invasive techniques of performing cholecystectomy and was one of the early authors of papers about mini-lap cholecystectomies.6 Thus, he was extremely interested in this patient and the surgery that she had undergone. Dr. DuBois sought out Dr. Mouret and continued to develop and perfect that technique. In May 1988, Dr. Dubois performed his first laparoscopic cholecystectomy,5 and after presenting his work to his colleagues, awoke interest in France.

INDICATIONS OF LAPAROSCOPIC CHOLECYSTECTOMY

Early reports of laparoscopic cholecystectomy were confined to a small series of selected groups of patients. As a result, much of the early literature lists a variety of contraindications and relative contraindications to the procedure. A number of articles report experience in these “difficult” patients to demonstrate that the laparoscopic procedure can be applied to virtually any patient who is a candidate for an open cholecystectomy. The few contraindications that remain include the following:

1. A contraindication to open cholecystectomy
2. Inability to tolerate a pneumoperitoneum
3. Pregnancy
4. Inexperience of the surgeon

Contraindication to open cholecystectomy includes patients with recent myocardial infarction, inability to tolerate a general anesthesia, and coagulopathies. The inability to tolerate a pneumoperitoneum is difficult to evaluate preoperatively, but if a patient is found at the time of surgery to be in this category, it is possible to continue the procedure without a pneumoperitoneum by using an abdominal wall-lifting device. Pregnancy is a contraindication from a medicolegal standpoint and not from a technical concern. Although there are reports of laparoscopic cholecystectomy in the pregnant patient, there are no studies that demonstrate the safety of a pneumoperitoneum with regard to long-term effects on the fetus.

SURGICAL ANATOMY OF THE GALLBLADDER AND CYSTIC DUCT GALLBLADDER

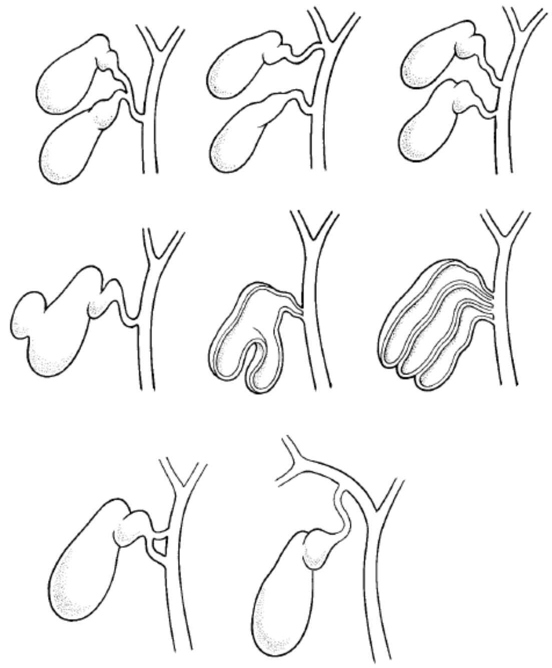
The gallbladder is a pear-shaped, distensible appendage of the extrahepatic biliary system, usually holding 30 to 50ml of bile. It lies in a depression on the inferior, or visceral, surface of the right lobe of the liver.

The position of the gallbladder marks the boundary of the right and left hepatic lobes in the American system. The gallbladder is attached to the liver by areolar connective tissue that contains multiple small lymphatics and veins. These lymphatic and veins connect the venous and lymphatic systems of the gallbladder with those of the liver. Rarely, one or more small accessory bile ducts pass through this tissue to enter the gallbladder directly (ducts of Luschka). In extremely unusual cases, major hepatic ducts might even drain directly into the gallbladder.

Arbitrary definitions divide the gallbladder into fundus, body, infundibulum, and neck. The fundus is the round, blind end of the gallbladder that usually projects about 1 cm beyond the free edge of the right lobe of the liver.The top of the fundus is often at the apex of an angle formed by the right lateral border of the rectus muscle and the ninth costal cartilage. In this position it comes into contact with the anterior peritoneum of the abdominal wall. The fundus becomes palpable in the right upper abdominal quadrant with gallbladder distension. Usually in association with stones or cholestasis, the fundus may become kinked upon itself, an anomaly referred to as a Phrygian cap. Grossly this may look like a fungating mass, but histologically the tissue only contains an abundance of fibrous tissue.

The fundus passes without a demonstrable transition into the body, which constitutes the largest segment of the organ. Unless a mesentery is present, the entire superior surface of the gallbladder body is closely attached to the visceral surface of the liver over the area of the gallbladder bed. This intimate relationship to the visceral surface of the liver easily permits direct spread of gallbladder inflammation, infection, or neoplasia into the parenchyma of the liver. This relationship also permits passage of a cholecystostomy catheter through the liver parenchyma into the gallbladder without spillage. The infundibulum of the gallbladder is the tapering transitional area between the body and neck of the organ. It usually appears as a shallow diverticulum, lying close to the undersurface of the cystic duct, and occasionally obscuring the duct from view. It is attached to the right lateral surface of the second portion of the duodenum by an avascular peritoneal fold called the cholecystoduodenal ligament. The free surface of the body and the infundibulum of the gallbladder also lie in close approximation to the first portion of the duodenum as well as to the hepatic flexure and the right third of the transverse colon.

The infundibulum of the gallbladder rapidly tapers into the neck, which may be narrow and curve upon itself in the form of an “S.” The neck is usually directed superiorly and to the left. It narrows into a sometimes poorly defined constriction at its junction with the cystic duct. The transition between the neck and the cystic duct can be gradual or abrupt. The neck is quite short, usually 5 to 7mm.15 An asymmetrical outpouching of the inferior surface of the infundibulum known as Hartmann's pouch lies close to the neck. It can often be used as a point of traction to provide exposure during cholecystectomy, but it is occasionally adherent to the cystic duct, making the operation difficult. Hartmann's pouch may also trap large gallstones that are unable to enter the neck or cystic duct.



Unusual morphologies of the gallbladder including septations or duplications or even agenesis may occasionally present during laparotomy or laparoscopy . These are all rare anomalies with which the hepatobiliary specialist should be familiar. A septated gallbladder is by definition a bilobar gallbladder with a single cystic duct but two fundi. Duplication of the gallbladder means the presence of two cystic ducts. A double cystic duct draining a unilocular gallbladder has once been described. More frequently encountered anomalies of the cystic duct and gallbladder are intrahepatic gallbladders and a gallbladder within the left lobe of the liver.

CYSTIC DUCT

The cystic duct is the route by which the gallbladder fills and empties its bile. It connects the neck of the gallbladder to the common hepatic duct. In as many as 10% of

cases, a portion of the right hepatic biliary system joins the cystic duct before its junction with the common hepatic duct. Past autopsy studies of this anatomy have been misleading, and most applicable information comes from recent clinical studies involving cholangiography. Generally, the cystic duct is about 4 cm long.The length may vary from 0.5 to 8 cm depending on the site of the gallbladder and the junction with the common hepatic duct. The circumference of the duct varies from 3 to 12mm. The mucous membrane that lines the cystic duct usually has 4 to 10 folds, referred to as the spiral valves of Heister. The valves regulate bile flow, serving to prevent excess distension or collapse of the cystic duct, particularly as intraductal pressure changes. The valves may be extremely tortuous, complicating cannulation during intraoperative cholangiography.

The cystic duct usually runs dorsally, to the right, and inferiorly to the common hepatic duct. The course may be quite tortuous, mimicking other ducts until dissected.

As a general rule, the cystic duct joins the right aspect of the common hepatic duct. The cystic duct may join the common hepatic duct at various angles; be parallel to the right side of the common hepatic duct before entering it; be dorsal to the common duct and enter its dorsal surface; be dorsal to the common duct and enter it from the left side; enter the right or left hepatic duct directly; or join the common duct just before it enters the posteromedial wall of the duodenum. The mode of entrance of the cystic duct into the common hepatic duct may be angular, parallel, or spiral. The angular type occurs in about 80% of people. The angle may vary from a right angle to an acute angle of 10°.With the parallel type of junction, the two ducts may run alongside each other for several centimeters. In such cases, the ducts may be closely adherent and impossible to separate without injuring the common bile duct. The complexity is compounded when a common sheath of dense connective tissue encircles the two ducts. In such cases it is considered safest to leave a long cystic duct stump attached to the common bile duct at the time of cholecystectomy. In the spiral type of junction, which occurs in about 2% of the population, the cystic duct may pass either ventral or dorsal to the common hepatic duct before joining it. Spiral cystic ducts may join on any surface of the common hepatic duct, including the left lateral side.

The variable site of the union of the hepatic and cystic ducts determines the length of the common bile duct. If this union is low, that is, distal within the porta hepatis near the duodenum, the supraduodenal portion of the common bile duct is very short or even absent. If this is the case, the cystic and common hepatic ducts run parallel for a considerable length, causing difficulties during cholecystectomy. The cystic duct may also be very short or absent, in which case the gallbladder may appear to empty directly into the common hepatic duct.

TRIANGLE OF CALOT AND ROUVIERE'S SULCUS

The region known as Calot's triangle differs today when compared to the area described by Calot in 1890 while he was a medical student. He described in his thesis a triangle bordered by the cystic artery, the cystic duct, and the common hepatic duct. The area described today as his triangle is the region bounded by the cystic duct, common (or right) hepatic duct, and inferior border of the liver. The change is thought to have occurred because of the practical use of the larger triangle that helps to frame and identify the cystic artery that lies within it. Recognition of critical structures and dissection within Calot's triangle is of great importance during cholecystectomy, especially at the apex of the triangle. The apex of the triangle contains the cystic artery, as discussed, as well as the right branch of the hepatic artery, 95% of accessory right hepatic arteries, and 90% of accessory bile ducts. An anomalous hepatic artery arising from the superior mesenteric trunk (replaced right hepatic artery) usually courses superiorly in the groove posterolateral to the common bile duct. Therefore, it appears on the medial side of the apex of Calot's triangle, just behind the cystic duct where it is vulnerable to injury during cholecystectomy. Some degree of replacement is thought to occur in up to 10% of patients.

Bile duct injuries during cholecystectomy most frequently occur because of poor exposure of Calot's triangle, leading to confusion between the common hepatic or common bile duct and the cystic duct. Similarly, vascular injuries or significant bleeding that can obscure the dissection can occur if the exposure of this anatomy is inadequate. Multiple styles and techniques are outlined in the literature to expand Calot's triangle to its greatest widths and thus improve exposure of the key structures while attempting to avoid tenting the common duct into the area of dissection. In the end, these various means are all dependent on repetition and the experience of the surgeon to avoid ductal or vascular injuries. Another landmark in this region that can be helpful in identifying the plane of the common bile duct and avoiding injuries during cholecystectomy is Rouviere's sulcus, identified by Rouviere in 1924 as a 2- to 5-cm sulcus lying anterior to the caudate lobe and running to the right of the liver hilum and usually containing the right portal triad. Based on anatomic studies by Couinaud and supported by subsequent laparoscopic cholecystectomy studies, this sulcus is identifiable in approximately 75% of patients and accurately identifies the plane of the common bile duct as substantiated by cholangiogram. Identification of the sulcus requires anterosuperior and leftward retraction of the neck of the gallbladder with exposure and dissection of the posterior hepatobiliary triangle bounded by the neck of the gallbladder, the liver surface, and the plane of the sulcus. Dissection maintained ventral to the plane of the common bile duct, with care taken to identify a possible posterior cystic artery branch or tortuous hepatic artery, is safe even with tenting of the common bile duct.

ANATOMIC CHANGES FROM GALLBLADDER AND BILIARY TREE

In addition to the pathophysiological conditions that necessitate cholecystectomy, there are multiple diseases that can lead to significant anatomic changes important for the hepatobiliary surgeon. Many of these conditions were initially thought to be contraindications to laparoscopic cholecystectomy, but as the laparoscopic surgical experience has grown, so have the indications for laparoscopic cholecystectomy. These situations include acute and chronic cholecystitis, the Mirizzi syndrome, acute pancreatitis, cirrhosis, and other less frequently encountered pathological conditions. Because these diseases are addressed in greater detail further in this volume, the anatomic changes and their clinical significance are briefly mentioned here.

Cholecystitis, as the name suggests, is marked by acute and/or chronic forms of inflammation and fibrosing changes of the gallbladder wall. Both acute and chronic cholecystitis are notable for significant anatomic changes seen at the time of cholecystectomy. The most significant of these findings is the abundance of adhesions surrounding the gallbladder. These adhesions of the gallbladder fossa (and sometimes the entire right upper quadrant, often with omental involvement) make the surgical dissection difficult by obliterating the usually distinct tissue planes as well as making the anatomy in the all-important triangle of Calot difficult to define. At times these adhesions, especially in chronic cholecystitis, can lead to adherence of the gallbladder to the colon, small bowel, or even the stomach. Cholecystoenteric, cholecystocolonic, and cholecystogastric fistulas can form in these conditions and potentially lead to the rare condition of gallstone ileus. This ileus is described as passage through a fistula of a large gallstone that would otherwise be unable to pass into the biliary tree from the gallbladder with subsequent bowel obstruction resulting from stone impaction in the distal ileum or ileocecal valve. In addition to the significance of the pathological adhesions, the friability of the gallbladder due to inflammatory changes (primarily notable in acute cholecystitis) can make retraction impossible and lead to significant incidental cholecystotomies with peritoneal soiling of bile and stones. Retraction difficulty is also seen in empyema with a gallbladder containing pus or in hydrops when the gallbladder distends with mucoid material secondary to outlet obstruction, both necessitating drainage of the gallbladder before it can be grasped for retraction.

The Mirizzi syndrome shows similar anatomic changes due to inflammation as those seen in acute cholecystitis, and it often presents such a difficult problem to the laparoscopic surgeon that conversion to open cholecystectomy is usually necessary. Mirizzi, an Argentinean surgeon, described this syndrome in 1948 as jaundice (and sometimes cholangitis) caused by an impacted stone in the gallbladder neck or cystic duct leading to external compression and obstruction of the common hepatic duct. This definition was expanded to two types in the 1980s. Type I is characterized by common hepatic duct obstruction by external compression (stone, tumor, lymphadenopathy, etc.) whereas type II is obstruction due to stone passage through a cholecystocholedochal fistula resulting from pressure necrosis between the gallbladder or cystic duct and common hepatic duct. Both are very rare, occurring in 0.7% to 1.4% of all cholecystectomies performed, but can have a high occurrence of gallbladder carcinoma (up to 28% of cases). The nature of the condition in both types requires very close proximity of the gallbladder or cystic duct to the common hepatic duct. This proximity, in combination with the significant inflammatory changes in the triangle of Calot intrinsic to the syndrome, makes anatomic differentiation of the ducts difficult during surgical dissection.

Pancreatitis is also known to create anatomic changes affecting the ability to perform laparoscopic cholecystectomy. The most notable anatomic changes do not involve the gallbladder itself but may distort the anatomy of surrounding structures instead. The intense retroperitoneal inflammation and edema that can accompany pancreatitis can have a mass effect on adjacent structures, leading to widening of the duodenal C loop, anterior displacement of the stomach, and duodenal mucosal thickening. These changes in addition to possible intraperitoneal inflammation or fluid collections can make adequate exposure of the gallbladder fossa and Calot's triangle difficult.

Cirrhosis and its anatomic changes may not directly affect the gallbladder but can make the surgical approach difficult. Associated portal hypertension can lead to the formation of varices leading to difficulty with exposure. Among these varices is the umbilical vein, which is open to create collaterals from the left portal vein to the epigastric vessels (caput medusa), and therefore presents a direct obstruction between the umbilical trocar site and the gallbladder during laparoscopic cholecystectomy. The bleeding potential of these and other varices as well as from the gallbladder fossa is the most frequent intraoperative complication during cholecystectomy in cirrhotics. The bleeding risk is further potentiated by the coagulopathy characteristic of the protein synthesis dysfunction caused by the hepatocellular failure of cirrhosis. Another anatomic change caused by the abnormal fibrosis and hepatocellular regeneration found in cirrhosis is the rigidity of the liver, making retraction of the gallbladder and surrounding tissue exceedingly difficult.

Other less common pathophysiological changes of the gallbladder can cause difficulty during cholecystectomy as well. Examples of these conditions include gallbladder diverticula and adenomyomatosis of the gallbladder. Diverticular disease of the gallbladder, similar to that of the colon, includes true and false diverticula. This complication can lead to trouble during resection caused by chronic scarring of the diverticulae to surrounding structures or even intrahepatic diverticulae, necessitating a subtotal cholecystectomy to avoid significant hepatic injury or bleeding. Adenomyomatosis also leads to similar changes of scarring or intrahepatic extensions, making cholecystectomy challenging. It is an acquired disease characterized by localized or diffuse extensions of gallbladder mucosa into, and often beyond, the muscular layer of the wall. Invaginations of the epithelium externally lead to Rokitansky–Aschoff sinuses, also seen in diverticular disease of the gallbladder. Adenomyomatosis has a known increase in occurrence of gallbladder carcinoma whereas no such relationship is noted with diverticular disease.

LAPAROSCOPIC CHOLECYSTECTOMY: THE TECHNIQUE

GENERAL PRINCIPLES

The general principles of laparoscopic cholecystectomy are no different than those that have been established and followed for open cholecystectomy. These basic principles are the key to safe surgery:

1. Gaining safe access to the abdominal cavity.
2. Ensuring adequate exposure before proceeding with the operation.
3. Careful and meticulous dissection with maintenance of hemostasis. No blind clipping or cauterization of bleeding sites.
4. Positive identification of the anatomy before any structure is ligated or divided.

SAFE ACCESS

Multiple techniques exist for accessing the abdominal cavity for laparoscopic procedures. These techniques can generally be divided into those that rely on the blind insertion of either a Veress needle or a trocar and those which rely on a direct cutdown under visual control to access the abdominal cavity (open technique). Once the initial access is achieved, all secondary ports are placed under direct visual control and should be relatively riskfree with regards to hollow organ or major vessel injury. Although there has been much debate on the safety of one technique compared to another, the complication of trocar injury to the retroperitoneal structures, such as the great vessels, can be nearly eliminated by the routine use of an open technique. In special circumstances when an open technique is precluded by large amounts of scarring in the midabdomen, a Veress needle technique can be used to gain safe access in either the right or left upper quadrant.

ADEQUATE EXPOSURE

It is hard to match the exposure that can be achieved with the laparoscopic approach, and this is perhaps the reason that laparoscopic cholecystectomy was accepted by physicians as quickly as it was by their patients. The surgical dictum that you can only operate on what you can see remains a guiding principle of laparoscopic surgery. Once safe access to the abdominal cavity is achieved, the exposure obtained depends on certain techniques that will assure the surgeon the best possible view. Exposure is facilitated by the inherent 16X magnification of the laparoscope, the liberal use of angled laparoscopes, appropriate port positioning, optimal patient and table position, and familiarity with the relevant anatomy. Technical hindrances include an inadequate or dysfunctional light source, broken fiber optics, camera malfunction, inadequate insufflation, fogging, bleeding, and poorly placed ports.

DISSECTION AND MAINTENANCE OF HEMOSTASIS

Rigorous attention to hemostasis is paramount to good exposure because relatively small amounts of bleeding can obscure the laparoscopic view. Laparoscopy is a visual procedure, and what you cannot see you cannot safely dissect. The best way to maintain hemostasis is to prevent bleeding through careful dissection and judicious use of pressure, coagulation energy and vessel ligation. Electrocautery, argon beam coagulation, laser, bipolar cautery, and ultrasound (harmonic scalpel) are all forms of coagulation energy that have been used successfully during laparoscopic cholecystectomy. Occasionally, multiple forms of energy are used in the same operation when the need dictates. The type of energy utilized by the surgeon is a personal choice and is dictated by the availability of the technology and the familiarity of the surgeon with that technology. If bleeding does occur, the source should be clearly identified before making any attempt to stop it. Blind clipping and coagulation should not be practiced because this can result in injury to important structures (i.e., common duct). Suction should be employed when needed, and irrigation should be used freely. Irrigating with a heparin-containing irrigation solution helps to clear a bloodstained field by keeping the blood fluid and therefore easy to aspirate.

IDENTIFICATION OF THE ANATOMY

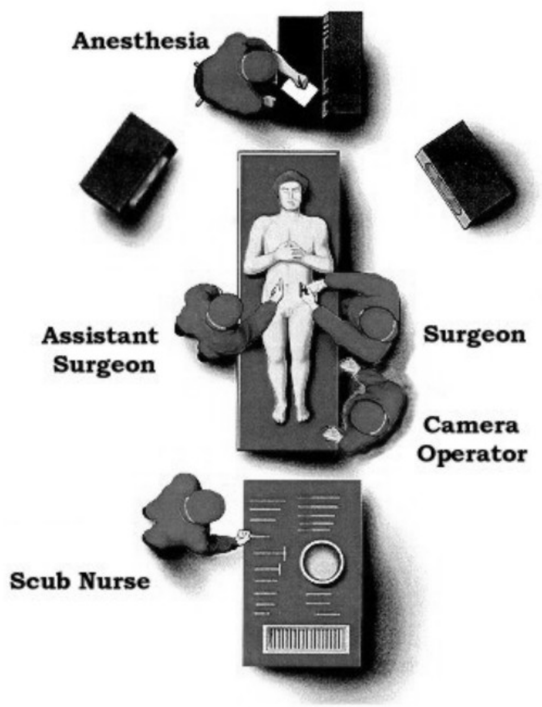
Biliary anatomy is consistent only in its variability. Even the routine, elective cholecystectomy can harbor a myriad of aberrancies in biliary anatomy. Further, the acutely inflamed gallbladder can result in gross distortion and contraction of the normal (or aberrant) anatomy. Absolute identification of the anatomy of the porta hepatis and triangle of Calot before ligation of any structure is the only safe way to reduce the risk of inadvertent injury, particularly to the common bile duct. No structure should be ligated or divided until it is clearly identified. If the anatomy cannot be clearly identified, then the surgeon is obliged to convert the procedure to an open technique, wherein the addition of tactile sense can sometimes help in further dissection and identification of the anatomy. With cholangiography techniques, open conversion is rarely required but should be kept as an option for particularly challenging cases.

GENERAL TECHNIQUE

THE WORKSPACE

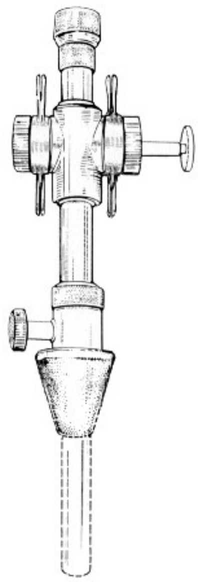
The operating room is organized as shown in Figure . Preoperative setup should include ensuring the availability of potentially needed instruments, the use of a bed that permits either static films or real-time C-arm fluoroscopy for cholangiography, and a systems check of the video, insufflation, and cautery units. The value of the ability to recognize and solve or troubleshoot problems that arise with this equipment cannot be overstated. The patient can be in the supine or lithotomy position, per surgeon preference.The primary and slave monitors must be positioned accordingly to maintain a direct line of vision for the surgeon.

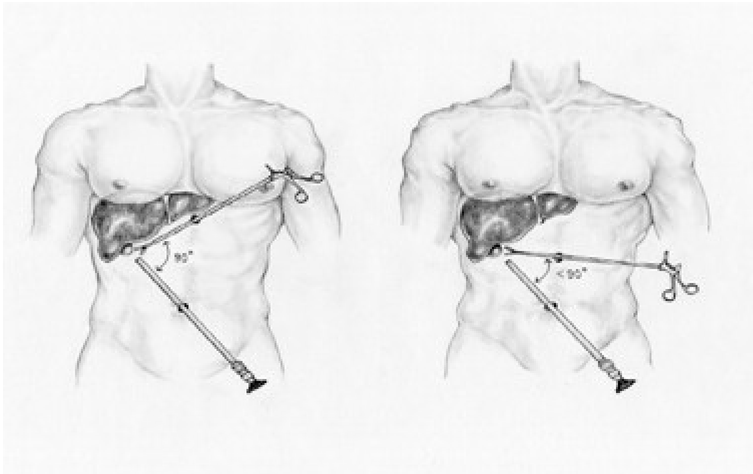
ACCESS



Although many access techniques are still generally accepted, the routine use of an open technique should reduce the risk of major trocar injuries. Trocar injury to a hollow viscus or to major vessels are two of the more serious complications of laparoscopic access and remain the second and third most common reasons that a lawsuit is brought against a laparoscopic surgeon. The major advantage of an open technique is the elimination of impaling injuries that occur when a sharp trocar is inserted too far and catches either bowel or a major retroperitoneal vessel between the sharp tip and the spine.These injuries are particularly treacherous, because they are more likely to be overlooked by the surgeon when gaining the initial access.

Open access is initiated with a 1.0 to 1.5-cm incision made in the vertical midline at the inferior border of the umbilicus. The subcutaneous tissues are separated with blunt dissection utilizing a hemostat. The umbilical raphe is identified as the thickened tissue extending down from the umbilicus to the anterior fascia. This raphe is grasped with a towel clamp as close to the anterior fascia as possible. With obese patients, a hand-over-hand technique with two towel clamps may be necessary to get down to this level. This maneuver will bring the anterior fascia up into the wound to give access for the surgeon to proceed with the fascial cutdown. A small incision in the fascia is made with a scalpel, just large enough to introduce the cannula to be used. Care should be used to try and catch the underlying peritoneum in the incision. Gentle spreading with a hemostat generally allows obvious access into the abdominal cavity under direct vision. If there is obvious tissue under the initial cutdown from underlying adhesion, then the surgeon has the option of abandoning this technique and utilizing a Veress needle technique in the right upper quadrant. The type of cannula that is chosen is the surgeon’s preference. A classic Hasson-type trocar can be used, which allows a larger fascial incision to be made without compromising the seal around the cannula to maintain the pneumoperitoneum. When using the Hasson-type trocar, a single, untied, 0-vicryl suture is placed through each side of the fascia. These sutures are used as fixation sutures for the Hasson trocar, which is equipped with anchoring sites for these sutures. If a larger fascial incision was created, resulting in a persistent air leak, the inferior and superior fascial edges can be sutured with a single interrupted stitch or with a figure-of-eight suture to reduce the diameter of the fascial defect through which the cannula passes. An alternative to the Hasson trocar is





a standard trocar cannula, using fascial sutures to seal around the cannula. Once the pneumoperitoneum is established, the secondary ports are placed with the aid of a 5-mm telescope. The telescope is then switched to one of the accessory ports, and the 5-mm cannula at the umbilicus is switched over to a 10-mm cannula under direct laparoscopic control. The larger 10-mm cannula seals the peritoneal incision.

TROCAR PLACEMENT

The first step in adequate laparoscopic exposure is that of proper trocar position. Once initial safe trocar access is achieved at the umbilicus, the placement of the accessory trocars can make a significant difference in the surgeon's ability to see the tissues and area of dissection. The most critical of these trocar positions is the operating port, which is placed in the epigastrium. This trocar should be placed as high in the epigastrium as possible so that the angle between the instruments and the axis of the camera is at its maximum (see Fig); this allows the surgeon to see the tips of the dissecting instruments and clip applier much easier than if passed along the viewing axis.

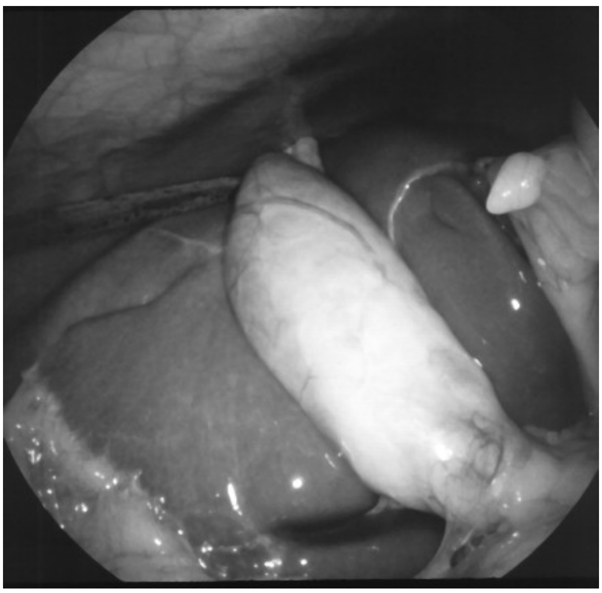
Caution must be used to place the trocar at or below the edge of the liver. Because the falciform ligament fixes the liver at this location, elevating the liver will not compensate for a trocar that is placed too high, as is the case with the lateral trocars. This epigastric cannula can be either 5 or 10mm, depending on the instrumentation available to the surgeon. Two 5-mm trocars are placed laterally just below the costal margin, one along the midclavicular line and the other along the anterior axillary line (see Fig). Even when the patient's liver extends below the costal margin, the edge of the liver is ultimately elevated, and with the high position of the 5-mm trocars, the surgeon has better leverage to manipulate the tissues for exposure.The placement of these lateral trocars is not as critical as the epigastric trocar, but the improved ability to manipulate and elevate the tissues does aid in gaining the best optimum exposure.

TABLE POSITIONING

Gravity is the surgeon's friend during laparoscopic surgery.With the pneumoperitoneum that is created, elevating the head of the table in a steep reverse Trendelenburg position allows the omentum and transverse colon to fall down toward the pelvic cavity. Because the liver is attached to the diaphragm, the liver along with the biliary structures remain in the upper abdominal cavity. A slight rotation of the table to the left will further draw the organs away from the right upper quadrant. This rotation also allows the surgeon to operate in a more comfortable position.

EXPOSING THE PORTA HEPATIS

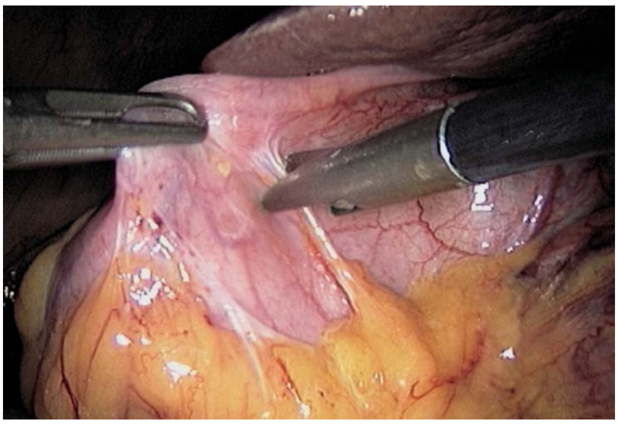
The ultimate ability to gain exposure with laparoscopic cholecystectomy lies in the ability of the surgeon to grasp the gallbladder and elevate the right lobe of the liver, exposing the gallbladder and the porta hepatis. With a normal liver, the liver is literally folded back onto itself within the space created by the pneumoperitoneum,giving an exposure that is literally a textbook view; this is achieved by grasping the fundus of the gallbladder with an atraumatic grasper placed through the lateral 5-mm trocar cannula and lifting and elevating the fundus over the liver edge (see Fig). Care must be taken to release any adhesions to the gallbladder or liver that may prevent this elevation. Often the elevation needs to be achieved in steps. As the adhesions are released, additional traction is applied to gain successively more



elevation, until maximum exposure has been achieved. This end goal is best obtained by grasping the very tip of the fundus. If the liver is thickened from fatty infiltration, edema, or cirrhosis, and an effective folding over of the liver cannot be achieved, the surgeon must rely on the simple lifting of the liver, best achieved by grasping the gallbladder more midbody and simply lifting straight up toward the anterior abdominal wall as opposed to up and toward the diaphragm (see Fig). The gallbladder is grasped down the body even more if additional lift is required.

With proper lift, exposure of the porta hepatis is completed by grasping Hartman's pouch and applying downward and lateral traction with a grasper placed through the midclavicular 5-mm trocar cannula. This maneuver helps to reestablish the normal angle between the cystic duct and the common bile duct that is closed with the upward traction applied to the gallbladder.

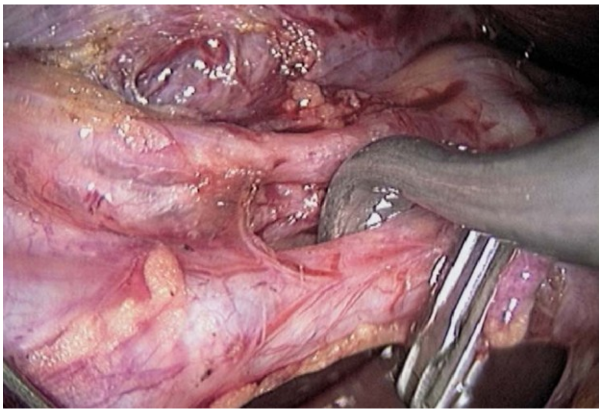
Cephalad traction on the gallbladder distorts the normal anatomic relationship between the cystic duct and common bile duct and can lead to



confusion in identification of the anatomy. By reestablishing a more normal angle between the cystic duct and the common bile duct, the surgeon is more able to identify and correctly dissect out the neck of the gallbladder. Care must be taken to not grab the gallbladder too close to the neck. If this occurs, the surgeon can pull the structures in the hepatoduodenal ligament into the operative field, causing tenting of the common bile duct and possibly leading to inadvertent dissection and transection of the common bile duct . This inadvertent misidentification of the common bile duct as the cystic duct is the most common type of bile duct injury seen during laparoscopic cholecystectomy.

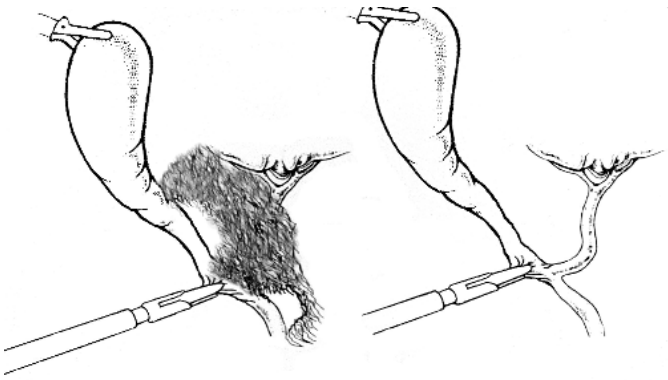
DISSECTION OF THE TRIANGLE OF CALOT

The triangle of Calot is defined by the cystic duct, the common hepatic duct, and the cystic artery. Proper dissection and exposure of these structures assures proper identification of the anatomy.



Dissection of cystic duct

A too vigorous dissection in the triangle of Calot can, however, lead to bleeding that is not only difficult to control laparoscopically but also dangerous. To avoid this possibility, the initial dissection is initiated on the lateral aspect of the triangle of Calot, that is, the cystic duct. Dividing the lateral peritoneal attachments of the infundibulum from the liver allows mobilization of the infundibulum. Dissection down the lateral aspect of the infundibulum allows identification of the lateral margin of the cystic duct. With this landmark identified, dissection is then carried out on the medial margin of the infundibulum. As the infundibulum is further mobilized, the neck of the gallbladder will begin to appear. Blunt dissection at the neck allows the surgeon to encircle the cystic duct. The dissection is continued until clear demonstration



of the infundibular–cystic duct junction is achieved (see Fig). This dissection must be circumferential and complete to ensure that no ductal structure is hidden in the tissues behind the area of dissection. With this landmark identified, the dissection is carried down the cystic duct a sufficient distance to allow instrumentation or ligation of the cystic duct. Isolation of the cystic artery is best achieved up on the infundibulum of the gallbladder. Not only does this minimize the risk of injury to an aberrant right hepatic artery, but if bleeding occurs during the dissection, the bleeding can be controlled with less risk to the ductal structures.

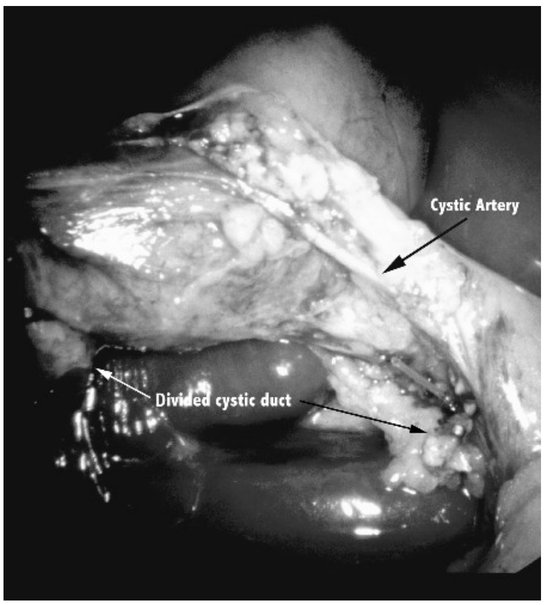
By keeping the dissection and identification of the anatomy high up near the neck of the gallbladder, the surgeon can minimize possible injury to the biliary tree. Coagulation energy should be used to a minimum in this area to avoid inadvertent injury to adjacent structures. Careful, gentle blunt dissection can usually define the appropriate plane of dissection without significant bleeding. With the cystic duct exposed, a cholangiogram is performed if desired. Cholangiography can give full detail of the ductal anatomy, not only to help identify incidental common bile duct stones but also to aid in the identification of the anatomy

LIGATION OF THE CYSTIC DUCT AND ARTERY

After the cholangiogram has been performed and the cholangiogram catheter is removed, the cystic duct is clipped with two proximal clips, placed just below the incision in the cystic duct used for the cholangiogram. The clip applier is placed through the epigastric port, and the clip should be inspected as it is placed to verify that it completely traverses the cystic duct before deployment. Once doubly clipped proximally and singly clipped distally, the cystic duct can be divided with scissors at the cholangiogram site. As with placement of the clips, it is important to visualize the tips of the scissors before cutting the duct to avoid inadvertent injury to structures behind the duct.With the cystic duct ligated and divided, upward traction on the neck of the gallbladder facilitates exposure of the cystic artery high on the neck of the gallbladder, making it quite easy to isolate, ligate, and divide (see Fig). Occasionally a posterior branch of the cystic artery must be ligated separately, particularly if it has a proximal site of origin. The artery must clearly be identified as supplying the gallbladder before ligation. Most cystic arteries can be seen not only to enter the gallbladder but also to branch along the gallbladder wall as they travel from the infundibulum to the fundus.

MOBILIZATION AND REMOVAL OF THE GALLBLADDER

Mobilization of the gallbladder is accomplished with an appropriate energy source. The choice of the energy source is the surgeon's preference. The dissection proceeds from the infundibulum to the fundus. The assistant's grasper retracting the fundus upward, the remaining liver attachments holding the gallbladder inward, and a grasper placed on the infundibulum of the gallbladder



retracting the neck outward away from the liver provide the essential traction and countertraction to facilitate the dissection. This traction–countertraction is of paramount importance in the mobilization of the gallbladder, by not only exposing the plane of dissection but also by placing those tissues that need to be divided under tension, facilitating their division. The left hand of the surgeon, which controls the infundibular grasper, retracts the infudibulum cephelad at first, exposing the posterior gallbladder wall as it lies in its bed. The infundibular retraction is then alternated between medial and lateral positions to expose and place the lateral and medial sides of the gallbladder under tension, respectively. The plane between the gallbladder and the gallbladder bed of the liver should be avascular in the uninflamed gallbladder. Bleeding in the routine cholecystectomy at this point often indicates departure from this plane. As the fundus is approached, it is often necessary to regrasp the fundus with the grasper that had been on the infundibulum. With two graspers on the fundus, one medial and one lateral, and the main portion of the gallbladder lying on the anterior surface of the liver, the remaining attachments of the fundus to the gallbladder bed can be divided.

Before dividing the final attachments of the gallbladder, the gallbladder bed should be inspected for hemostasis or bile leakage (from a duct of Luschka). The clips on the cystic duct and artery should be inspected, but not manipulated, to ensure they have not been dislodged during mobilization of the gallbladder. These inspections are facilitated by being performed before completely separating the gallbladder from its bed. Once the gallbladder has been detached, the liver will fall down to its more normal location and the exposure of the gallbladder bed and cystic duct and artery stumps will be obscured. Bleeding from the liver bed usually responds to electrocautery. The presence of biliary leakage from the hepatic bed may warrant placement of a drain.

When the final gallbladder attachments are divided, the gallbladder is placed over the liver. The laparoscope is changed from the umbilical port to the epigastric port, and with a toothed grasper placed through the umbilical port, the neck of the gallbladder is grasped. The gallbladder is brought into the umbilical trocar and the trocar and gallbladder are removed together, under direct vision. The fixation sutures must be released before removing the trocar if a Hasson cannula has been used. The gallbladder neck, once seen outside the abdomen, is grasped with a Kelly clamp to facilitate its complete extrusion. Alternatively, if there has been spillage of bile, or if the patient had acute cholecystitis with a tense or fragile gallbladder, the gallbladder can be placed in a retrieval bag before removal. The fascial incision may need to be extended if the gallbladder is thickened and does not pass through the site comfortably. If there are multiple or large stones that preclude extraction of the gallbladder, they can be crushed within the gallbladder and removed with the aid of a stone forcep. The forcep can be passed through the neck of the gallbladder before removal of the gallbladder.With the gallbladder decompressed of the stones, it can usually then be extracted. If not, a fascial extension may be required. If a retrieval bag is used, the neck of the bag is brought through the fascial opening in a similar fashion with its opening exiting through the fascial defect. Ringed forceps can then be used to remove the gallbladder and stones.

THE DIFFICULT GALLBLADDER

ACUTE INFLAMMATION

Acute cholecystitis was originally believed to be a relative contraindication to a laparoscopic approach to cholecystectomy. Although the conversion rate is higher (25% compared to 2%), laparoscopic cholecystectomy can be performed safely in the face of acute inflammation.

It is important to differentiate between the patient with early acute cholecystitis (<24h) and the patient who has been symptomatic for more than 48 to 72h. Performing laparoscopic cholecystectomy in the early period greatly improves the chance for a successful, uncomplicated removal of the gallbladder. As the disease and the degree of inflammation progress, the technical difficulty increases. At greater than 48 h, the amount of edema, adhesion formation, scar, distortion of the normal anatomy, and increased vascularity greatly increases the difficulty of the procedure. This greater difficulty forces the possibility for conversion to open cholecystectomy to avoid added risk of complications.

So long as the basic principles (as previously outlined) are followed, a safe laparoscopic cholecystectomy can be achieved. The problem arises when a surgeon is unable to adhere to these principles and does not know when the threshold for conversion to an open approach has been reached. The surgeon must know their own limitations. The basic technique of laparoscopic cholecystectomy with acute inflammation is the same as for an elective, nonacute cholecystectomy, with some modifications.

ACCESS

Safe access to the abdomen is usually not hindered by the presence of acute gallbladder inflammation. If the state of inflammation is advanced, the patient can have a degree of intestinal ileus, but safe access to the abdominal cavity should still be achievable without significant difficulty. The distended or tense gallbladder may be physically palpated and can often vary from its usual subhepatic location. Rarely does this finding prompt altering the trocar sites, or interfere with safe access so long as the surgeon avoids a right upper quadrant (RUQ) primary puncture.

EXPOSURE

Adequate exposure may be hindered by a very distended gallbladder. Furthermore, a tense or thick-walled gallbladder may resist grasping or may be too fragile to be grasped safely. Such a gallbladder warrants decompression before exposure of the triangle of Calot. An aspirating needle can either be placed through the right upper lateral port or passed via a percutaneous approach to drain the gallbladder. The needle can be attached either directly to the suction tubing or to a syringe. The gallbladder is pierced with the aspirating needle in the region of the top of the fundus. An assisting grasper may be required to provide stabilization or countertraction for the penetrating needle. If the contents of the gallbladder are too thick to be aspirated through this needle, an alternative approach is to insert the 5-mm RUQ midclavicular trocar into the fundus of the gallbladder so a 5-mm suction/irrigator can be advanced into the gallbladder. Carefully, the gallbladder is gently irrigated and suctioned out. The hole in the fundus of the gallbladder is then closed with an endoscopic ligature before proceeding with the cholecystectomy. Additional trocars are rarely required, although the surgeon should never hesitate if their use means allowing adequate exposure to carry out a safe procedure. If the inflammation is exceptionally intense, an additional 5-mm port in the left flank can occasionally be of benefit to allow passage of an instrument to help retract a distended transverse colon with a thickened phlegmasous omentum.

An exceptionally thick-walled gallbladder can be difficult to grasp with the usual laparoscopic grasper and often requires an aggressive toothed grasper. If a 5-mm version of this instrument is not available, converting one of the lateral 5-mm trocars to a 10-mm port allows the use of larger, stronger instruments. Percutaneous sutures can also be used to retract the gallbladder by placing a suture (such as 2-0 prolene) transcutaneously, into the abdomen, and then laparoscopically through the area of the gallbladder to be retracted, then back through the abdominal wall. These sutures can be tightened and secured (untied) outside the abdomen with a hemostat. Exposure of the triangle of Calot is often difficult in the setting of acute inflammation. The tissue planes are edematous, distorted, and often prone to bleeding. This inflammation causes scarring with contraction of the gallbladder and adjacent structures, distorting the anatomy and making the dissection treacherous and dangerous. Dissection must proceed deliberately and cautiously. All structures must be identified before manipulating, cauterizing, or ligation.

HEMOSTASIS

Although hemostasis should always be meticulously maintained, the acute inflammation causes generalized bloody oozing that obscures exposure. The routine use of heparin (5000 units/liter) in the irrigating fluid allows the blood to be continuously irrigated clear and easily aspirated from the operative field, allowing for an unobstructed view. Bleeding points should be identified, grasped, retracted away from adjacent structures, and then cauterized, clipped, or sutured. Bleeding whose source cannot be clearly identified should not be subjected to blind cautery or clipping. Pressure can be applied by pressing the infundibulum of the gallbladder on the bleeding site either directly with a grasping forceps or with a 4 ¥ 4 sponge introduced through one of the 10-mm ports. Pressure often controls the bleeding enough to allow proper exposure and identification of the source of bleeding. Bleeding that persists, that is excessive, or whose source cannot be clearly identified should prompt consideration of conversion to open cholecystectomy.

IDENTIFICATION OF THE ANATOMY

Identification of the cystic duct and cystic artery can be difficult. Acute cholecystitis may be associated withenlargement of the node of Calot, which can serve as a landmark for identification of the cystic duct and artery. This lymph node is located overlying the cystic artery, or duct, near the infundibulum of the gallbladder. Dissection in this region should always begin lateral to the node and close to the gallbladder, remaining high in the cystohepatic triangle. Early dissection near the junction of the cystic duct and the common bile duct should be avoided. Early cholangiography should be performed to provide a roadmap before extensive dissection and certainly before ligation of any structure. Misidentification of the common bile duct as the cystic duct is frequently cited as a cause of inadvertent transection of the common bile duct.

In those cases where clear identification of biliary ductal anatomy cannot be achieved either through an anatomic dissection or cholangiography, an attempt at removing the gallbladder in a retrograde fashion can be made before converting the patient to an open procedure. Occasionally, cholecystography can be helpful in delineating the neck of the gallbladder before further dissection in this area. The anatomic relationships of the cystic artery may be also be distorted and on occasion absent due to thromboses from the inflammation. It is therefore beneficial to leave the identification of the cystic artery until after the cystic duct has been identified, ligated, and divided. Upward traction on the neck of the gallbladder after the cystic duct has been divided allows identification of the cystic artery high up on the neck of the gallbladder. Taking this care helps avoid inadvertent injury to either a right hepatic artery that may have been pulled up into the triangle of Calot due to the inflammation or an aberrant right hepatic artery that lies naturally in this location but is obscured by the inflammation, making it difficult to identify. Both these situations are potentially hazardous and, therefore, only structures that clearly supply the gallbladder should be ligated.The presence of a posterior branch of the cystic artery should always be considered. Of utmost importance is a low threshold for conversion to open cholecystectomy if the anatomy cannot be identified.

MOBILIZATION AND REMOVAL OF THE GALLBLADDER

Once the anatomy is identified and the cystic duct and cystic arteries ligated and divided, the gallbladder is excised from the liver bed. It is very beneficial to place all inflamed gallbladders in a specimen bag for removal. Not only is the inflamed gallbladder usually damaged by dissection and prone to spilling material during extraction, but as the gallbladder is involved with acute inflammation and likely infected its removal in a specimen bag reduces possible trocar site infection. Additionally, with the neck of the specimen bag exteriorized, morcellation of a thickened inflamed gallbladder can ease the extraction without extension of the fascial incision.

COMPLICATIONS OF LAPAROSCOPIC CHOLECYSTECTOMY

BILE DUCT INJURY AND LEAK

The most feared complication of laparoscopic cholecystectomy is a bile duct injury. Due to the tenuous axial blood supply of the extrahepatic biliary tree, injury in this area carries significant morbidity.7,8 In addition, complex and variable anatomy often makes recognition of an injury difficult, especially for many general surgeons who infrequently explore the porta hepatis and hepatic hilum. Furthermore, the public's high expectations for rapid discharge and recovery make these complications particularly distressing in light of their possible long-term implications. The bile duct injury during laparoscopic cholecystectomy has forced surgeons to rethink the idea of minimally invasive surgery and has tested their conceptions of informed consent.

GENERAL CONSIDERATIONS

Successful management of bile duct injuries depends on the type of injury, prompt recognition of a problem, complete definition of the anatomy, and multidisciplinary expert intervention. When an injury is recognized in the operating room, several principles should be followed:

(1) conversion to an open procedure,

(2) hepatobiliary consultation,

(3) close attention to anastomotic tension and blood supply, and

(4) drainage or exclusion of the repair.

If a patient appears ill or fails to completely recover following what appeared to have been a routine laparoscopic cholecystectomy, the surgeon should obtain blood work and perform appropriate imaging studies. Interventionists from gastroenterology and radiology should be involved early and recognized as an integral part of the treatment team; percutaneous and endoscopic methods of defining biliary and vascular anatomy and accomplishing drainage are paramount to successful outcome. Surgeons practicing in communities without specialist support or extensive experience in complex biliary surgery certainly should consider transfer of the patient to a tertiary referral centre.

BILIARY INJURIES WITH ASSOCIATED VASCULAR INJURY

The right hepatic artery is at risk during laparoscopic cholecystectomy, as it appears in the triangle of Calot 82% of the time and may therefore be mistaken for the cystic artery and thus ligated. It may also be inadvertently injured while attempting to control hemorrhage during the course of dissection. Bleeding encountered during laparoscopic surgery should be addressed by tamponade, the isolation of the bleeding vessel, and precise clip or ligature placement; if these maneuvers are unsuccessful, conversion is indicated. This factor emphasizes the importance of identifying the cystic artery, following its course to the gallbladder wall, and ligating it close to the gallbladder, even if this entails ligating anterior and posterior branches of the cystic artery separately. The right hepatic artery, in addition to supplying well-oxygenated blood to the right lobe of the liver, perfuses the common

duct from above whereas the gastroduodenal or right gastric artery supplies the duct from below. Therefore, a transection of the common duct in conjunction with a right hepatic artery injury may create ischemia in the proximal common or hepatic duct. This compound injury makes primary repair of a duct injury particularly hazardous and supports a generous proximal debridement before an anastomosis of any kind.

In addition to the possibility of duct leakage and stricture formation after such an injury, the portion of liver drained by this duct is also at risk for necrosis and abscess formation, which may necessitate hepatic resection or even transplantation in extremely rare circumstances. Alternatively, patients may present with hemobilia. Surgeons who are referred patients for biliary reconstruction with stricture, hepatic necrosis, or abscess should review prior operative notes and query the primary surgeon specifically with regard to intraoperative bleeding. Preoperative angiography is indicated if there is suspicion of vascular injury, whether by history, chart review, or the presence of multiple clips in a “shotgun” pattern on Xray(see fig).

RISK FACTORS AND PREVENTION OF INJURY DURING LAPAROSCOPIC CHOLECYSTECTOMY

Several studies have documented risk factors to assess the likelihood that a biliary injury will occur. While “no surgeon is immune and no case should be considered routine,” considering these factors could help surgeons determine what additional maneuvers can to lessen risk. Risk factors for biliary injury during laparoscopic cholecystectomy include aberrant anatomy, adhesions, acute or chronic inflammation, hemorrhage, and perhaps inexperience of the surgeon. Obesity, a predictor for conversion to laparotomy, does not appear to be a risk factor for bile duct injury, though this has been argued.

Dissection in the triangle of Calot is dangerous if aberrant anatomy of the extrahepatic biliary system and vasculature is not considered. More than two-thirds of biliary complications of laparoscopic cholecystectomy result from a misinterpretation of the anatomy with or without a cholangiogram. This finding indicates that emphasis has been placed on identifying the cystic duct–common duct junction but not on defining the entire course of the cystic duct and its entrance into the gallbladder; in fact, visualizing the cystic duct–common duct junction is not entirely necessary. Several anatomic variants deserve mention in discussing injury potential during laparoscopic cholecystectomy. First, as previously mentioned, is the cystic duct that drains into the right hepatic duct; this variant should be considered every time the cystic duct–common duct junction is identified to avoid injury to the right hepatic duct. A second variation is the cystic duct that parallels and is attached to a main duct. Traction on the Hartman pouch toward the right lower quadrant, correctly used to "open the angle" between the cystic and hepatic ducts, can "tent" such a duct and lead to injury. A cholangiogram can be helpful, and cautery should be avoided. The third variant is a cystic duct that travels posterior to the common duct before joining it on the left side; therefore, one cannot assume, when two ducts are visualized, that the one on the right is the cystic duct. Dissecting close to the gallbladder and staying away from the porta hepatis is the rule; a retained stone in a long cystic duct remnant is rarely problematic. Finally, the presence of a "sessile" gallbladder or short cystic duct can lead to injury, as can the situation in which the gallbladder is fibrosed to the common bile duct or common hepatic duct. In such situations, clips or loops may not be appropriate and may end up impinging upon the common duct; an endoscopic stapling device has been advocated for this use,61 but this is an extremely dangerous anatomic variant, and unless the stapler can be placed clearly away from the common duct, laparotomy is warranted.

Another risky anatomic situation is found with Mirizzi's syndrome, seen in less than 1% of laparoscopic cholecystectomies. Extrinsic compression of the hepatic duct by a cystic duct calculus with associated inflammation puts the hepatic duct at tremendous risk of injury during dissection of the triangle of Calot, especially if a fistula between the ducts has formed. Therefore, dissection of this triangle is contraindicated when this syndrome is present.64 Because the syndrome is often not recognized (preoperatively or intraoperatively), a high index of suspicion is required to institute preventive measures. If the syndrome is recognized preoperatively (shrunken, atrophic gallbladder; jaundice; dilated duct; suggestion of compression on cholangiogram), initial therapy should be endoscopic, and definitive therapy should be via laparotomy. If the syndrome is recognized intraoperatively, the surgeon should strongly consider converting to laparotomy. Also, a cholangiogram should be performed (through the gallbladder if possible), and if this is nondiagnostic, intraoperative ultrasound may aid in delineating the anatomy. Furthermore, the fundusdown technique should be considered, as should opening the gallbladder to extract the stone. Moreover, a partial cholecystectomy may be necessary, leaving behind a densely adherent portion of the gallbladder wall; rarely, a biliary–enteric bypass may be indicated.

Adhesions and inflammation can also add to the difficulty in performing a safe laparoscopic cholecystectomy. Much has been written about optimal timing of cholecystectomy in a patient with acute cholecystitis, and it has been shown that laparoscopic cholecystectomy can be performed safely in the setting of acute cholecystitis, particularly if it is done early in the course of the disease. There is probably an increased rate of bile duct injury in this setting, however, and the threshold to perform a cholangiogram or convert to open surgery must be adjusted accordingly.

As with any dissection, there is a time and place for electrosurgery. Although most bowel injuries incurred during laparoscopic surgery are caused by trocars, electrical burns also account for many injuries. Several points are to be considered in decreasing the incidence of electrical injury. First, before use, instruments should be inspected for defects in insulation (courts have not exonerated surgeons for equipment failures).Second, electrosurgery should never be used outside the visual field, and only those electrosurgical generators equipped with a return electrode monitoring system should be used. Third, laparoscopic port cannulas should be either all metal or all plastic to prevent capacitive coupling of energy to surrounding structures, and other metal instruments should be kept clear of the cautery to prevent arcing. Finally, to minimize the potential for capacitive coupling when performing electrosurgical dissection, one should favor the use of "cutting" current, reserving "coagulation" current for surfaces requiring electrical fulguration. Pulling clear adhesions and peritoneum off the body of the gallbladder after brief pulses of current is acceptable, whereas simultaneous dissection and coagulation is not. Monopolar cautery should be discouraged in the triangle of Calot and should never be used near unidentified structures. Alternative devices such as bipolar and harmonic instruments are less convenient and sometimes more expensive but may lessen the risk of certain injuries.

PATIENTS AND METHODS

My study was conducted in the Department of general surgery, Rajiv Gandhi Government General hospital, Chennai for a period of 9 months from april 2012 to November 2012.

My study was to analyse the multiple possible riskfactors for conversion of laparoscopic cholecystectomy to open surgery in our hospital as a multivariate analysis which helps to study on the per-operative prediction of laparoscopic cholecystectomy conversion to open surgery.

One hundred cases of planned elective laparoscopic cholecystectomy was targeted and studied prospectively in the our department.

SELECTION OF SUBJECT

All consecutive patients planned for elective laparoscopic cholecystectomy for benign gallbladder disease in Department of general surgery, Rajiv Gandhi Government General hospital were selected for the study.

EXCLUSION CRITERIA

Patients with evidence of concomitant choledocholithiasis were excluded from the study pre-operatively. Patients who were planned for open cholecystectomy were also excluded.

DESIGN OF STUDY

Prospective analysis on consecutive patients planned for elective laparoscopic cholecystectomy.

STUDY POPULATION

101 patients planned for elective laparoscopic cholecystectomy and proceeded

METHODS

The following materials were evaluated in each patient before surgery

1. Clinical data
2. laboratory data
3. Ultrasonographic parameters

The following material were evaluated for the patients who had a conversion from laparoscopic cholecystectomy to open surgery on the operating table

- Per-operative Indicaton for conversion

Sixteen characteristics were evaluated including the following main characteristics for statistical analysis

1. Age
2. Sex
3. Body mass index
4. Pre-operative diagnosis
5. Total leucocyte count
6. Serum alkaline phosphatase
7. Serum albumin
8. Gall bladder wall thickness
9. Pericholecystic fluis
10. Per-operative indication for conversion

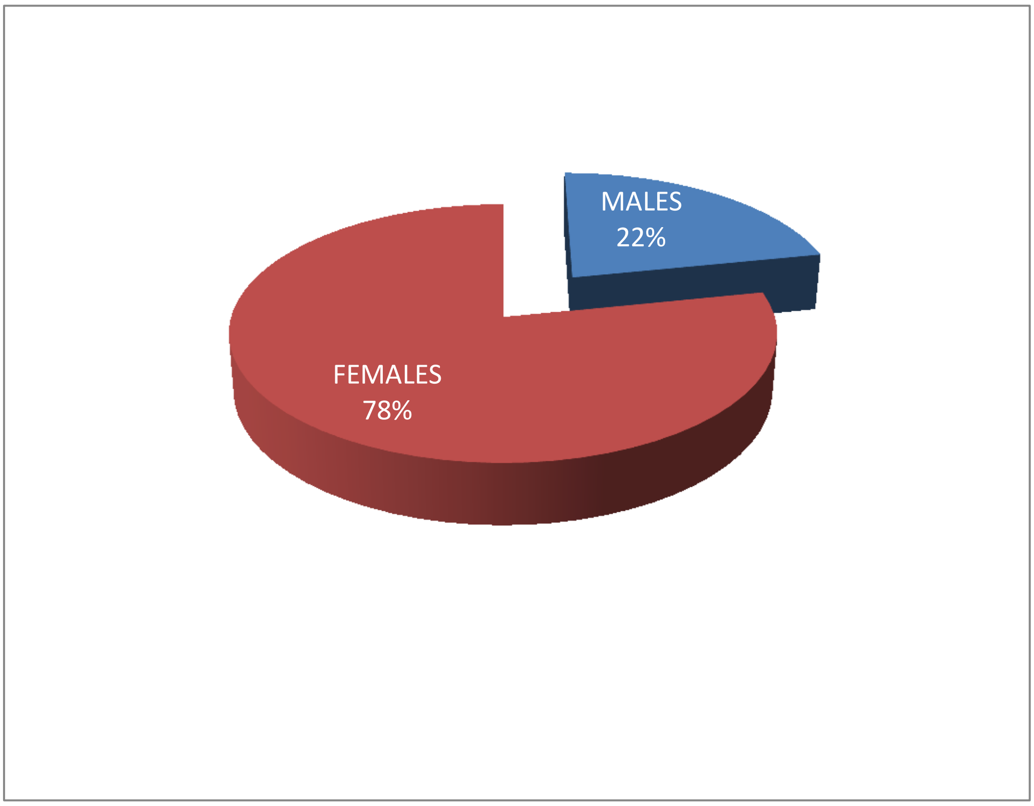
RESULTS

A total of 101cases were studied during the period of APRIL 2012 TO NOVEMBER 2012.

SAMPLE SIZE - 101 (n=101)

Sex distribution

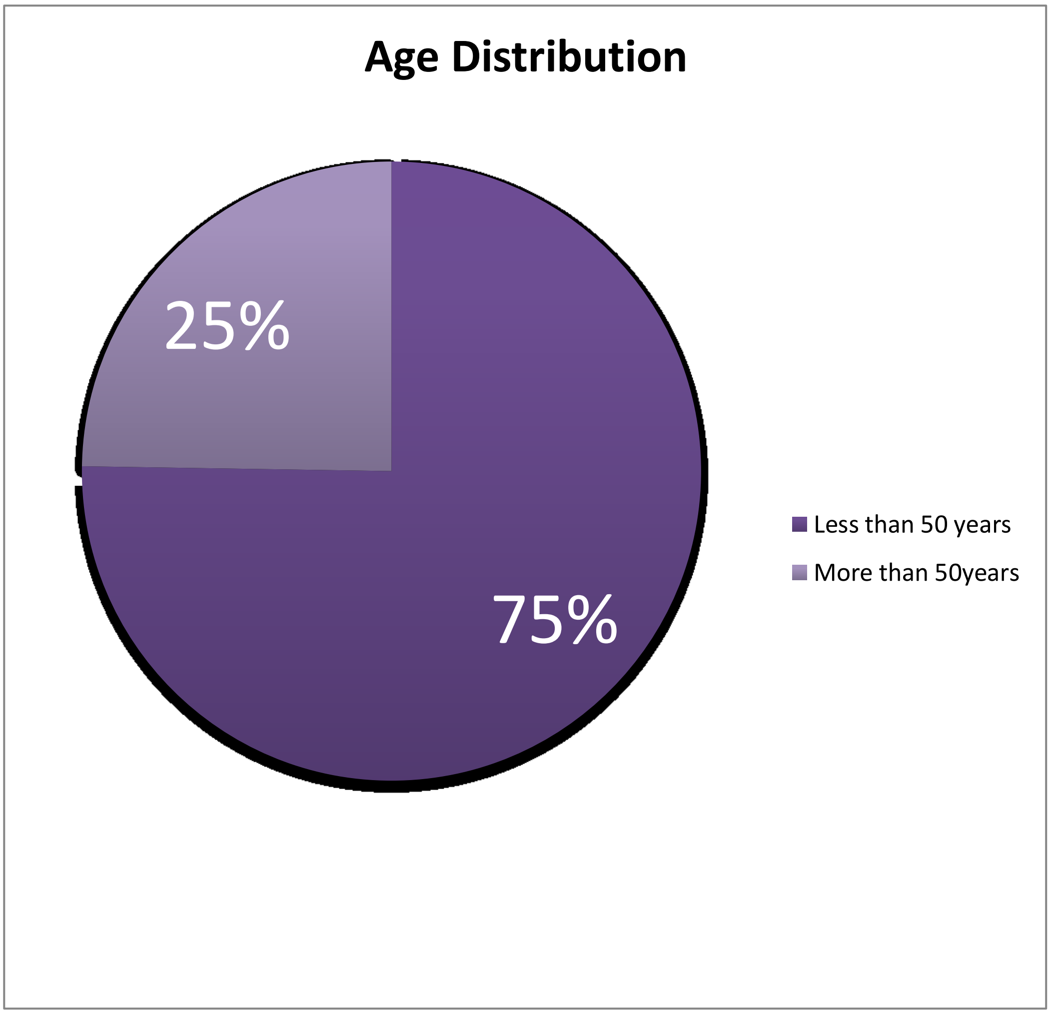
Sex	Frequency	Percent	Valid Percent	Cumulative Percent
Male	22	21.8	21.8	21.8
Female	79	78.2	78.2	78.2
Total	101	100.0	100.0	



AGE GROUP - 13 TO 73 YEARS

MEAN AGE OF SAMPLE - 42.98 Years

Age in years	Frequency	Percent	Valid Percent	Cumulative Percent
Upto 50	76	75.0	75.0	75.0
Above 50	25	25.0	25.0	25.0
Total	101	100.0	100.0	



A total of 101 patients met the inclusion criteria. Laparoscopic cholecystectomy was attempted on all 101 patients. The patient characteristics of our study population are listed in Table 1 below.

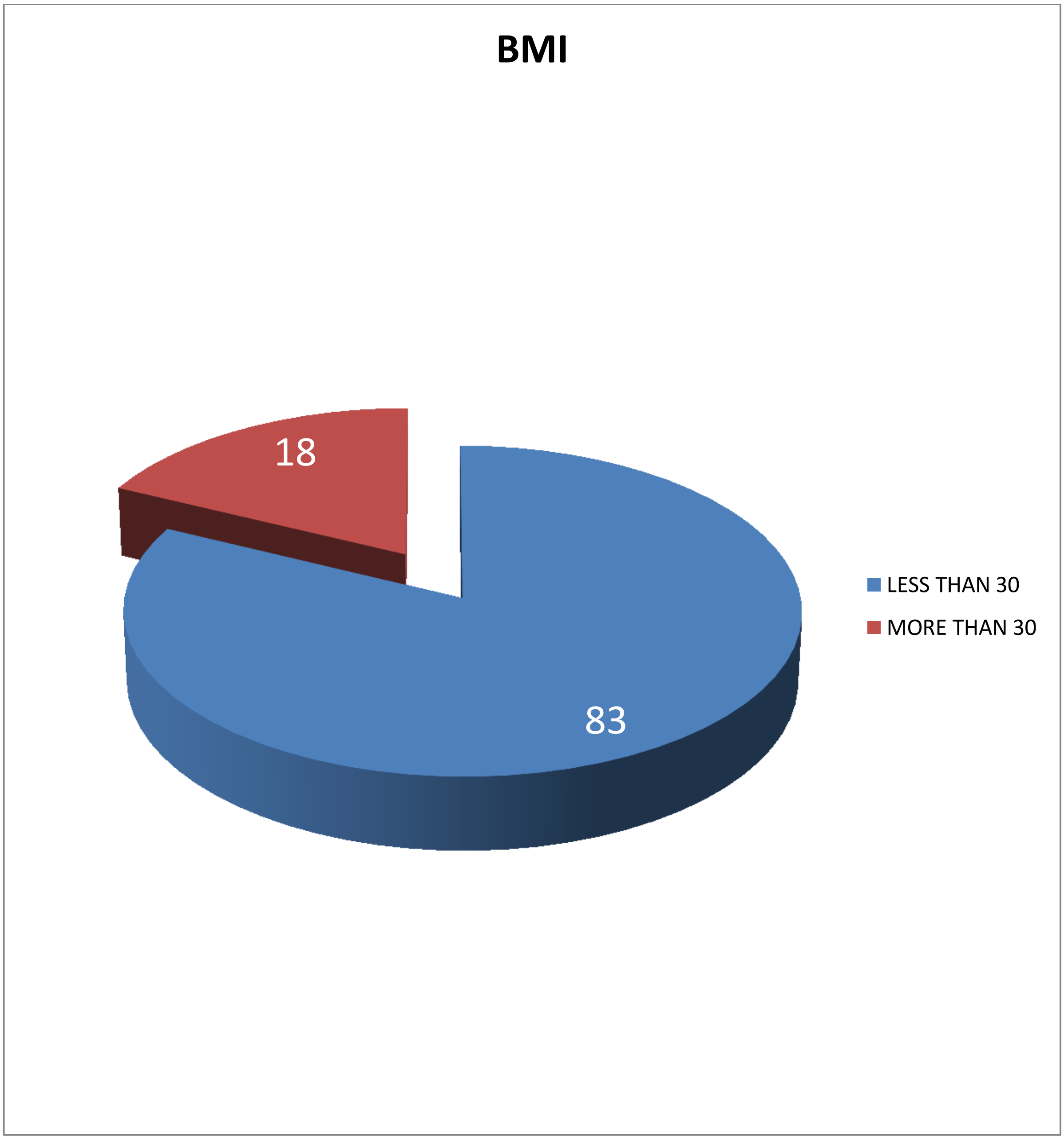
Table 1

Variable	**n**	**%***
Female	79	78
Mean age	42.98	± 20.02
Age > 50 yrs	76	75
Obese	18	18
Pre-operative diagnosis		
Chronic cholecystitis	74	74
Acute cholecystitis	16	16
Low albumin	1	1
Elevated WBC count	2	2
Elevated alkaline phosphatase	1	1
Elevated bilirubin	2	2
Pericholecystic fluid on usg	4	4
Co-morbidity		
Diabetes mellitus	18	18
Previous abdominal surgery	23	23
Thickened gallbladder	12	12

**Expressed as valid percent where denominator is number of patients with available data.*

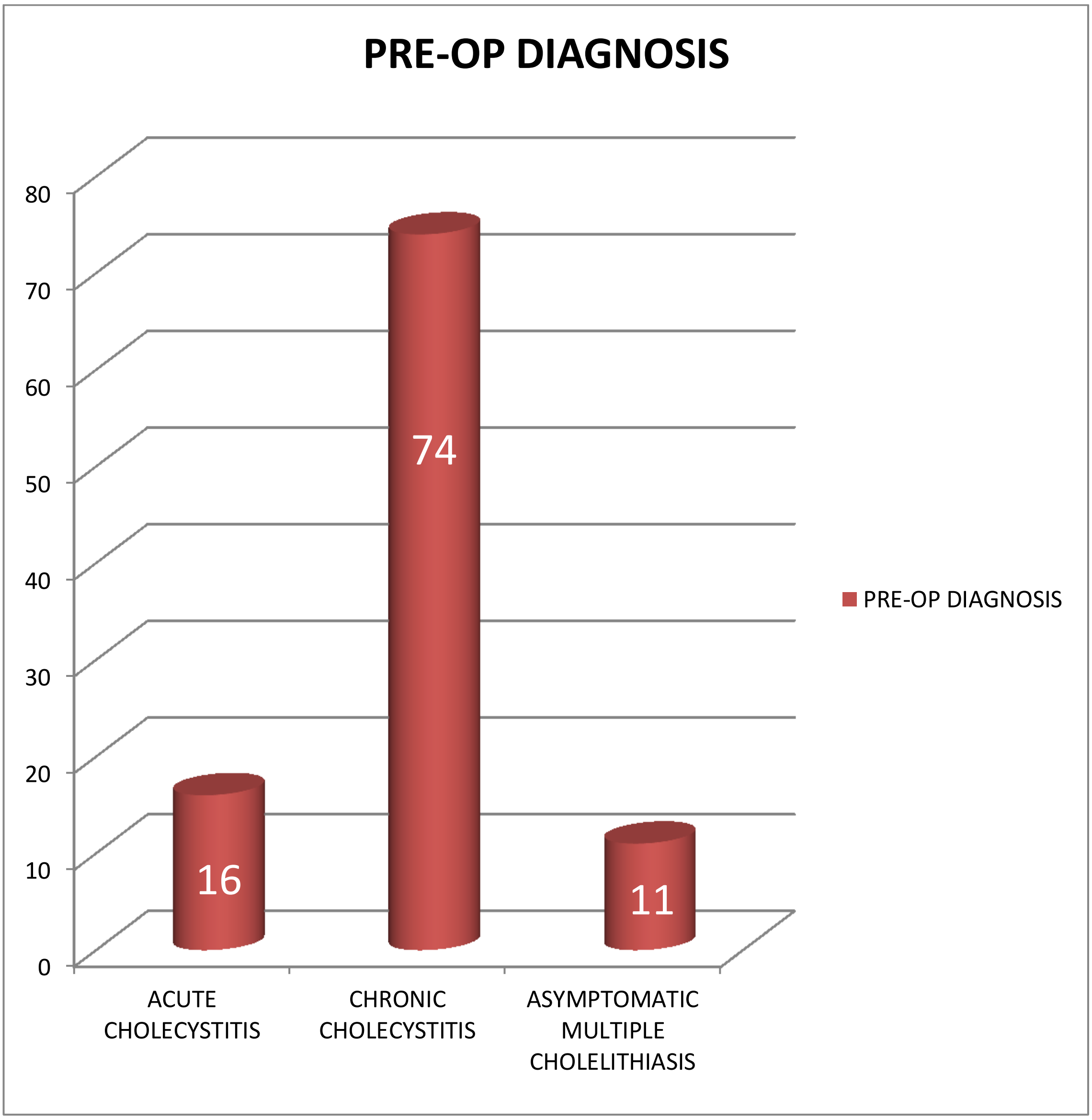
OBESITY

Of all the subjects, the body mass index above 30 who are obese were 18 patients representing 18%.



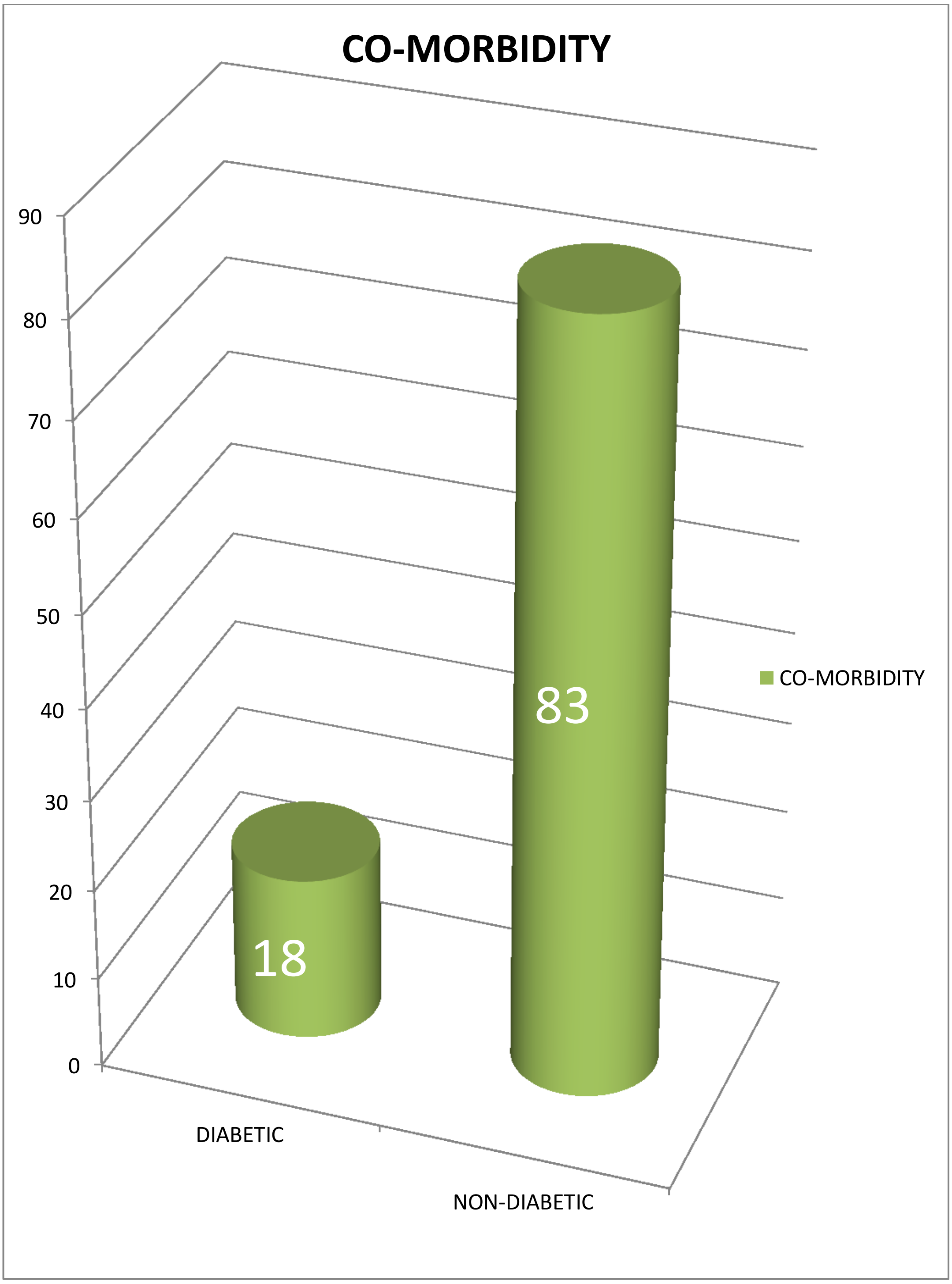
PRE-OP DIAGNOSIS

16% of the patients were diagnosed as acute cholecytitis pre-operatively and 74 patients evaluated as chronic cholecytitis. The rest of the 11 patients were asymptomatic but with multiple calculi on ultrasound**.**

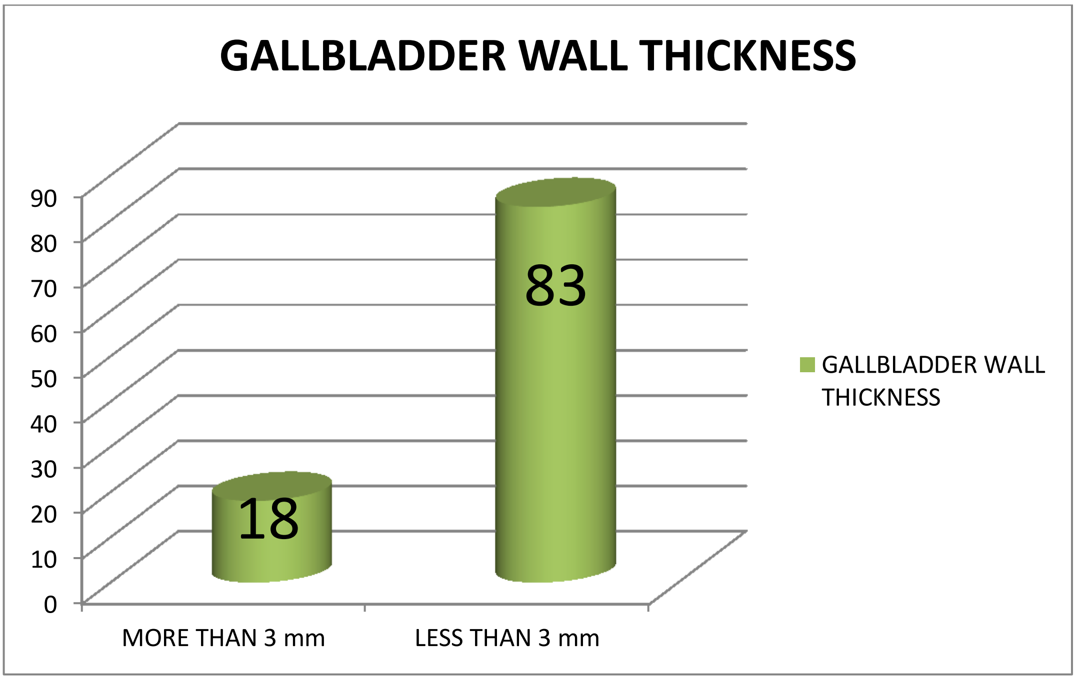


CO-MORBID ILLNESS

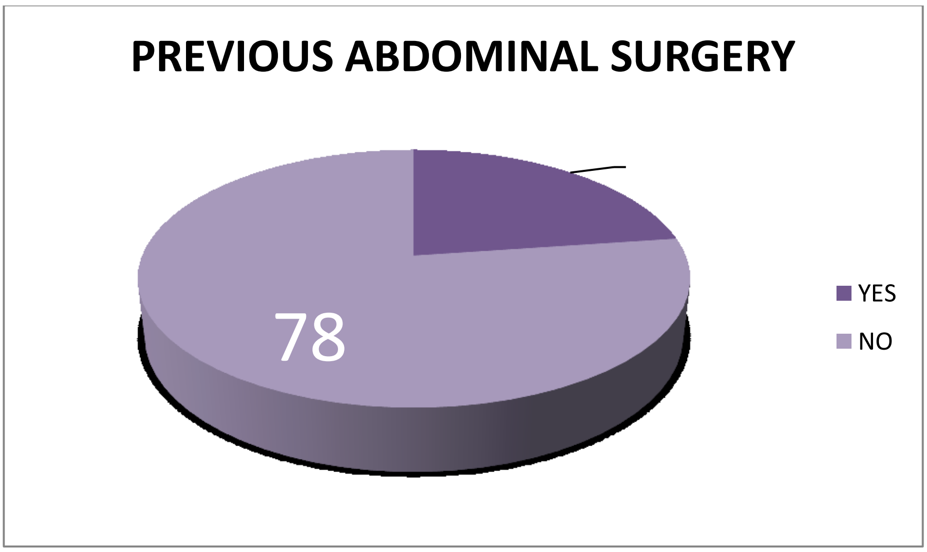
We evaluated a single co-morbid illness, diabetes mellitus as a possible risk factor. 18 patients were diabetic and on treatment.



18 patients were on ultrasound found to have a thickened gallbladder i.e wall thickness more than 3 mm on ultrasonogram.



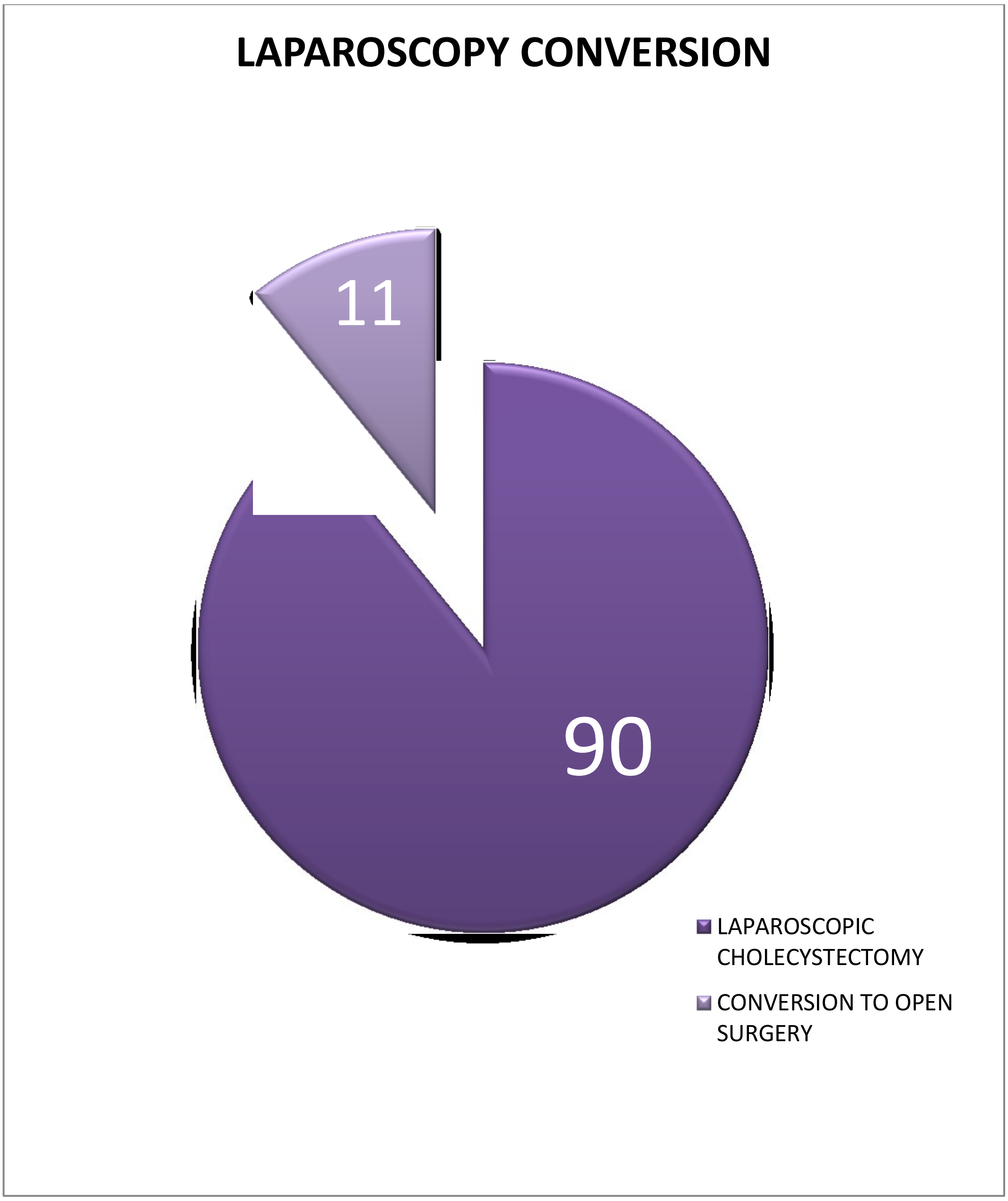
23 patients had a previous history of abdominal surgery most common being puerperal sterilisation. Second common being abdominal hysterectomy in females.



CONVERSION RATE

11 patients underwent conversion of laparoscopic cholecystectomy to open cholecystectomy due to several indication.

Percentage = 10.89%



BIVARIATE ANALYSIS

preoperative parameters were evaluated for their effect on conversion from laparoscopic to open cholecystectomy and 6 parameters were significant on bivariate analysis (Table II).

Table II. Bivariate analysis of laparoscopic and converted patients

factor	Laparoscopic n	Converted n
female	68 (86.11%)	11(100%)
Age >50 yrs	23 (25.5%)	2 (18.2%)
Diabetes mellitus	14 (15.5%)	4 (36.4%)
Acute cholecystitis	16 (17.8%)	2 (18.2%)
Elevated ALP	0	1
Low albumin	0	1
Thickened gallbladder	14 (15.5%)	4 (36.4%)
Elevated WBC	2	2 (18.2%)
Elevated total bilirubin	2	0
Pericholecytic fluid	2	2 (18.2%)

ALP, alkaline phosphatase; WBC, white blood cell count

MULTIVARIATE ANALYSIS

Logistic regression analysis demonstrated that female gender, elevated WBC, ultrasound findings of pericholecystic fluid and thickened gallbladder ,and the presence of diabetes mellitus, were independent predictors of conversion (Table III). All 5 factors were more frequently identified in patients who had a diagnosis of acute cholecystitis.

Table III. Factors independently predictive of conversion to open cholecystectomy on multivariate analysis

Factor	**Odds ratio**	**95% confidence interval**	**P value**
Female	2.2704	1.1373 to 4.5325	0.0201
Elevated WBC	3.9268	0.5369 to 28.7201	0.1779
Diabetes mellitus	1.2605	0.3905 to 4.0691	0.6986
Thickened gallbladder	1.5048	0.4736 to 4.7810	0.4884
Pericholecytic fluid	3.3636	0.4476 to 25.2792	0.2385

CAUSES OF CONVERSION

Eleven patients (10.89%) required conversion to open cholecystectomy. The most frequent reasons for conversion were adhesions inflammation and unclear anatomy

Table IV. Reasons for conversion to open cholecystectomy

Reason	**n (%)**
Adhesions	6
Inflammation	2
Unclear anatomy	2
Injury	1
CBD stones	0
Multiple reasons	0

CBD – Common bile duct

Intraoperative complications occurred in one patient, which was common bile duct injury and converted to open cholecystectomy. No patients died of those had laparoscopic cholecystectomy but one patient died who had conversion. Death was due to infection in that patient. No deaths occurred as a result of intraoperative complications.

DISCUSSION

Conversion from laparoscopic to open cholecystectomy is required when safe completion of the laparoscopic procedure cannot be ensured. The identification of parameters predicting conversion improves preoperative patient counseling, provides for better perioperative planning, optimizes operating room efficiency, and helps to avoid laparoscopic- associated complications by performing an open operation when appropriate.

Our results demonstrate that female gender, elevated WBC, ultrasound findings of pericholecystic fluid and Thickened gallbladder are associated with conversion to open cholecystectomy. No subjective variables were included in an effort to improve the predictive value of our results. Conversion rates did not decline significantly during the study period. Our analysis was performed during a "steady state" of laparoscopic cholecystectomy.

Preoperative and intraoperative factors that predict or contribute to conversion have been evaluated previously, but no consensus has emerged. A recent review by Tang and Cuschieri5 identified 109 publications addressing this issue over 15 years. Among these studies, 4 scoring systems have been developed to predict conversion to open cholecystectomy.

These scoring systems have demonstrated variable and conflicting results and are affected by a small number of factors evaluated, inclusion of subjective variables, and collection of data early in the experience of laparoscopic cholecystectomy. None of these systems has been widely incorporated into surgical practice. Furthermore, the only study to be validated prospectively had a negative predictive value of 100%, but the positive predictive value was only 43%.

Our model predicted conversion to open cholecystectomy based on 5 easily obtained parameters. To facilitate the clinical application of this information, however, a reasonable estimate of risk was made based on the number of factors identified. For example, a patient with 2 risk factors has an approximate conversion risk of 12.5%. A range of risk actually exists based on which factors are present owing to differences in the odds ratios of each parameter. A patient with 4 risk factors has an estimated risk for conversion of 50%. Thus, depending on the situation, an approximation or more precise calculation of risk can be derived.

The presence of acute cholecystitis has been shown to predict conversion to open cholecystectomy. In our analysis, the preoperative clinical diagnosis of acute cholecystitis was a significant predictor of conversion on bivariate and multivariate analyses. Despite the availability of ultrasound and leukocyte count to assist with the clinical diagnosis of acute cholecystitis, there was a poor correlation with the pathologic findings; therefore, we excluded it from the multivariate analysis. Our data demonstrate that patients with the constellation of clinical symptoms typically associated with acute cholecystitis do not always demonstrate the pathologic findings to support the diagnosis. To our knowledge, the correlation be-tween the preoperative clinical and pathologic diagnosis of acute cholecystitis has not been evaluated previously. All 5 factors that independently predicted conversion to open cholecystectomy were found significantly more frequently in patients with pathologic diagnosis of acute cholecystitis. The objective parameters identified by this analysis provide a more accurate prediction of the rate of conversion than the clinical suspicion of acute cholecystitis.

women have been identified to have a greater incidence of conversion to open cholecystectomy than men. The etiology of this association is unclear. Inflammation and dense adhesions are frequently cited as reasons for conversion in women.

The association between an elevated WBC and conversion has been reported previously. This parameter likely reflects the inflammatory response associated with more acute diseases and is more commonly present with acute cholecystitis.

Pericholecystic fluid results from the translocation of fluid from the surrounding tissues owing to severe inflammation of the gallbladder. This factor has been previously demonstrated to predict conversion.

In our series, pericholecystic fluid and gallbladder thickness of more than 3 mm was the radiographic finding predictive of conversion. Acute cholecystitis was 7 times more common among patients with pericholecystic fluid on ultrasound.

Diabetic patients undergoing laparoscopic cholecystectomy have been found to have significantly increased rates of conversion as well as intraoperative and postoperative complications. The reason for the greater conversion rate in this group of patients is unclear. One explanation may be the presence of more severe inflammation among diabetic patients with acute cholecystitis compared with nondiabetics. Because of autonomic and peripheral neuropathy, some diabetic patients may not develop symptoms of gallbladder disease until later in the course of their illness.

We evaluated the effect of obesity. Neither parameter was found to have an increased risk for conversion. Obesity has been previously identified as a risk factor for conversion. The previously identified association between obesity and conversion may be due to the propensity for obese patients to develop diabetes mellitus. The lower conversion rates among obese patients in our study may also be attributed to the greater experience in the laparoscopic management of patients with this condition.

Others have demonstrated that previous upper abdominal operations increase the risk for conversion to open cholecystectomy. This may be due to increased adhesion formation. It is possible that our analysis did not demonstrate this to be a risk factor for conversion because of the overwhelming common lower abdominal surgeries in women.

All injuries were treated at operation and there were no missed injuries. No patients died of those had laparoscopic cholecystectomy but one patient died who had conversion. Death was due to infection. It is difficult to compare mortality rates between reports without adjusting for risk.

CONCLUSION

Although our study has favorable characteristics to predict conversion from laparoscopic to open cholecystectomy, it has some limitations. Our results are based on prospective data alone. We did not assess the impact of symptom duration on conversion rate. We chose not to include this factor in our analysis because of its subjective nature and the inherent inaccuracies associated with estimating the time of symptom onset. However, the duration of symptoms may be associated with the degree of inflammation encountered at operation and thus would influence the conversion rate. We also did not evaluate the time from hospital admission to operation. Patients with longer hospital stays before operation may have more severe inflammation; however, the time from symptom onset to operation is likely to correlate with conversion rates. It is possible that the utility of this model is that its parameters more accurately predict the diagnosis of acute cholecystitis.

For patients with a high predicted rate of conversion, it may be advantageous to proceed with open cholecystectomy. This would negate the potential for trochar injuries, problems due to pneumoperitoneum, and other complications specifically associated with laparoscopy. A high presumed risk for conversion was frequently cited as a reason for the use of a planned open approach. Because patients undergoing open cholecystectomy were not included in our analysis, the complication rate in patients who had conversion to open operation may be lower than would have been seen if all cholecystectomies were initially approached laparoscopically.

Our results demonstrate that an accurate and easily derived estimation of risk for conversion from laparoscopic to open cholecystectomy can be obtained from readily available preoperative data. Recognizing when a patient is at increased risk for conversion would improve preoperative counselling and assist with appropriate allocation of resources in the operating room, may increase safety by limiting delay in conversion to open cholecystectomy, and can identify patients who might benefit from a planned open approach. If validated, this prediction system may improve patient outcomes by reducing unnecessary injuries related to laparoscopy that is unlikely to succeed.

PROFORMA

CLINICAL DATA

NAME :

AGE :

SEX : MALE / FEMALE

COMORBID DISEASE :

-DIABETES MELLITUS : YES / NO

PREVIOUS ABDOMINAL SURGERY : YES / NO if yes,__________________

BODY MASS INDEX : > 30 kg/m2 / < 30 kg/m2

PRE-OPERATIVE DIAGNOSIS : ACUTE CHOLECYSTITIS / CHRONIC CHOLECYSTITIS / OTHER(if any) ______________________________________

LABAROTORY DATA

TOTAL LEUCOCYTE COUNT :

TOTAL SERUM BILIRUBIN :

SERUM ALKALINE PHOSPHATASE :

SGOT :

SGPT :

SERUM ALBUMIN :

ULTRASONOGRAPHIC PARAMETERS

GALL BLADDER WALL THICKNESS : < 3 mm / > 3mm

PERICHOLECYTIC FLUID : YES / NO

NUMBER OF CALCULI :

CALCULUS SIZE :

COMMON BILE DUCT DIAMETER :

LIVER PARENCHYMA : NORMAL / FATTY INFILTRATION / LIVERFIBROSIS

PROCEDURE : SUCCESSFUL LAPAROSCOPIC CHOLECYSTECTOMY / CONVERSION TO OPEN CHOLECYSYECTOMY

if conversion proceeded,INDICATION FOR CONVERSION :

ADHESIONS :

INFLAMMATION :

ABNORMAL ANATOMY :

INJURY :

COMMON BILE DUCT STONES :

OTHER / TECHNICAL :

MULTIPLE REASONS :

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