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# ANATOMY APPLIED TO CHOLECYSTECTOMY

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**Abstract**: Cholecystectomy is the surgical removal of the gallbladder, being recommended mainly in cases of cholecystitis and gallbladder neoplasms. Gallbladder removal surgeries have been described for about a century in the medical literature. [1], the techniques currently used are laparotomy or laparoscopy. The latter is the least invasive technique and is considered the gold standard, but laparotomy is important in cases where adequate medical equipment is not available, in urgent cases and when laparoscopy is not indicated. The risks of postoperative complications in both procedures are low, influenced by the nature of the surgery, age and the presence of comorbidities in the patient. Complications arising from the surgery itself are around 3.9% for patients undergoing laparotomy and 1.7% for those who opted for laparoscopy, while systemic complications are 5.2% for laparotomy and 1.6 % for laparoscopy[19].
**Keywords**: Laparoscopic, Cholecystectomy.

## INTRODUCTION

Cholecystectomy, which consists of the surgical removal of the gallbladder, is an operation that dates back to the 19th century. In 1882, Carl Langenbuch performed the first cholecystectomy[1] surgery, through laparotomy, a technique that persisted as the main technique in performing cholecystectomy for more than 100 years, since it was only in the 1980s that a less invasive approach was adopted for the procedure, through laparoscopy, performed in 1985 by the German Erich Mühe [1], although it was not recognized by the German academic community at the time as an effective technique for the procedure. Currently, laparoscopic cholecystectomy is the most commonly performed digestive tract surgery, indicated for the treatment of gallstones (with possible cholecystitis due to the presence of gallstones) and gallbladder neoplasms. In the United States, the prevalence of cases involving gallstones in the adult population is 10 to 15%, while in Europe it is 5.9 to 21.9%[2]. In Brazil, there are few studies that assess the prevalence of this pathology, but a value of 6.4% has already been found in a study carried out with 1000 people in the city of Curitiba. Being female, of indigenous ethnicity and high body mass index (BMI) are the main risk factors for developing gallstones [2].

With regard to neoplasms of the gallbladder, it is a rare condition and ranks fifth among neoplasms of the gastrointestinal tract. Female gender, occurrence of cholelithiasis, indigenous or eastern European ethnicity are important risk factors [2].

Finally, it must be noted that laparoscopic cholecystectomy is still the gold standard of surgery, despite exceptionally considering transgastric and transvaginal access. [1].

## GOALS

2.1. Carry out a systematic review on the topic "Anatomy Applied to Cholecystectomy";

2.2. Discuss the main anatomical aspects relevant to clinical practice, as well as related surgical procedures;

2.3. Present semiological analysis applied to the diagnosis of conditions that lead to surgery.

## METHODOLOGY

With the intention of preparing a systematic review on the subject, a search for articles was carried out on PubMed and Scientific Electronic Library Online platforms using the keywords "laparoscopic", "cholecystectomy".

Thus, 26 publications were selected, from 2010 to 2020. An analysis of the articles was carried out and the most relevant aspects were addressed in this work.

In addition, the textbook "Gray's anatomy:

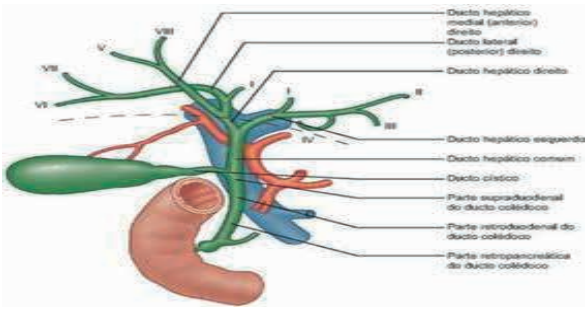
the anatomical basis of clinical practice (40th edition)" was consulted.

## RELEVANT ANATOMICAL ASPECTS FOR CHOLECYSTECTOMY

At first, the most striking anatomical factor of the gallbladder and surroundings is its inconsistency: anatomical variations in different areas are commonly found in patients [3]. Therefore, in the anatomical study of cholecystectomy, special attention must be given to such variations.

### GALL TREE

The biliary tree is the system of vessels and ducts that carry bile from the hepatic parenchyma to the descending part of the duodenum, and is typically divided into intrahepatic and extrahepatic parts[3]. Except for specific cases, the first part is of little relevance to cholecystectomy. The general layout of the biliary tree is illustrated by Figure 1.

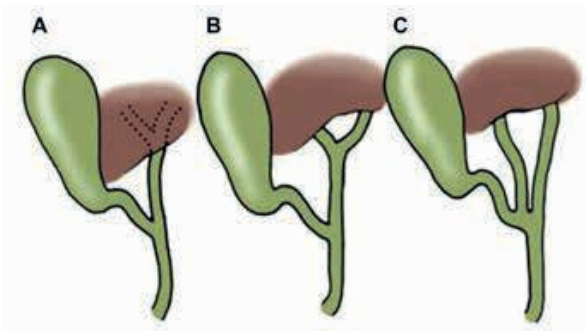



The figure 1 - General arrangement of intrahepatic and extrahepatic biliary trees. There is a schematic simplification of the intrahepatic segmental ducts (I-VIII), which often undergo ramifications before flowing into the main ducts. The dashed line indicates the height of the liver parenchyma.

Picture Taken from: Gray's Anatomy: The Anatomical Basis of Clinical Practice. 40. ed. Rio de Janeiro: Elsevier, 2010.

### EXTRA HEPATIC GALL TREE

The classic extrahepatic biliary tree is composed of short sections of the right and left hepatic ducts, which unite at the common hepatic duct. This receives the cystic duct, coming from the gallbladder, and the union of both gives rise to the common bile duct, which flows into the descending part of the duodenum.[4]. Typically, the confluence of the right and left hepatic ducts occurs beyond the margins of the hepatic parenchyma, near the right end of the porta hepatis, forming the common hepatic duct. However, this phenomenon can undergo important anatomical variations, as shown in Picture 2.



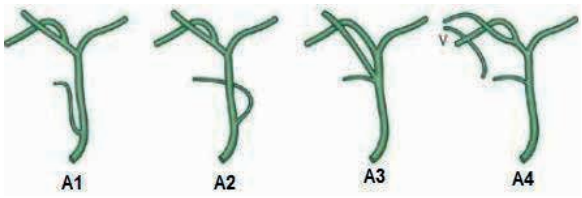

Picture 2 - Variations of the confluence of the right and left hepatic ducts. A: Intrahepatic confluence; B: Typical extrahepatic confluence; C: Atypically low extrahepatic confluence.

Picture taken from Keplinger KM, Bloomston M. Anatomy and embryology of the biliary tract.

Surg Clin North Am. 2014 Apr;94(2):203-17.

The common hepatic duct lies to the right of the hepatic artery, in addition to being anterior to the portal vein on the free margin of the lesser omentum. Its length is variable, depending mainly on the connection point of the cystic duct to it, from where the common bile duct forms[3]. Typically, it is 2.5 to 3.5 cm long, while the common bile duct is 7 to 10 cm long and around 6 mm in diameter in adults. The cystic duct is 2 to 4 cm long and

drains the contents of the gallbladder into the common bile duct.[3]. There are several anatomical variations associated with the cystic duct, the most relevant of which are illustrated in Figure 3.




Picture 3 - Anatomical variations of the cystic duct. A1: low input; A2: Entry from the medial side; A3: Entry shared with the right lateral sectoral duct; A4: Presence of an accessory cystic duct, generating direct biliary communication between the liver and the gallbladder.

Picture taken from: Gray's Anatomy: The Anatomical Basis of Clinical Practice. 40. ed. Rio de Janeiro: Elsevier, 2010.

The common bile duct descends posteriorly and slightly to the left, anterior to the omental foramen, on the right border of the lesser omentum, where it is anterior to the portal vein and passes to the right of both the portal vein and the hepatic artery. Further, it generally runs behind the upper part of the duodenum and the right side of the gastroduodenal artery, and then continues into a groove on the superolateral part of the posterior aspect of the head of the pancreas. It is anterior to the inferior vena cava and, in some cases, is embedded in the pancreatic tissue.[4].

Besides, regarding the common bile duct, it must be noted that it is medium to the descending part of the duodenum, therefore, it approaches the right end of the pancreatic duct. Normally, it penetrates together with the pancreatic duct in the duodenal wall, forming the hepatopancreatic ampulla - which is related to the anatomy of pancreatitis associated with gallstones. These ducts rarely enter the duodenum separately.[4] In this ampulla is located the sphincter of Oddi, a circular muscle responsive to cholecystokinin that controls the entry of bile and pancreatic juice into the duodenum. [4].

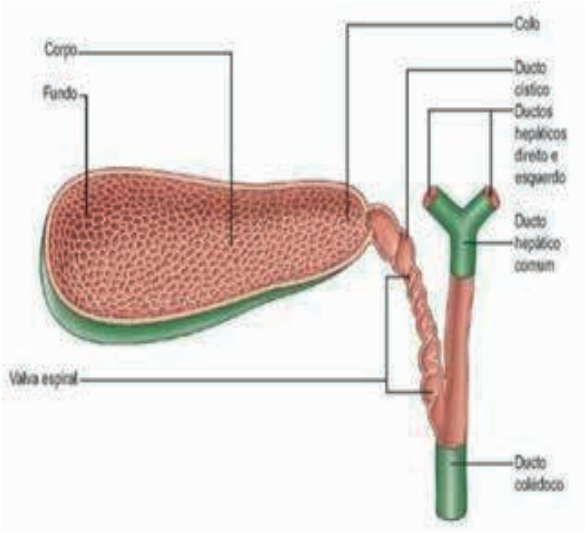
## GALLBLADDER

It is a pear-shaped organ with the primary function of storing and secreting hepatic bile; it must be noted that such a function is not essential for human physiology. In life, it has a blue-gray color, an expected length of 5 to 8 cm and a usual volumetric capacity of 20 to 30 mL, reaching up to about 50 mL in certain situations. Through the bile ducts, it communicates with the liver and the duodenum[4].

It is usually located in a shallow fossa of the hepatic parenchyma, between the square and right lobes of the liver. Anatomically, it is divided into neck, body and fundus. The neck is the most medial part, located close to the portal of the liver, usually attached to it by a short peritoneal connection. Its medial end continues into the cystic duct[4].

The body is the central enlargement of the gallbladder, anterior to the descending part of the duodenum and the right part of the transverse colon, and is usually in contact with the surface of the Liver.

The fundus is the distal part of the gallbladder, located at its lateral end and often projecting beyond the lateral hepatic margin. It is often adjacent to the transverse colon. It is often in contact with the anterior part of the abdomen, behind the ninth dorsal cartilage, in the region where the rectus abdominis muscle crosses with the costal margin. This region has clinical importance for the investigation of gallbladder enlargement.[4]. The general anatomy of the gallbladder is illustrated by Picture 4.



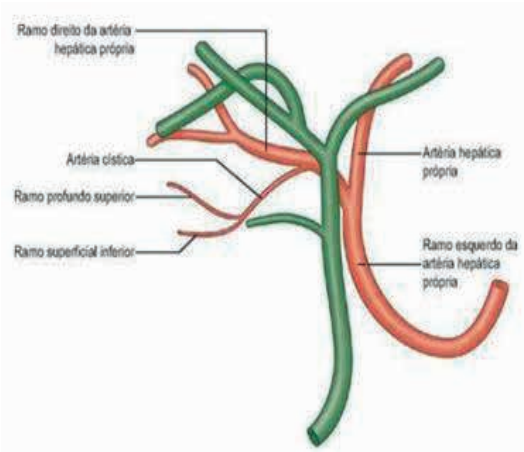

Picture 4 - Anatomy of the gallbladder and major adjacent ducts

Picture taken from: Gray's Anatomy: The Anatomical Basis of Clinical Practice. 40. ed. Rio de Janeiro: Elsevier, 2010.

Besides, there are great variations in the size and shape of the gallbladder, such as: an elongated and mobile bottom or a posteriorly folded bottom, forming the so-called Phrygian cap. In rare cases, there is a bifid or fully duplicated vesicle, usually with duplication of the cystic duct. In addition, its attachment varies widely, at one extreme presenting an intraparenchymal pattern when it is completely covered by the liver and, at the other extreme, manifesting a mesenteric pattern, hanging from a short mesentery formed by two layers of peritoneum separated by connective tissue and some small vessels[4].

## ARTERIAL SUPPLY

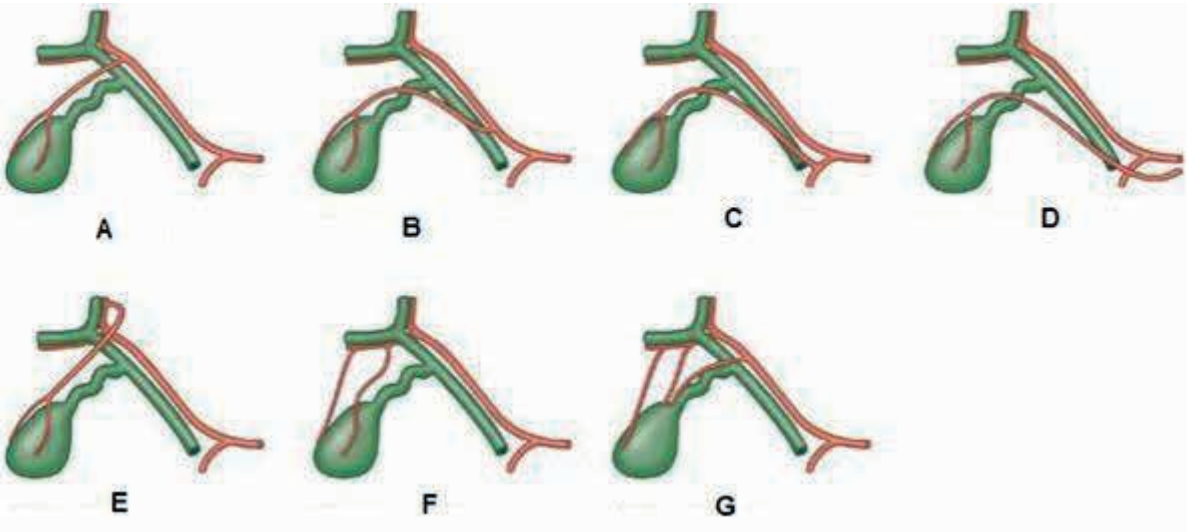
The common hepatic artery, together with its branches and sub-branches, are of great importance for the arterial supply of the biliary tree and gallbladder. Certainly, the cystic artery is the most relevant, as this is usually a branch of the right hepatic artery, passing posteriorly to the common hepatic duct and anteriorly to the cystic duct, reaching the upper surface of the neck of the gallbladder and dividing into the superficial and deep branches. Anastomoses of these branches are responsible for the arterial supply of the gallbladder, which may also receive additional arterial supply from various branches of the liver arteries, especially from the IV or IV hepatic segments V[3]. The classic course of the cystic artery is illustrated by Picture 5.




Picture 5 - Expected anatomy of the cystic artery.

Picture taken from: Gray's Anatomy: The Anatomical Basis of Clinical Practice. 40. ed. Rio de Janeiro: Elsevier, 2010.

The cystic artery, and the arterial supply of the gallbladder as a whole, usually undergo important variations, the main ones being illustrated in Picture 6. The common bile duct receives arterial supply through a fine network of vessels that receives contributions from various sources. About 2 to 4 ascending and descending arteries form long, narrow anastomotic channels along the duct.[4] The main contributions usually come from branches of the retroduodenal artery and from the branch of the gastroduodenal artery. There may also be contributions from descending branches of the right hepatic artery and the cystic artery, the latter of which may also originate branches that irrigate other ducts, such as the common hepatic duct.[3].




Picture 6 - Anatomical variations of the origin and distribution of the cystic artery. A: Origin of the common hepatic artery; B: Origin of lower portions of the common hepatic artery; C: Origin of the gastroduodenal artery; D: Origin of the right gastric artery, celiac or superior pancreaticoduodenal trunk; E: Origin of the left hepatic artery; F: Deep accessory artery irrigates the gallbladder; G: Multiple non-dominant arteries supply the gallbladder.

Image taken from: Gray's Anatomy: The Anatomical Basis of Clinical Practice. 40. ed. Rio de Janeiro: Elsevier, 2010.

## VENOUS DRAINAGE

Rarely, venous drainage of the biliary tree and gallbladder is provided by a single vein (cystic)[3]. Generally, this is done by a set of small veins that go to the hepatic parenchyma in several ways. Veins draining the upper surface of the body and neck usually enter the liver directly, where they join the segmental portal veins. The remainder usually forms one or two small cystic veins, which join the veins that drain the hepatic ducts and the upper part of the bile duct.

## LYMPHATIC SYSTEM

Most of the lymphatic vessels of the gallbladder and bile ducts drain to the cystic lymph node, which is the most anatomically relevant lymph node in the region. [3], usually located above the cystic duct. Furthermore, most of the lymphatic vessels that depart from the hepatic face of the gallbladder go to the intrahepatic lymphatic system.

## HEPATOCYSTIC TRINE AND CALOT'S TRIANGLE

The hepatocystic triangle is the nearly triangular space formed by the common hepatic duct on the left, the cystic duct on the right, and the inferior border of the V-space of the liver above. It is delimited by two juxtaposed peritoneal layers, with a large amount of loose connective tissue inside. Its contents are usually: the cystic artery, the cystic lymph node and other biliary lymphatic vessels, one or two small cystic veins, and some autonomic nerves leading to the gallbladder[4]. Calot's triangle is the name given to the triangular space delimited anatomically by the cystic duct, common hepatic duct and cystic artery. It differs from the hepatocystic triangle since, in the latter, the cystic artery is the content of the space, whereas in Calot's triangle it is one of the anatomical components that delimit the space.

## INDICATIONS FOR CHOLECYSTECTOMY

### CHOLECYSTITIS

Acute cholecystitis can be caused by several processes that can generate inflammation in the gallbladder region, usually due to calculi in the infundibulum or cystic duct (cholelithiasis).[5] Gallstones in the gallbladder can be of a lipid nature, formed by cholesterol, or caused by excess calcium and bilirubin, these stones being more brownish in color. The continuous distension of the gallbladder wall by the calculi, together with the production of mucin, can generate local ischemia, evolving with gallbladder necrosis and regional or diffuse peritonitis. Furthermore, the formation of stones inside the gallbladder can cause obstruction of the bile ducts and the pancreaticoduodenal papilla, giving rise to processes of acute pancreatitis and duodenal inflammation. Inflammation may worsen in the presence of secondary infections by opportunistic microorganisms that settle in the gastrointestinal tract.

Usually, acute cholecystitis can be diagnosed on clinical examination by the presence of pain and sensitivity in the right epicondyle region, as well as by palpation of the "cystic point" - also in the upper right region of the abdomen -, with a positive Murphy sign in case of Painful sensation on deep inspiration, with abrupt cessation of breathing movement[6].

Cholelithiasis, with or without an established inflammatory process, is the most frequent indication for cholecystectomy, and surgery is indicated even in asymptomatic cases as a form of prophylactic surgery. Its indication is within the preference of surgeons, since there are no international guidelines that indicate which patients to offer a cholecystectomy or clinical treatment. The earlier the cholecystectomy, the lower the resulting morbidity, thus reducing the risk of associated complications. Surgical access, either by laparotomy or videolaparoscopy, depends on the surgeon's skill, the available material and the patient's clinical condition. A notable contraindication for performing laparoscopic cholecystectomy is in patients who cannot tolerate pneumoperitoneum.[6;11].

### NEOPLASMS

Gallbladder neoplasms are not common, they are frequently diagnosed by finding during a cholecystectomy surgery for cholelithiasis; approximately 1-2% of patients undergoing this surgery are diagnosed with gallbladder cancer after histopathological analysis. The greatest risk factor for the development of gallbladder neoplasms is cholelithiasis, since it is found in 75 to 98% of cases with gallbladder carcinoma, with a greater association with large stones, and the literature shows that patients with stones larger than 3 cm present a 10 times greater risk of developing carcinoma[7]. This relationship is due to the constant epidemiology of patients undergoing cholecystectomy for acute calculous cholecystitis, in which it is observed that most patients with gallstones present for long periods of time develop gallbladder carcinoma, in the case of chronic inflammation[7]. In this case, the carcinoma may be the cause or consequence of the inflammatory process generated in acute calculous cholecystitis, in addition to the stones themselves that contribute to the characteristic inflammatory response in these individuals.

This neoplasm usually has a poor prognosis mainly due to the delay in diagnosis and the high probability of involvement of nearby noble structures. The gallbladder has a close relationship with the IV and V segments of the liver, which favors hepatic invasion. In addition, the duodenum, colon and anterior abdominal wall are often affected.

Therefore, gallbladder carcinomas

are not usually a frequent indication for cholecystectomy, but constitute surgical findings due to more frequent indications, such as acute or chronic cholecystitis[8].

### PORCELAIN GALLBLADDER

It is an uncommon variant of chronic cholecystitis, characterized by extensive calcification of the gallbladder walls, which may be partially or completely affected. The main cause for calcification of the gallbladder walls is still the subject of discussion in the medical field, but it is believed that the number, type and duration of gallstones are related to this process. The term "porcelain" is used due to its consistency and appearance, in which the vesicle is collected and hardened. Its prevalence in cholecystectomies is 0.06% to 0.8%, constituting an even less frequent indication than neoplasms[8].

## COMPLICATIONS OF CHOLECYSTECTOMY

At laparoscopy, non-biliary injuries that cause bleeding are responsible for more than a third of complications and the second leading cause of death (after anesthesia-related complications)[15]. Bleeding can be divided into intraoperative and postoperative. The first occur in the creation of pneumoperitoneum (insertion of the Veress needle or the first trocar), or as a consequence of dissection or inadequate technique; causes vascular lesions, slippage of staples or ligatures of the cystic artery, bleeding from the liver bed, among others. Vascular injuries are the most potentially serious and can occur in the aorta, inferior vena cava, right hepatic artery and portal vein, or in smaller vessels, such as the epigastric, mesenteric or omental branches. Postoperative bleeding, on the other hand, consists of lighter hematomas to more significant bleeding (injuries from the operation that were not noticed or slippage of staples). Blood emerging from the Veress needle is an indication that a large vessel has perforated, in which case rapid conversion from laparoscopy to open surgery is required.

There are also other possible outcomes. The work of Harry C Alexsander et al [16] showed that bile leakage was reported in 38% of studies, bile duct injuries were reported in 32%, hernia in 21%, wound infection in 51%, and retained gallstones in 21%. Mortality was reported in 38% of the studies.

Iatrogenic bile duct injury (IVB) is one of the main complications associated with cholecystectomy. Biliary duct stenosis is a pathology that, recurrently, can cause clinical conditions, such as biliary cirrhosis, liver failure and even lead to the patient's death. LIVB must always be suspected when the following symptoms occur after cholecystectomy: early postoperative jaundice, peritonitis, abdominal distention, imaging studies revealing intrahepatic bile duct dilation. Roux-en-Y hepatic-jejunostomy is now considered the therapeutic option of choice[17].

Patients submitted to laparoscopy experience a series of discomforts even in the post-anesthesia care unit (PACU) and in the medical-surgical ward (CME). At the PACU, more than half of the patients experienced some type of discomfort, with hypertension being the main one (54.5%), followed by abdominal pain (8.5%), nausea or vomiting (5.5%) and hypoxia ( two%). In CME, pain was present in 32.5%, followed by nausea or vomiting (19,2%)[18]. Regarding complications that occur within 30 days after laparoscopy, postoperative infection, hemorrhage, hematoma or seroma, postoperative fistula, bile duct perforation or wound rupture are highlighted; individuals with obesity, blood disorders, stroke or chronic nephropathy are among the most susceptible to the occurrence of these complications. Other possible complications include sepsis, cardiovascular

events, infection of other organs, for example. Elderly people with symptomatic cholelithiasis are at greater risk of having such complications, in addition to those with blood disorders, ischemic heart disease, conduction disorders or arrhythmias, chronic obstructive pulmonary disease or respiratory failure, chronic nephropathy, and chronic liver or pancreas diseases. In laparotomies, there is an occurrence of 3.9% of complications related to the surgery, and 5.2% of systemic complications; in laparoscopies, the ratio is 1.7% and 1.6%, respectively [19].

Postoperative pain is a common factor that impairs patients' quality of life. It may occur due to risk factors such as the pathology of complicated cholecystitis and the high score of operative difficulty, since problems in the dissection of the hepatocystic triangle can cause injury to the intraoperative nerve that innervates visceral structures[20]. Furthermore, among the complications of cholecystectomy, there is the possibility of having a remnant of the cystic duct that could lead to the formation of stones and cause Mirizzi syndrome. [21]. This syndrome consists of obstruction of either the common hepatic duct or the common bile duct, secondary to extrinsic compression due to impaction of stones in the cystic duct or gallbladder infundibulum. [22].

The post-cholecystectomy complication rate is influenced by the nature of the surgery (early, conventional, emergency laparoscopy), the presence of comorbidities, and age. [23]. Early laparoscopic cholecystectomy (LC) is the safest technique and has low mortality, in addition to reducing hospitalization time. Longer hospital stay after a surgical procedure is most commonly associated with surgical site infection[24]. The risk of infection in conventional surgery compared to laparoscopic surgery is six times greater, however, the frequency of infection after a conversion from laparoscopic to conventional cholecystectomy was equal to the risk for a planned open cholecystectomy[25].

The earlier it is - preferably within a week at most after the onset of symptoms - the greater the safety and feasibility of the procedure. [26]. Early LC is associated with reductions in the rate of complications. There is an exponential increase in the risk of developing Post Cholecystectomy Syndrome (PCS) with increasing duration of preoperative symptoms[21]. The morbidity rate is almost twice as high in patients undergoing urgent laparoscopic cholecystectomy (13.1%) when compared to those undergoing elective surgery (7.3%).Postcholecystectomy syndrome (PCS) is the term used to describe the perpetuation of biliary colic or abdominal pain in the right upper quadrant with a variety of gastrointestinal symptoms. Symptoms include intolerance to fatty foods, nausea, vomiting, bloating, diarrhea, jaundice, and intermittent episodes of abdominal pain. This picture can appear in the postoperative period, but also from months to years after surgery. PCS can result from biliary phenomena such as bile salt-induced diarrhea, retained stones, bile leakage, biliary strictures, cystic duct remnants, stenosis, and dyskinesia of the sphincter of Oddi. Furthermore, extrabiliary occurrences, especially gastrointestinal causes, may also cause symptoms consistent with postcholecystectomy syndrome[21].

Regarding complications, it is necessary to analyze the risk of conversion from laparoscopy to the conventional procedure. The skill of the laparoscopic technique is a predisposing factor for conversion, as well as possible anatomical changes in the gallbladder or portal triad. The inflammatory process of the gallbladder can lead to scarring fibrotic reactions that make the laparoscopic approach difficult, requiring conversion. In addition, cardiovascular, renal, pulmonary, neurological, hepatic, and hemorrhagic

disease were more prevalent in patients with conversion. Morbimortality, recovery, surgical site infection rate and length of stay were higher in those requiring conversion[21]. It is concluded that the identification of prognostic factors regarding the severity of the lithiasic disease may result in some modifications in its treatment.

Age is a predictive factor for more postoperative complications due both to a higher prevalence of complicated biliary disease and to the higher morbidity and mortality of surgery in the elderly [20]. In a systematic review, postoperative results of general and major complications were observed, which increased from 7 to 10 times in perioperative mortality in patients >80 years. There were significantly higher rates of conversions, even tripling in the elderly population [27].

Therefore, although the current risk estimate considers the presence of comorbidities or the American Society of Anesthesiologists grade (ASA)[27], the adoption of risk profiles of various age groups must also be considered during preoperative counseling. Preoperative optimization of comorbidities, medications, dementia screening, and frailty management by an expert physician or a full multidisciplinary team can help improve surgical outcomes in these patients.

## CONCLUSION

It is understood that for an effective surgical practice, knowledge of applied anatomy is essential, since the bile ducts are an important site of diseases and surgical techniques require foundations of anatomical variations. Finally, a thorough knowledge of the clinical indications for cholecystectomy is necessary, assessing the clinical signs as well as the possible risks of cholecystectomy.

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