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Imaging of cholelithiasis: what does the surgeon need?

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Laparoscopic cholecystectomy (LC) has become the standard approach for cholecystectomy despite relatively scant evidence that it is superior to open cholecystectomy (OC) in several prospective randomized studies [1–4]. The overwhelmingly fast spread of the laparoscopic technology and the purported lower invasiveness and quicker recovery after LC as opposed to OC have led to important modifications in the management of biliary disease and especially in the attitude of many surgeons toward common bile duct (CBD) stones.

Despite consensus that only symptomatic gallbladder stones require surgery [5], the general enthusiasm for laparoscopic surgery has lowered the threshold for LC. In most developed countries, the total number of cholecystectomies performed has increased by 14–24% during 1991–1993 [6, 7]. Data from Scandinavia suggest that the number of procedures has remained stable [6]. When cholecystectomy was performed for symptomatic cholelithiasis, the prevalence of CBD stones was 8–15% in patients younger than 60 years and 15–60% in patients older than 60 [5]. Performing LC in an increasing number of patients with little or only short-lasting symptoms has decreased the prevalence of CBD stones in the surgical population. Because the predictive values of any diagnostic test are directly related to the prevalence of the disease in the population tested, it is more than likely that the currently available preoperative diagnostic tools have lower positive predictive values than in populations with truly symptomatic cholelithiasis.

Although LC is relatively safe (mortality rate $<0.1\%$), it is associated with a 0.36–0.7% incidence of CBD injuries, which is almost twice the incidence for OC [6–8]. Obviously, the increasing absolute number of cholecystectomies has increased the overall number of operative CBD injuries.

The increasing number of cholecystectomies has also been responsible for the rising number of preoperative biologic and radiologic tests currently performed for the detection of CBD stones. A large variety of morphologic diagnostic investigations are available to the present-day clinician: conventional or endoscopic ultrasound, intravenous cholangiography, spiral computed tomographic (CT) cholangiography, magnetic resonance (MR) cholangiography, endoscopic retrograde cholangiography (ERC), and laparoscopic ultrasound. In addition to their variable efficiency for the detection of CBD stones, these techniques differ in terms of invasiveness, cost, and availability. Standardized and cost-efficient diagnostic strategies for CBD stones are required more than ever to limit the performance of diagnostic tests that may not only be noncontributive for most patients referred for cholecystectomy but also potentially harmful.

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What information does the surgeon need from preoperative imaging techniques?

All surgeons undertaking cholecystectomy require two types of information:

1. In patients with biliary symptoms, the existence of cholelithiasis has to be demonstrated. Percutaneous ultrasound (US) allows the detection of relevant cholecystolithiasis and confirms clinically suspected acute cholecystitis in most cases.
2. Conversely, in patients with known cholelithiasis, arguments validating the symptomatic nature of stones remain exclusively clinical. Because of its sensitivity, low invasiveness, and widespread availability, US may have contributed to increased operative rates in patients with little or no specific symptoms of cholelithiasis.

Diagnostic and therapeutic choices in cholelithiasis must be considered together. The utility of preoperative biliary imaging depends entirely on the therapeutic attitude adopted when and if CBD stones are detected.

Table 1. Sensitivity and positive predictive value of preoperative indicators of CBD stones according to a meta-analysis by Abboud et al. [9]

Indicator	Sensitivity (95% CI)	Probability of CBD stones (95% CI)
CBD stones on US	0.35 (0.27–0.49)	0.60 (0.45–0.73)
Dilated CBD on US	0.42 (0.28–0.56)	0.43 (0.38–0.49)
Cholangitis	0.11 (0.02–0.19)	0.67 (0.50–0.80)
Acute cholecystitis	0.50 (0.11–0.89)	0.15 (0.13–0.17)
Acute pancreatitis	0.10 (0.08–0.12)	0.19 (0.17–0.21)
Preoperative jaundice	0.36 (0.26–0.45)	0.53 (0.45–0.61)
Serum bilirubin+	0.69 (0.48–0.90)	0.35 (0.33–0.73)
Serum alkaline phosphatase+	0.57 (0.46–0.69)	0.22 (0.21–0.23)
Serum amylase+	0.11 (0.02–0.20)	0.14 (0.11–0.17)

CBD, common bile duct; CI, confidence interval; US, ultrasound; +, above upper normal range; cholangitis, fever + pain + jaundice

The diagnostic choice: is it necessary to detect and treat all CBD stones?

To be able to detect and treat all CBD stones, a reliable screening method is required. Table 1 presents the sensitivity and positive predictive value of several preoperatively available indicators for CBD stones [9] and shows that 46–90% of patients with CBD stones have a serum bilirubin higher than the upper limit of the normal range and 33–37% of patients with an elevated serum bilirubin have CBD stones. In other words, all imaging techniques performed for elevated bilirubin will be normal in two of three patients. All diagnostic probabilities indicated in Table 1 have been calculated for a 10% prevalence of CBD stones. In a population with a lower prevalence of CBD stones (i.e., the patient with low-level or asymptomatic cholelithiasis), the predictive values according to these criteria will be lower. When several methods for screening of CBD stones are performed similarly, the costs, availability, and morbidity of these methods should be compared. Even when all available clinical, biologic, and morphologic criteria are used, one-third of all CBD stones will not be suspected preoperatively and more than half of all patients with criteria for suspicion of CBD stones will have no stones.

Is it possible to improve the efficiency of screening for CBD stones?

Currently it is possible to define a patient population in whom the probability of CBD stones is so low that no further investigations are justified:

- The scoring system developed by Huguier et al. [10] can be calculated preoperatively and allows the selection for further investigation only in those patients in whom the probability of CBD stones exceeds the risks of a false-negative exploration. The score allowing this discrimination is $R = 0.04 \times \text{age} + 3.1$ (if US CBD diameter > 10 mm) $+ 1.2$ (if gallbladder stones < 10 mm) $+ 1$ (if biliary colic) $+ 0.7$ (if acute cholecystitis). The probability of CBD stones is less than 2 % when $R < 3.5$.

The scoring system by Hauer-Jensen et al. [11] allows the same selection but includes data that can only be obtained intraoperatively (i.e., palpable CBD stones, cystic duct diameter > 4–5 mm). Thus, it cannot be used for preoperative decision making.

Therapeutic choices

Common bile duct stones may be treated endoscopically or surgically.

Nonsurgical treatment of CBD stones: endoscopic sphincterotomy (ES)

ES may be used routinely or when it is thought to be superior to surgery.

Endoscopic treatment may be chosen to avoid surgical reintervention in patients with residual CBD stones after a previous cholecystectomy or to avoid a surgical procedure in patients without acute cholecystitis who have symptomatic CBD stones but are medically unfit for surgery.

ERC and ES, however, require general anesthesia and are associated with technical failure rates of approximately 5%, and ES has a mortality rate of 1–2% and specific complications in 7–10% of patients, due mainly to acute pancreatitis, hemorrhage, and duodenal perforations [12, 13]. The sensitivity of ERC for the diagnosis of CBD stones is 0.8–0.85. The performances and morbidity of the endoscopic approach are such that they imply that ERC with or without ES should be proposed on an intention-to-treat basis only to patients with a high risk of having choledocholithiasis (i.e., the presence of cholangitis or jaundice) [9, 14].

In all other cases, MR cholangiography seems to be as sensitive but less invasive and allows a selection of patients for ES [15]. Presently, the place of endoscopic US (EUS) is questionable from an economic point of view. Despite lower morbidity when compared with ERC, EUS requires general anesthesia and, unless it is performed in an operating theater, it does not allow a therapeutic approach other than ES during the same anesthesia.

Endoscopic treatment of CBD stones may be performed routinely before cholecystectomy (split approach). In the early days of LC, the absence of surgical competence to diagnose and treat CBD stones led to widespread acceptance of the two-step approach of ERC with ES followed by LC. The risk of having to convert to

open surgery when laparoscopic treatment of CBD stones has failed and the easier planning of operating schedules when the presence of CBD stones is known preoperatively have been used as arguments for the two-step approach. Some consensus meetings have concluded that the choice of the best therapeutic option depends on the local competence in any given hospital [5, 14]. It is difficult, however, to accept that any disease may not be treated optimally because of incompetence. All surgeons dealing with biliary diseases should acquire the necessary surgical skills for laparoscopic removal of CBD stones.

ES may also, at least theoretically, be performed postoperatively, when IOC during LC has demonstrated CBD stones, but the surgeon has not remove them. Exposing a patient to the risk of failed postoperative ES and thus surgical reintervention seems unreasonable when the problem can be resolved laparoscopically in an one-stage procedure. One randomized study comparing these two strategies has shown that definitive ductal clearance is higher in laparoscopically treated patients and that hospital stay is longer for patients with postoperative endoscopic stone removal [16].

From a practical standpoint, it is difficult to propose a strategy of preoperative detection and treatment of CBD stones to every patient with cholelithiasis because the available imaging techniques for preoperative screening are invasive (EUS and ERC), costly, or contraindicated in some patients (MRI). Further, it seems hard to believe that any of these techniques may become sufficiently available to be performed in all patients scheduled for LC.

Therefore, preoperative treatment of CBD stones should be proposed only to those patients with suspected stones. The limits of suspicion criteria for CBD stones have been mentioned: More than 50% of all preoperative diagnostic tests will be normal and one-third of patients with CBD stones will go undetected.

The question as to whether some CBD stones do not warrant treatment because they either may remain asymptomatic or are capable of migration without symptoms remains a matter of controversy. The complications of untreated CBD stones are cholangitis and acute pancreatitis. Both conditions are potentially fatal, and there is no way to predict in which patients such complications will occur.

Surgical treatment of CBD stones

Once one admits that all CBD stones have to be treated surgically, either by laparoscopy or by an open technique, then the informational performances of any preoperative diagnostic technique have to be compared with the performance of available tools for intraoperative stone diagnosis: IOC and laparoscopic US (LUS).

LUS is feasible in almost all patients, adding 5–10 min to the procedure. For the detection of CBD stones, the sensitivity of LUS (0.93) is slightly lower than that for IOC, although its specificity has been reported to range from 0.96 to 1.0 [14, 17, 18]. LUS seems somewhat less efficient for the detection of aberrant biliary anatomy. This technique is very helpful whenever the cystic duct cannot be catheterized. Unlike IOC, however, it is not therapy-orientated and therefore requires additional cystic duct dissection whenever a CBD stone is detected.

IOC is feasible in 94–99% of all patients undergoing LC without additional morbidity, adding 10–12 min operating time to the procedure [8, 19, 20]. When performed systematically in patients with symptomatic cholecystolithiasis, IOC detects CBD stones in about 12% (4–20%) of patients [8, 19].

IOC perfectly fulfills the criteria of a screening method. As is the case of preoperative diagnostic tools, it is possible to restrict IOC to a selected population, thus avoiding a maximum of "normal" cholangiograms [10, 11]. IOC allows the diagnosis of all CBD stones at the time of LC because it preceeds either transcystic maneuvers or choledochotomy to remove CBD stones. If the surgeon performs IOC routinely, then there is no need for any preoperative imaging technique whose diagnostic value is inferior.

The potential benefits of preoperative diagnosis of CBD stones is better planning of operative schedules and the possibility of restricting the use of IOC (unless it is performed routinely for reasons of safety and anatomic verification). These potential benefits, however, have to be compared with the costs of any other preoperative imaging techniques, with the realization that whatever the criteria used for the detection of CBD stones, at least half of these patients will have a normal and thus unnecessary imaging procedure.

In patients with preoperatively detected choledocholithiasis, IOC has additional therapeutic benefits. The one-stage laparoscopic treatment of CBD stones compares favorably with laparotomy and with the split approach (ES with stone extraction followed by LC). One prospective randomized study of laparoscopic one-stage treatment versus the split-approach (ES + LC) has shown that final duct clearance rates are similar with similar morbidity but with a significantly shorter hospital stay for the single-step approach [20]. In addition, the laparoscopic approach leaves the lower choledochal sphincter intact and thus avoids late complications of ES such as stone recurrence and cholangitis. These complications have been reported to occur in as many as 10% (range 6–24%) of all sphincterotomy patients when follow-up is more than 10 years [21].

Does preoperative biliary imaging reduce the risks of operative injury of the CBD?

Imaging techniques can theoretically detect anatomic variations or anatomic characteristics representing risk

factors for technical difficulties that require conversion to laparotomy. Routine IOC can detect anatomic aberrations in up to 19% of cholangiograms [8]. From a practical standpoint, however, there is no correlation between anatomic anomalies and an increased risk of CBD injury.

Bile duct injuries occur in 0.36–0.7% of all LC and are thus more frequent than the 0.2–0.3% incidence reported for OC [7, 8]. Most CBD injuries are due to errors in surgical technique, and 60–90% of injuries occur during procedures without IOC or when IOC has been misinterpreted [8, 22]. Countries with wide use of IOC have lower incidences of bile duct injuries than those where IOC is not frequently performed [6]. Although it is clear that IOC will not prevent injuries that have occurred before IOC, it allows intraoperative detection of most injuries and thus prompt repair. Cholangiography also may help to limit the extent of injury and subsequent repairs by avoiding resection of a mistakenly transected CBD [22]. IOC has recently been shown to reduce the risk of bile duct injury and should therefore be performed routinely, independently of its diagnostic values in the detection of CBD stones [23].

Other than IOC, the best way to prevent CBD injuries is careful dissection. Teaching of laparoscopic biliary surgery must include knowledge of the main anatomic variations of the CBD to allow correct interpretation of an IOC.

So what preoperative information does the surgeon really need?

In the near future, the usefulness of preoperative diagnosis of CBD stones may have to be reconsidered if routine IOC becomes compulsory (quality-control organizations, insurance companies) for the prevention of biliary duct injuries during LC.

The progressive evolution toward a wider diffusion of laparoscopic techniques for the treatment of CBD stones in the surgical community and the evolution of social security systems toward reimbursement per pathology instead of remuneration for every medical procedure may have an impact on the current therapeutic liberty to multiply preoperative diagnostic tests without proven superiority over IOC. This may put an end to ongoing controversies concerning sequential treatment modalities for CBD stones versus the possibility of single-stage laparoscopic diagnosis and treatment of CBD stones.

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