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The standard of laparoscopic cholecystectomy

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Abstract *Background:* Laparoscopic cholecystectomy today is the standard operation for all gall stone disease. Nevertheless, a number of questions are still being discussed: What are the optimal steps? Or, more important, is the laparoscopic technique really superior to the open procedure according to the criteria of evidence-based medicine? How should we proceed in case of an occult choledocholithiasis? Is intraoperative cholangiography mandatory, and does the concept for the treatment of silent gall stones need to be revised in the era of laparoscopic cholecystectomy? *Method:* Literature review. *Results:* Eleven randomised studies show the superiority of the laparoscopic technique. Only one study shows no advantage provided the length of the incision in the open procedure is less than 8 cm. According to our own experience, up to 98% of all gall bladders can be removed laparoscopically when following the described standard technique, with a conversion rate of less than 1%. In the case of an occult choledocholithiasis the concept of "therapeutic splitting" has proved successful; the risk of a residual stone is below 1%. Routine intraoperative cholangiography is not cost effective. The risk of complications for a silent gall stone in the long term is higher than for laparoscopic cholecystectomy in young patients with incidental gall stones. *Conclusion:* The laparoscopic technique has given new impulses to the surgery of the gall bladder and has proven to be an effective, patient-friendly alternative to open surgery.

Keywords Gall bladder stones · Laparoscopic cholecystectomy · Intraoperative cholangiography · Silent gall stones · Occult common bile duct stones

Introduction

More than 100 years after the first cholecystectomy by Langenbuch [1], a gall bladder was removed through a laparoscope for the first time, in 1985, by Mühe [2]. In 1987, Mouret [3] performed the first laparoscopic cholecystectomy with the establishment of a pneumoperitoneum. Since then rapid development has occurred, and laparoscopic cholecystectomy can now be considered the gold standard for the surgical treatment of gallstone disease.

Numerous randomised controlled studies have been able to show significant advantages for the minimally invasive technique against the conventional procedure. Patients with a laparoscopic cholecystectomy have less pain [4–9], less restriction of their pulmonary function [6, 9], fewer complications [10], a shorter hospital stay [4, 6, 9–12], a shorter period of inability to work [4, 5, 9, 13], fewer incisional hernias [14] and a better quality of life [10].

Laparoscopic cholecystectomy has decisively altered the clinical management of gallstones. Whereas patients with a conventional cholecystectomy generally received pain killer as well as intravenous treatment up to the third

postoperative day, and rarely left the hospital before the tenth postoperative day, today there is a large number of patients with a cholecystectomy who are treated on an outpatient basis [15, 16]. In a recently published prospective randomised study, Secco and co-workers [17] found higher hospital costs (€820.48 per patient) for laparoscopic cholecystectomy than for a mini-cholecystectomy; because of the shorter period of inability to work, by 10 days; however, the costs/day were reduced by €164.96, according to a cost-benefit analysis. Thus, from a socioeconomic point of view, laparoscopic cholecystectomy even offers advantages when compared with mini-cholecystectomy.

The randomised study of Majeed and co-workers [18] showed no difference between patients with a laparoscopic cholecystectomy and those with surgery through a small incision (<8 cm). When appraising this study, however, one has to comment that the authors were obviously a lot more experienced in the mini-cholecystectomy technique than in laparoscopic procedures, which is supported by the considerably shorter operation time for the open procedure (40 min vs 60 min) as well as the high rate of conversion of 20% in the laparoscopic group. Another point of critique is the fact that the rate of conversion was twice as high in the first half of the study than in the second half, which would also indicate that the authors had not yet overcome their learning curve at the beginning of the study. Furthermore, the study extended over 3.5 years, so obviously only approximately five patients per month were accepted into this study. The cost analysis by Fullarton and co-workers [19] further supports this argument. They calculated an average cost of £2,026 for their first 50 laparoscopic cholecystectomies but then only £1,744 for the subsequent 50 patients and, thus, significantly less than for their conventionally operated-on patients (£2,102).

The current situation in Germany

Recent surveys in Germany [20, 21] showed that approximately 70% of all gall bladders are removed laparoscopically, with a rate of conversion of 7%. The success rate in centres just like our own can be higher than 98% for the bland gallstone disease and approximately 95% for acute cholecystitis, with a conversion rate of about 1% [22]. The experience of an institution and a strictly standardised surgical concept are of the utmost importance for the success rate.

In our own clinic, with an almost constant number of patients every year (an average of 569 cholecystectomies/year, minimum 479 cases in 1991, maximum 665 cases in 1998) between 1991 and 2002 we found a clear change in the surgical technique towards the laparoscopic procedure (n=6,258) over the course of time. In the introduction year of the laparoscopic technique (June 1991), 12.5% of all patients were operated on laparoscopically; in the 2002 this figure stood at 98.5%. Since 1991, the share of laparoscopic procedures for acute cholecystitis also increased, from 2.8% in 1991 to 98.2% in 2002. Our results show that, following a 2–3 year period of introduction of the new technique, almost all gall bladders can be removed laparoscopically—this includes the whole team of surgeons all the way down to the interns. The key to this success is a high volume of patients, strict standardisation of the surgical technique and a consequent concept of education. The median operation time with regard to all patients was 52 min, the rate of conversion 1.1%, morbidity 4.04% (Table 1); only two patients died (0.03%) during their hospital stay, considering that more than 1,000 patients had histologically proven acute cholecystitis.

Table 1 Biological data and patient outcome (June 1991–June 2003)

Parameter	
Number of patients	6,258
Age (years)	53 (15–92)
Gender	
Number of female patients (%)	3,717 (59.4)
Number of male patients (%)	2,541 (40.6)
BMI	25.5 (14.9–58.3)
Duration of surgery (min)	52 (15–245)
Number of conversions (%)	68 (1.1)
Number exhibiting morbidity (%)	253 (4.04)
Number of deaths (%)	2 (0.03)

Preoperative diagnosis

Next to securing the general operability, preoperative diagnosis should achieve the following goals:

1. Diagnosing cholecystolithiasis
2. Excluding occult choledocholithiasis
3. Excluding a symptomatic accompanying illness, particularly of the stomach

Securing the diagnosis is done exclusively by ultrasound today. The consistency of the gall bladder wall, as well as the precise gallstone status, can be accurately described. We need to emphasize that CT and MRT are of no importance in the routine diagnostic procedure. The diagnostic assessment of the choledochus is still a problem. Whereas the determination of the diameter is comparatively definite, the diagnosis of choledocholithiasis is rarely possible. A duct size of more than 7 mm, however, is considered to be pathognomonic and suspicious for occult choledocholithiasis. Securing an occult choledocholithiasis has become particularly important in the era of laparoscopic cholecystectomy because the biliary duct is much less accessible than the gall bladder, with the

laparoscopic technique. It also requires special expertise in contrast to open cholecystectomy, where intraoperative cholangiography was performed routinely, and whenever necessary, the exploration of the bile duct is carried out. The diagnostic emphasis in the laparoscopic era is, therefore, on the preoperative diagnosis. Several concepts are being discussed; a cost-benefit analysis, however, would always be desirable. Randomised studies exist only with regard to intraoperative diagnostic techniques, which will be discussed later.

There is no doubt that a concept that ignores possible choledocholithiasis is the cheapest but least effective. A concept with a routine ERC and, if necessary, papillotomy and stone extraction is certainly very effective but would surely also require highest costs. A routine intravenous cholangiography is not justified according to Truong and co-workers [23], as its benefit within the preoperative bile duct diagnosis is small. Sarli and colleagues [24] reached the same conclusion: they found a benefit in only 8.6% of all patients. Even though Sarli [25] et al. found an incidence of 7%–20% for occult choledocholithiasis, the study by Erickson and Carlson [26] showed routine ERC, with papillotomy if necessary, not to be cost effective. That also applies to intraoperative cholangiography, not least because of the high rate of misinterpretations [27], particularly whenever there is no experience with laparoscopic bile duct exploration. Resulting from Sarli and co-workers' experiences [25], and our own [28], we recommend therapeutic splitting with selective preoperative ERC according to a score system.

This system includes the sonographic proof of a dilated bile duct (>7 mm), a rise of SGOT above 40 U/l and of alkali phosphatase above 280 U/l, as well as the proof of so-called dangerous stones, which are stones with a diameter of less than 5 mm, in the gall bladder. Jaundice and pancreatitis in the medical history have to be included in the scoring system. Long-term studies show that, following the concept of therapeutic splitting based on thorough preoperative laboratory tests, and including a scoring system, one can expect a risk of less than 1% for a postoperative residual stone [28, 29]. Next to the medical history and ultrasound examination, preoperative diagnosis must, therefore, include the laboratory parameters for cholestasis.

Intraoperative cholangiography (IOC) is still controversial. Should it be a routine procedure or should it be reserved for special situations, such as whenever preoperative ERC did not succeed or when there are intraoperative anatomical uncertainties?

There are two randomised studies concerning that question, however. They both have the same conclusion: routine IOC does not have any advantage but requires an additional 15 min of time and, thus, higher costs, of approximately $700 [30, 31].

A second argument frequently cited in favour of IOC is the avoidance of biliary duct lesions. Undoubtedly, this presents a weak spot in the laparoscopic technique, as the literature states that the average incidence of a bile duct lesion during laparoscopic cholecystectomy is 0.27%, higher than for open cholecystectomy at 0.17% [32].

In a number of studies, however, it could be shown that there is no correlation between the frequency of bile duct lesions and a routine IOC; 20%–50% of all lesions occurred only after IOC had been performed, and approximately 25% of all findings were misinterpreted [33–35].

Only approximately 20%–30% of all patients with cholecystolithiasis ever have complaints. These can be expressed as typical bilious colic, but they can also appear, unspecifically, in the form of food incompatibilities or dyspepsia symptoms. Moynihan [36] has already pointed out that the symptoms are often projected to the stomach, so that the differentiation from a genuine stomach disease can be difficult. The question, therefore, is whether or not a stomach examination is necessary before a planned laparoscopic cholecystectomy. A number of prospective studies [37–42] unanimously reached the same conclusion.

With typical symptoms present, a routine gastroscopy is not necessary, as pathological results could be found 0 in only 8%–16%, which, again, led to a change in the therapeutic concept in merely 1% of all cases. With atypical symptoms present, however, gastroscopy must be recommended, as pathological results could be found in up to 44%, which, again, led to a change in the therapeutic concept in 9%–12% of all cases.

Standard technique

The surgical technique follows the descriptions of the French School [43–45]. The patient is put in the reverse Trendelenburg position, the surgeon stands between the patient's legs, the camera assistant sits at the patient's right side and the assistant stands at the patient's left side (Fig. 1).

The monitor is positioned behind the right shoulder of the patient. Four trocars are being used: the camera trocar (10 mm) at the upper edge of the umbilicus; another 10 mm trocar in the medioclavicular line in the left upper abdomen, for the use of the electric hook, the clip applicator and for the camera while the gall bladder is being removed; a 5 mm trocar in the epigastric angle for a grasper and the irrigation; another 5 mm trocar in the right middle abdomen for another grasper.

The establishment of the pneumoperitoneum is usually achieved with a Veress needle. Whenever adhesions are expected we use an open entry for the pneumoperitoneum. In very obese patients with a large distance between xyphoid and umbilicus, we introduce the optic trocar about a hand's breadth above the umbilicus in the midline to avoid having problems with too much distance to the liver and the gall bladder, which frequently stands higher than normal. In most cases a 0° angle optic was used; the

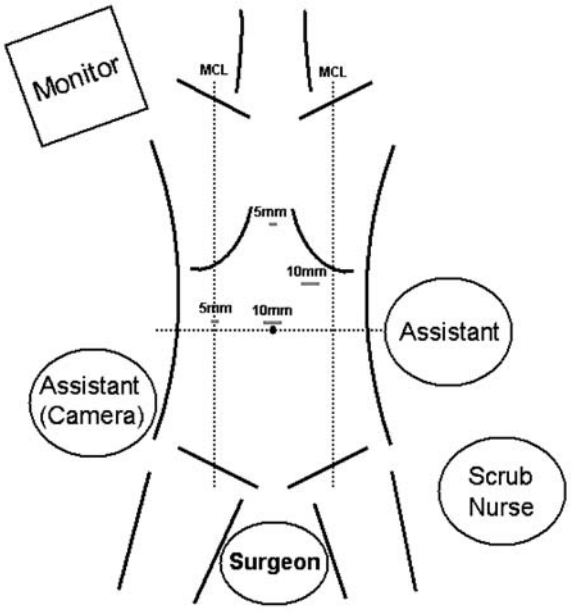

Fig. 1 Operational setting for laparoscopic cholecystectomy

30° angle optic can be particularly advantageous in very obese patients or men with a very deep situs; here, it can provide a significantly better view into the triangle of Calot.

The dissection is always done with the hook, connected to monopolar current, held by the surgeon's right hand through the 10 mm trocar in the left middle abdomen. The surgeon's left hand holds the grasper, which is introduced through the 5 mm trocar in the right middle abdomen. While the first assistant is pulling the gall bladder fundus cranially above the liver's edge with a grasper in the 5 mm trocar in the epigastric angle, the surgeon exposes the infundibulum in a caudolateral direction. Thus, the triangle of Calot is exposed, and the cystic duct and cystic artery are straightened so that their initially acute angle of junction with the choledochus and the hepatic artery is transformed into a right angle, resulting in a wider distance between the structures to be dissected and those that have to be preserved. Now, a decisive step is the V-shaped (ventral and dorsal) incision of the gall bladder peritoneum at the edge of the fatty tissue of the triangle of Calot. This serves to open further the triangle of Calot and the distance between the named structures so that they can now be easily isolated and severed following their occlusion with clips. A basic principle must be the complete circular dissection of the cystic duct where it exits from the infundibulum and the cystic artery where it joins the gall bladder wall. We can then safely position the clips and avoid any injuries to the choledochus and hepatic artery. In doing so we also have no problem in recognising rare anomalies such as the junction of the cystic duct with the right hepatocholedochus or the junction of the cystic artery with the right hepatic artery. Only in very obscure situations will we need to dissect the junction of the cystic duct with the choledochus, but, naturally, electrocoagulation must then be applied very sparsely or even completely avoided. When working with the electric hook we usually apply the coagulation mode and only rarely the cutting mode. Occlusion of the cystic duct is usually achieved with two titanium clips towards the choledochus and another one towards the gall bladder. For the occlusion of the cystic artery one or two titanium clips are enough—the artery is then severed distally with the electric hook. The clip applicator is reusable. Only a very thick cystic duct is occluded with a Lapro clip. Once all the structures in the triangle of Calot are safely taken care of, the gall bladder can easily be enucleated from its hepatic bed with the electric hook, the assistant now not holding the fundus anymore but rather the gall bladder serosa at the edge of the liver bed so that the line of dissection can be placed there.

The exposition of the triangle of Calot, as described above, holds a key position in the safe realisation of the operation. In the case of acute cholecystitis or a heavily thickened and calloused infundibulum, it is often not possible to hold the infundibulum with the Olsen–Reddick grasper. In these cases, it is recommended that the 5 mm trocar in the right middle abdomen be exchanged for a 10 mm trocar so that a Babcock grasper can be introduced. With the help of this instrument, it is always possible to hold the infundibulum safely at its lowest point and, thus, expose it for the ensuing dissection. In such difficult cases, the dissection can also be performed with a spatula. With its help, the inflamed tissue can be removed from the gall bladder wall more easily than with the hook. In the case of a very firmly filled gallbladder and the corresponding difficulty of getting a hold on the gall bladder, another trick is to evacuate the gall bladder percutaneously.

Haemostasis is another critical point. While this does not pose any problem in the non-inflamed gall bladder, it can be very difficult in inflamed gall bladders and even lead to conversion. Argon-beam coagulation has decisively proven successful in these situations. Combined with regularly repeated suction/irrigation, almost complete haemostasis can always be restored, which enables continued safe dissection to be undertaken. There is absolutely no question about the need to convert in uncertain situations. The personal experience and responsibility of the surgeon are of decisive importance for the success of the surgery; they should not be pressed into any defined time frame, however.

For the removal of the gall bladder, the 10 mm trocar at the umbilicus is usually exchanged for a 20 mm trocar, which, in turn enables the extraction of the gall bladder from the abdomen to be undertaken without a lot of manipulation in the wound. In simple cases with a tender

gall bladder wall and small stones, the extraction can also be done easily through the 10 mm trocar. In complicated cases, especially when the gall bladder has been opened or acute inflammation is present, the use of a bag is recommended in order that contamination of the wound and a possible secondary infection be avoided. Perioperative, single-shot, antibiotic prophylaxis is recommended for high risk patients (acute inflammation, obesity, old age).

The operation is ended with a secure closure of the fascia at the umbilicus. It is not necessary to close the fascia at the working trocar sites because of the muscles that lie over it.

Is the "silent gallstone" also an indication for surgery?

There is no doubt about the indication for surgery in symptomatic gallstone disease. Today, for asymptomatic gallstone disease there is the principle "requiescat in pace" [46]. At the beginning of the last century [36, 47], as well as in the 1980s, however, some authors [48] took the view that every gallstone is a foreign body that must lead to complications sooner or later and therefore requires immediate therapy. Then, epidemiological studies at the beginning of the 1980s [49], including cost-benefit analysis, showed that prophylactic cholecystectomy for a silent gallstone comes with higher costs and that the patient would lose some days of life quality because of the morbidity. Since all these studies referred to conventional cholecystectomy, which represents a significantly bigger procedure than laparoscopic cholecystectomy, as was illustrated above, however, that concept definitely needs to be scrutinised. Firstly, we have to analyse the risk, which lies in the possible complications during the long-term course of the initially asymptomatic gallstone disease. Glenn [48] has already found that approximately 30%–50% of all patients with a silent gallstone eventually become symptomatic in their further course. Attili and coworkers [50] could show, in their more-than-10 year observational study of 118 initially asymptomatic gallstone patients, that every fourth one had to be operated on within this time because of colic. Moreover, one of those 118 patients developed cancer after 8 years, so the authors concluded that the natural course of gallstone disease is less benign than is generally assumed.

According to the large study by Friedmann et al. [51], asymptomatic patients and patients with minor complaints have to expect serious complications in their further course in approximately 15% of cases.

Approximately 10% of these patients will develop acute cholecystitis; in 2% jaundice will develop, 1% will suffer pancreatitis, and in 0.8%–1.2% of patients cancer will develop in the gall bladder. Furthermore, approximately 0.1% of these patients will have to expect cholangitis and 0.5%–1.4% a Mirizzi syndrome that poses special surgical problems. As a matter of principle, we can assume that about 1%–2% of these patients per year will develop serious symptoms or complications. Furthermore, in about 10%–15% of these patients choledocholithiasis will develop that might, initially, remain completely unnoticed (occult). The morbidity risk in laparoscopic cholecystectomy is, nevertheless, considerably smaller, at 4%, according to our own experiences with a large group of patients (Table 1); and, herein, the results of our learning curve, as well as the results from more than 1,000 operations for acute cholecystitis, are included. One group of asymptomatic patients aged below 50 years had a significantly shorter operation time (37 min vs 52 min), and morbidity was close to 0% (Table 2). Moreover, we could show that the later the surgery is performed during the course of the gallstone disease, the more there is a significant increase in the share of patients with acute cholecystitis: the operation time is prolonged, the rates of conversion and morbidity increase fourfold, the hospital stay is extended accordingly and the percentage of patients with occult choledocholithiasis is increased too (Table 3).

Table 2 Biological data and patients' outcome (group of patients without pain and not older than 50 years)

Parameter	
Number of patients (*n*)	135
Gender	
Number of female patients (%)	91 (67.4)
Number of male patients (%)	44 (32.6)
Duration of surgery (min)	37 (25–90)
Number of conversions (%)	0 (0.0)
Number exhibiting morbidity (%)	1 (0.7)
Number of deaths (%)	0 (0.0)
Hospital stay (days)	6.1 (4–13)

Because these convincing results and the literature analysis thoroughly weigh the pros and cons, it is mandatory for one to reassess the indication for a cholecystectomy in patients with a "silent gallstone", at least for selected cases. As long as the study situation is inadequate and no definitive answer can be given according to the criteria of evidence based medicine, it would certainly be no mistake for one to follow the suggestion by Patiño and Quintero [52], which recommends a scoring system for the indication for a cholecystectomy in asymptomatic cholecystolithiasis. This scoring system should include the life expectancy (more than 20 years), the diameter of the stones (more than 2 cm and less than 3 mm in an open cystic duct), the presence of polypoid alterations in the gall bladder, proof of a porcellaneous gall bladder and the presence of co-morbidities (alimentary diabetes). Furthermore, the authors recommend a generous indication for surgery in women under 60 years of age and in regions with a high incidence of cancer.

Table 3 Outcome for laparoscopic cholecystectomy in relation to the age of the patients

Parameter	Aged <50 years (*n*=1,807)	Aged >75 years (*n*=287)
Number with acute cholecystitis (%)	254 (14)	68 (23.7)
Number of conversions (%)	11 (0.6)	5 (1.7)
Number exhibiting morbidity (%)	32 (1.8)	24 (8.4)
Duration of surgery (min)	43 (15–213)	55 (22–210)
Hospital stay (days)	7.1 (2–39)	9.9 (4–30)
Number of pathological ERCs (%)	21 (1.2)	17 (5.9)

Summary

According to the criteria of evidence-based medicine, laparoscopic cholecystectomy is significantly superior to the conventional technique. A strictly standardised surgical technique is decisive for successful realisation. In the diagnosis and therapy of occult choledocholithiasis, the concept of therapeutic splitting—selective preoperative ERC, if necessary, with a papillotomy, and laparoscopic cholecystectomy—seems to be cost effective. There are no data with a high degree of evidence. Intraoperative cholangiography neither pays significantly for the diagnostic procedure of occult choledocholithiasis nor for the avoidance of biliary duct lesions (degree of evidence: 1 b). Preoperative gastroscopy is recommended only for patients with unclear symptoms.

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