Subtotal Cholecystectomy—“Fenestrating” vs “Reconstituting” Subtypes and the Prevention of Bile Duct Injury: Definition of the Optimal Procedure in Difficult Operative Conditions

Steven M Strasberg, MD, FACS, Michael J Pucci, MD, L Michael Brunt, MD, FACS, Daniel J Deziel, MD, FACS

Less than complete cholecystectomy has been advocated for difficult operative conditions for more than 100 years. These operations are called partial or subtotal cholecystectomy, but the terms are poorly defined and do not stipulate whether a remnant gallbladder is created. This article briefly reviews the history and development of the procedures and introduces new terms to clarify the field. The term partial is discarded, and subtotal cholecystectomies are divided into “fenestrating” and “reconstituting” types. Subtotal reconstituting cholecystectomy closes off the lower end of the gallbladder, reducing the incidence of postoperative fistula, but creates a remnant gallbladder, which may result in recurrence of symptomatic cholecystolithiasis. Subtotal fenestrating cholecystectomy does not occlude the gallbladder, but may suture the cystic duct internally. It has a higher incidence of postoperative biliary fistula, but does not appear to be associated with recurrent cholecystolithiasis. Laparoscopic subtotal cholecystectomy has advantages but may require advanced laparoscopic skills. (J Am Coll Surg 2015;11:1–8. © 2015 by the American College of Surgeons. Published by Elsevier Inc. All rights reserved.)

Laparoscopic cholecystectomy is a well-established procedure with clear benefits for patients over open cholecystectomy. However, it is associated with an increased rate of bile duct injury. Biliary injuries occur more commonly when operations are made more difficult due to the presence of severe acute and/or chronic inflammation. Under these conditions, secure ductal identification by the critical view of safety (CVS) may be very challenging because CVS requires clearing of the inflamed hepatocystic triangle in order to demonstrate the cystic duct, cystic artery, and the cystic plate. It is a rigorous method, but as we have previously stressed,1,2 this is actually one of the strengths of the CVS method of identification. The infundibular technique, in which the funnel-shaped infundibular-cystic duct junction is the rationale for identification, is much easier to achieve than CVS. However, biliary inflammatory fusion and contraction can make the common bile duct resemble the cystic duct when this technique is used,3 and this increases the chance of biliary injury. The CVS method protects against injury because when the CVS has not been achieved after a reasonable trial of dissection, the surgeon is more likely to realize that conditions are too difficult to proceed in the usual manner and opt for a different approach before a biliary injury occurs. It is good that the CVS method prevents biliary injury, but if there is to be an effective and safe method of dealing with difficult gallbladders, it must include a safe and effective bail-out technique when CVS cannot be attained. By safe we mean without bile duct injury and by effective we mean without need for a second operation. Otherwise the surgeon will be tempted to push on with a risky dissection in the hepatocystic triangle in order to avoid a second procedure or perform a cholecystostomy, which will usually necessitate a second operation. Stated otherwise, it is commendable when surgeons reach the decision that it is unsafe to proceed with a total cholecystectomy, but obviously there should be a good way to finish the procedure when its time “to get out of Dodge.”

Paradoxically, 2 of the most useful “bail out” procedures—partial cholecystectomy and subtotal cholecystectomy—are
not clear and well-defined operations. Even the terms partial and subtotal are imprecise because they fail to encompass an essential element in these operations, which is whether a functional remnant gallbladder may result as a consequence of performing these procedures. In 1966, Bodvall and Overgaard defined “gallbladder remnant” as a wider part of the free end of the cystic duct that gives the appearance of a diminutive gallbladder. Today, remnant gallbladders may be diagnosed by ERCP (Fig. 1), magnetic resonance cholangiopancreatography (MRCP) (Fig. 2), or by ultrasound (Fig. 3). The functional remnant gallbladder may communicate with the remainder of the biliary tree just as the parent gallbladder does. Stones can form or be retained within these remnants and may cause recurrent biliary colic and all of the usual complications of cholecystolithiasis. The potential consequences of leaving a gallbladder remnant are well known. Bodvall and Overgaard attributed the first report of clinically significant complications of gallbladder remnants after cholecystectomy to Florken in 1912, and summarized literature to 1966. The subject was reviewed again in 2009 by Pernice and Andreoli. A brief summary of the literature, which is mostly composed of small case series or case reports, is that gallbladder remnants may become symptomatic and require excision in a second operation at any time from shortly after the initial operation to many years later. The latter is an important point because most publications dealing with the outcomes of less than complete cholecystectomy have short patient follow-up times and therefore, may underestimate the consequences of leaving a gallbladder remnant. Furthermore, operations to remove remnant gallbladders may be difficult, so procedures that do not result in remnant gallbladders are more desirable than those that do (Fig. 4).

Excellent recent systemic reviews of outcomes of procedures reported in papers under the terms partial or subtotal cholecystectomy by Henneman and colleagues and Elshaer and associates are available. The purpose of this paper is...
to clarify the procedures that have been described under the terms partial and subtotal cholecystectomy in respect to whether they are associated with a potentially functional remnant gallbladder and then to propose new terms that more appropriately depict what is actually done in these procedures. We believe that clarification of the procedures and what they are called will help surgeons choose what type of procedure to select and will also facilitate clinical studies in this area. Based upon referrals to our centers we strongly suspect that many surgeons still believe that no good option between cholecystostomy and total cholecystectomy is available and that anything less than a complete cholecystectomy may result the need for a second procedure. As noted earlier, this belief may encourage the surgeon to push on with dissection in the hepatocystic triangle when there is danger in doing so, or to do a cholecystostomy when a more satisfactory procedure is available—one that will take care of the patient’s problem in a single operation. Part of the lack of awareness of options seems to be the confusing terminology. An effective, reliable, standard, widely known, and accepted operation needs to be available when the CVS cannot be achieved. The CVS is only 1 part of COSIC (culture of safety in cholecystectomy), and a reliable bail-out operation is another key component of safety. These operations may also be helpful when cholecystectomy is difficult due to associated hepatic cirrhosis.

A BRIEF HISTORY OF OPERATIONS IN WHICH ONLY A PART OF THE GALLBLADDER IS REMOVED

In 1898, Hans Kehr operated on a 27-year-old woman with acute cholecystitis, intending to extirpate the gallbladder. Due to difficult conditions, he removed the gallbladder such that “the hardened posterior wall and the part of the bladder lying next to the cystic duct remained.” He sewed the remaining gallbladder over on itself, with a strip of gauze as a drain. This seems to be the first description of a modification of cholecystectomy due to difficult operative conditions in which the intent was to remove as much of the gallbladder as possible without dissecting the inflamed hepatocystic triangle. The idea was to deal with the gallbladder problem in 1 operation while avoiding the risk of a major biliary or vascular injury. The next development of subtotal cholecystectomy occurred not because of the problem of the difficult gallbladder, but due to the problem of postoperative bile leakage and bleeding from the liver bed after routine elective total cholecystectomy. Pribram, from Berlin, described a technique in which the gallbladder was bivalved along its longitudinal axis, stones were removed, and then thermal ablation of both portions of the gallbladder wall was performed. The technique consisted of a deep destruction of the wall down to the serosa. The preserved flaps of serosa were folded and sutured together to reperitonealize the liver bed. Pribram did not perform any anatomic resection in these cases, nor did he use this method to avoid dissection in the region of the cystic duct in the difficult gallbladder. In fact, he recommended ligation and division of the cystic duct and the cystic artery external to the gallbladder, as in total cholecystectomy. Variations on Pribram’s technique, which included actual removal of the free portion of the gallbladder wall and ablation of the remaining portion attached to the liver, were recommended by Thorek in Chicago and by Bailey and Love in London. A free graft of omentum or falciform ligament was sutured over the remnant gallbladder on the liver. As did Pribram, however, these surgeons also divided the cystic duct and artery.

The idea of less than complete cholecystectomy for the specific purpose of dealing with difficult operative conditions during cholecystectomy was advanced by Estes, of Bethlehem, PA, in 1938. In an operation for gangrenous cholecystitis on 25 patients, which he termed partial cholecystectomy, the gallbladder was incised longitudinally and the wall of the gallbladder was excised up to the point that it was attached to the liver. The part attached to the liver itself was left behind and the free cut edge of the gallbladder was oversewn. The remaining mucosa was treated with iodine. Estes specifically stated that the cystic duct was not sutured or ligated and that no part of the gallbladder was sutured together to produce a closed cystic structure, ie, a gallbladder remnant. Recovery was
Bornman and Terblanche clearly described and illustrated the principle of safety: to stay 1 step away from danger. McElmoyle described 2 cases of “partial cholecystectomy” in which he resected the free wall of the gallbladder down to the cystic duct. He noted that the cystic artery would be cut within or on the wall of the gallbladder as one trimmed the inferior aspect of the gallbladder wall near the cystic duct and recommended oversewing the wall at that point to occlude the vessel. McElmoyle trimmed the inferior aspect of the gallbladder wall and noted that the cystic artery would be excised specifically for the prevention of bile duct or vascular injury during a difficult cholecystectomy. No attempt is made to dissect the cystic duct or artery when inflammation obscures the neck of the gallbladder. The gallbladder is opened and the redundant portions excised. The cystic duct and the portions of the body, neck, and infundibulum lying above and to the left side are left in situ as a “shield to the vulnerable structures.” The cystic duct is not closed; its mucosa is ablated and a drain is placed. McElmoyle reported 23 cases with excellent results and no biliary fistula. What Estes, Lerner, and McElmoyle all recognized was that a portion of the gallbladder wall should intentionally be left behind as a buffer between the edge of the dissection on the gallbladder and the dangerous hepatocystic triangle. This was the “shield” of McElmoyle, which fulfills a main principle of safety: to stay 1 step away from danger. McElmoyle’s description was particularly eloquent. Bornman and Terblanche clearly described and illustrated a similar operation 30 years later using the name subtotal cholecystectomy, but gave the option of internal suture of the cystic duct or external suture over a probe advanced into the cystic duct from within the gallbladder.

While these authors were describing their techniques, others were presenting a modification in which the lowest portion of the gallbladder was resutured. This step was done to avoid biliary fistula but may also result in the creation of a remnant gallbladder. Maingot, who contributed much to the performance of biliary surgery, and Grey Turner, who recognized the seriousness of biliary injury, suggested a similar approach in 1936 and 1944, respectively, which they dubbed subtotal cholecystectomy. Note that the terms partial and subtotal were used in some cases to describe the same operation, and in neither case did the terms indicate whether a remnant gallbladder was produced.

**MEANING OF PARTIAL AND SUBTOTAL CHOLECYSTECTOMY AND INTRODUCTION OF FENESTRATING AND RECONSTITUTING AS MODIFYING TERMS**

Partial in surgical terminology literally means removal of a part of an organ. It is quantitatively a vague term that can mean removal of a small or large part of the organ. Subtotal means removal of almost all of an organ. It is less vague as to extent. Normally, a partial resection is less than a subtotal resection, as in the terms partial gastrectomy and subtotal gastrectomy. However, a review of the literature showed that in regard to the gallbladder, some authors use the term partial to describe a near total excision; others use the term subtotal to describe the same extent of resection. It is a source of confusion that 2 terms are used for the same procedure. Furthermore, neither term indicates whether a gallbladder remnant is produced as a result of the procedure. The lack of nomenclature relating to gallbladder remnants is also a source of confusion, so much so that recent review articles on this subject have subclassified subtotal cholecystectomies or pointed out the variations. Therefore, 2 adjustments to terminology are required, the first to deal with the overlapping terms partial and subtotal, and the second to introduce words that will indicate whether a particular technique leaves a remnant gallbladder or not.

As a starting point, it is suggested that the term subtotal should be preferred over the term partial to designate the extent of this resection because subtotal is clearly more accurate than partial. If only the top half or less of the gallbladder is removed, which is not what is being discussed in this article, the term fundectomy would seem appropriate. In that way, the term partial cholecystectomy could be completely eliminated in reference to excision of the gallbladder. Secondly, to designate whether or not a remnant gallbladder is produced by the procedure, it is proposed that that the modifiers fenestrating (no gallbladder remnant produced [Fig. 5]) and reconstituting (gallbladder remnant produced [Fig. 6]) be introduced to describe these operations. Therefore, 2 types of subtotal cholecystectomies would be recognized, namely, subtotal fenestrating cholecystectomy and subtotal reconstituting cholecystectomy.

**SUBTOTAL CHOLECYSTECTOMY AND THE CYSTIC DUCT**

As noted in the historical section, the cystic duct and artery were sometimes ligated external to the gallbladder when a less than complete cholecystectomy was performed early in the development of cholecystectomy. But as emphasized by McElmoyle and others, this
method is undesirable when a subtotal operation is performed in the presence of difficult operative conditions. In fact, to do so, the surgeon must use the infundibular technique to display the cystic duct. As explained earlier, this method of identification may be unreliable in the presence of severe inflammation. Under these conditions, occlusion of the cystic duct should be attempted only from the interior of the gallbladder by a purse-string suture, as described in 1 method by Bornman and Terblanche. The suggested alternative method of advancing a probe into the cystic duct from the interior of the gallbladder to identify and ligate the cystic duct

**Figure 5.** Subtotal fenestrating cholecystectomy. (A) The free, peritonealized portion of the gallbladder has been excised except for a lip at the lowest portion of the gallbladder. This acts as a shield to protect against inadvertently entering the hepatocystic triangle (“Shield” of McElmoyle). The portion of the gallbladder adherent to the liver has been left in situ. Stones have been extracted. The cut edge of the gallbladder may be oversewn. The mucosa is usually ablated. The cystic duct may be closed from the inside with a purse-string suture (inset). The cystic duct may be very short, and attempts to ligate the cystic duct outside the gallbladder may result in injury to the common bile duct. (B) As in Figure 5A, except a portion of the gallbladder adherent to the liver has been excised.

**Figure 6.** Subtotal reconstituting cholecystectomy. (A) The free, peritonealized portion of the gallbladder has been excised. The portion of the gallbladder adherent to the liver may be left situ as in Figure 5A or partially excised as shown here. The lowest portion of the gallbladder is closed with sutures or staples, reconstituting an intact lumen in which stones may reform. (B) As in Figure 6A, except that only the lowest part of the gallbladder remains. As in Figure 6A, this is closed, reconstituting an intact lumen in which stones may reform. Whether the subtotal cholecystectomy is “fenestrating” or “reconstituting” depends on whether the lowest part of the gallbladder is left open (fenestrating) or closed (reconstituting) and not on the amount of gallbladder that is left attached to the liver.
external to the gallbladder has the potential danger of advancing the probe into the common bile duct and mistakenly ligating that duct instead of the cystic duct. This would be prone to occur when the cystic duct is very short, as may happen when it is effaced by a large stone.

**SUBTOTAL FENESTRATING CHOLECYSTECTOMY AND SUBTOTAL RECONSTITUTING CHOLECYSTECTOMY: ADVANTAGES, DISADVANTAGES**

Subtotal fenestrating cholecystectomy has the advantage that a remnant gallbladder is much less likely to result than if the lumen of the gallbladder is re-established at Hartmann’s pouch, as in the reconstituting technique. If an ERCP were done immediately after a subtotal reconstituting cholecystectomy, an area at the end of the cystic duct wider than the cystic duct would be present and the criterion of Bodvall and Overgaard for the existence of a gallbladder remnant would be fulfilled. Although closing over Hartmann’s pouch results in a gallbladder remnant, it was found, as might be expected, to reduce the incidence of postoperative bile fistula in the reviews of subtotal cholecystectomy by Henneman and colleagues and Elshaer and associates. However, although bile fistula was more common with the fenestrating technique, these fistulas seem to resolve spontaneously in most cases. Those that do not may be associated with retained common bile duct stones and relieved endoscopically. Based on presently available information, it would seem that the fenestrating type of subtotal cholecystectomy would be preferable, but knowledge in this area is very incomplete. There certainly have been no head-to-head comparisons of fenestrating vs reconstituting techniques. Furthermore, the extent to which Hartmann’s pouch is resected is probably quite variable, and the effect of leaving different size remnants on the chance of developing subsequent symptoms is unknown. In fact, there is no good information regarding the incidence of symptomatic gallbladder remnants after subtotal reconstituting or subtotal fenestrating cholecystectomies. A recent meta-analysis discussed this issue, but articles on the subject rarely provide long-term follow-up of patients, and gallbladder remnants may become symptomatic years after subtotal cholecystectomy, so good data on this topic are lacking. Possibly, there is a watershed in the reconstituting subtotal cholecystectomy procedure in which so little of the gallbladder lumen is left that it is equivalent to occluding the lumen of the cystic duct from within the gallbladder. If so, it must be an occlusion very close to the cystic duct because some symptomatic gallbladder remnants that required excision at a second procedure had an internal diameter of only about 1 cm. Clearly, many important aspects of the outcomes of these operations will not be known until large studies involving small and large hospitals are available. This will not be possible using administrative databases because for now, subtotal cholecystectomy does not have its own CPT code.

The modern technique for performing these operations is straightforward (Figs. 5 and 6). The gallbladder is opened along its long axis and emptied of stones, including removal of stones in the lumen of the gallbladder neck and cystic duct if possible. Also, consideration may be given to attempting imaging either via cholangiography through the lumen of the gallbladder or with intraoperative ultrasound. In either the fenestrating or reconstituting type of procedure, the portion of the gallbladder adherent to the liver is usually left in situ and ablated. The latter may be done with electrocautery, argon beam, or saline-linked radiofrequency ablation. Alternatively, some or all of the gallbladder adherent to the liver may be removed (Figs. 5 and 6). When this is done, the gallbladder wall and cystic plate may be removed down to bare liver, as shown in the diagrams, or the cystic plate may be left in situ. The cut edge of the gallbladder adherent to the liver may be oversewn with a continuous suture. In some cases, the gallbladder will be gangrenous. If so, the gangrenous portion should be excised without extending the extent of the subtotal resection. In the fenestrating procedure, the very bottom of the gallbladder remains open to the peritoneal cavity. There will be a “lip” or “shield” of gallbladder (Fig. 5), where the cystic artery branches come onto the gallbladder and these will be transected at that point. Oversewing the cut edge of the gallbladder here may be necessary, although when inflammation is severe, these vessels are sometimes thrombosed. The cystic duct may be sutured from the inside using fine sutures, although this is often not possible. The area should be carefully drained with 1 or 2 closed suction drains, depending on the extent of the contamination. In the reconstituting type, the lip is usually somewhat larger and the lumen is closed by various means including sutures and staples (Fig. 6). Note again that the procedures are not distinguished by the amount of gallbladder left adherent to the liver, but by whether or not a closed remnant gallbladder is created.

**LAPAROSCOPIC VS OPEN SUBTOTAL CHOLECYSTECTOMY**

Based on the meta-analysis of Elshaer and coworkers, it seems that a subtotal fenestrating cholecystectomy is more likely to be done when an open approach is used.
Paradoxically, in their data, bile leaks were more common after a laparoscopic procedure. Possibly, this is due to the improved ability to suture the cystic duct orifice when the procedure is done open. The ideal procedure in circumstances when the CVS cannot be achieved would have several attributes, including the following:

1. Does not leave a remnant gallbladder that will become symptomatic and require a later operation.
2. Has low morbidity due to bile fistula. If a fistula occurs it should resolve spontaneously over a short period.
3. Can be done laparoscopically.
4. Can be done by a general surgeon without additional fellowship training in hepato-pancreato-biliary or minimally invasive surgery.

These attributes are, in some cases, in tension with each other. Subtotal fenestrating cholecystectomies are understandably less likely to leave a functional gallbladder remnant, which might require a second procedure, but are more likely than subtotal reconstituting cholecystectomies to result in fistulas. Subtotal reconstituting cholecystectomies are probably easier to do laparoscopically and seem to be favored by minimally invasive surgeons, but result in the remnant gallbladder problem. Laparoscopic subtotal cholecystectomy provides the advantages of minimally invasive surgery, but general surgeons, who do most cholecystectomies in the US, may not have the skills to do these procedures laparoscopically.

CONCLUSIONS

Which technique is best may vary with the experience of the surgeon. For a surgeon experienced in minimally invasive techniques, a subtotal fenestrating cholecystectomy with drain placement would seem to best fulfill the listed aims. However, for many surgeons, the safest approach will be to do an open procedure of the same type. The key principle, however, should not be lost in the details of the technique. That principle is that a subtotal fenestrating cholecystectomy is a standard operation that should be used liberally when surgeons encounter difficulty in getting to the CVS. We believe that clarification of the procedures and what they are called will help surgeons choose what type of procedure to select, and it will also facilitate the performance clinical studies in this area.

Author Contributions

Study conception and design: Strasberg, Pucci, Brunt, Deziel

Acquisition of data: Strasberg, Pucci, Brunt, Deziel

Analysis and interpretation of data: Strasberg, Pucci, Brunt, Deziel

Drafting of manuscript: Strasberg, Pucci, Brunt, Deziel

Critical revision: Strasberg, Pucci, Brunt, Deziel

Acknowledgment: The authors gratefully acknowledge the contribution made to this manuscript by Jennifer Brumbaugh, MA, Webmaster and Medical Illustrator, Department of Surgery, Thomas Jefferson University, who produced Figures 5 and 6. The editors are also grateful to Dr Martin Hertl, MD, FACS, Rush University Medical Center, for translation of reference 12.

REFERENCES

11. Kehr H. Introduction to the Differential Diagnosis of the Separate Forms of Gallstone Disease: Based upon His Own Experience Gained from 433 Laparotomies for Gallstones. Philadelphia: P Blakiston’s Son and Co; 1901.