Objectives: To describe a series of patients who have had cystic duct stump leaks (CDSLs) after laparoscopic cholecystectomy and to compare the current presentation and management with that in previous studies.

Design: Two-institution retrospective case series and review of the previously published literature.

Setting: Two teaching hospitals.

Patients: Twelve patients who had CDSLs of 5751 patients who underwent total laparoscopic cholecystectomy.

Main Outcome Measures: Symptoms at presentation, laboratory values, imaging modalities, treatment modalities, and operative indications and techniques.

Results: Between January 1, 1998, and March 31, 2007, 12 patients (0.21%) developed CDSLs a mean of 2.3 days postoperatively. Five patients (42%) were reported to have abnormal cystic ducts. A mean of 3 surgical clips were used for closure. Abdominal pain (58%) was the most common presenting symptom; 9 patients (75%) had an elevated white blood cell count, and 9 (75%) had abnormal liver function test results. Ten patients (83%) underwent endoscopic retrograde cholangiopancreatography (ERCP), and 8 (67%) were definitively treated with ERCP stenting of the common bile duct. Two patients (17%) required adjunctive computed tomography–guided drainage. There was 1 death.

Conclusions: A CDSL can occur for a variety of reasons. Any patient with a postoperative picture consistent with a bile leak should undergo ERCP. If a CDSL is discovered, the common bile duct should be stented. Computed tomography–guided drainage is indicated if the patient does not improve after ERCP. Operative intervention should be reserved for the most serious of circumstances.
ies of patients with CDSLs after LC and review the literature to describe CDSLs since the learning curve of LC has been reached.

**METHODS**

We retrospectively reviewed morbidity and mortality records from The Mount Sinai Hospital, New York, New York, and Elmhurst Hospital Center, New York, since 1998 for the phrase cystic duct stump leak and for each of these words individually. We found 35 distinct patients; after removing improperly categorized cases, we were left with 12 CDSLs. Medical records were reviewed and data were compiled.

We collected data on comorbidities and the reason for performing LC. Operative notes were reviewed for gross findings, methods of duct closure, use of cholangiography, complications, and other pertinent information. We reviewed patients' notes and discharge summaries for in-hospital events. Radiology and endoscopic retrograde cholangiopancreatography (ERCP) findings were also available to illustrate diagnostic and treatment methods.

**RESULTS**

There were 12 reports of CDSLs between January 1, 1998, and March 31, 2007, in 5751 LCs, for an incidence of 0.21% (Table 1). There was a 3:1 female to male ratio, and the mean age of the patients was 44.9 years. One procedure was an emergency, and the remaining were elective. Intraoperatively, 5 of the cystic ducts (CDs) (42%) were reported to be abnormal; 9 (75%) were closed with a mean of 3 titanium clips. Intraoperative cholangiography was performed in 5 patients (42%), and all the results were negative for stones. Six patients (50%) had Jackson-Pratt drains placed intraoperatively (Table 1).

The CDSLs presented a mean of 2.3 days postoperatively, with the most common symptom being abdominal pain (58%) (Table 2). Nine patients (75%) presented with a white blood cell (WBC) count greater than 12,000/µL (to convert to ×10³/L, multiply by 0.001), and 9 (75%) with abnormal liver function test results. Endoscopic retrograde cholangiopancreatography was performed in 10 patients (83%), and 6 of these (60%) were performed in conjunction with another imaging study (Table 3).

Definitive treatment was achieved in 8 patients (67%) via ERCP and stenting. One patient required a second ERCP. Computed tomography (CT)–guided drainage was used to treat 2 patients adjunctionally. Three patients (25%) required surgery, and 1 patient required no intervention. There was 1 death.

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**Table 1. Series of Patients With CDSLs: 1998-2007**

<table>
<thead>
<tr>
<th>Sex/ Age, y</th>
<th>Year</th>
<th>IOC</th>
<th>CD</th>
<th>Closure</th>
<th>JP Drain</th>
<th>Time to Leak, POD</th>
<th>Imaging</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>M/54</td>
<td>1998</td>
<td>No</td>
<td>Edema</td>
<td>Clips, 2 + 2</td>
<td>1</td>
<td>0</td>
<td>ERCP</td>
<td>ERCP + stent</td>
</tr>
<tr>
<td>F/20</td>
<td>1999</td>
<td>No</td>
<td>Normal</td>
<td>Clips, 2 + 1</td>
<td>0</td>
<td>2</td>
<td>HIDA/ERCP</td>
<td>Exploratory laparoscopy + washout</td>
</tr>
<tr>
<td>F/41</td>
<td>2000</td>
<td>No</td>
<td>Normal</td>
<td>Clips, 2 + 1</td>
<td>0</td>
<td>3</td>
<td>CT/HIDA</td>
<td>Exploratory laparotomy + tie</td>
</tr>
<tr>
<td>F/32</td>
<td>2002</td>
<td>Yes</td>
<td>Normal</td>
<td>Clips, 2 + 1</td>
<td>0</td>
<td>3</td>
<td>CT/ERCP</td>
<td>ERCP + stent</td>
</tr>
<tr>
<td>F/29</td>
<td>2002</td>
<td>No</td>
<td>Normal</td>
<td>Clips, 2 + 1</td>
<td>0</td>
<td>2</td>
<td>CT/ERCP</td>
<td>CT-guided drain/ERCP + stent</td>
</tr>
<tr>
<td>F/80</td>
<td>2003</td>
<td>No</td>
<td>Normal</td>
<td>Clips, 1 + 1</td>
<td>0</td>
<td>3</td>
<td>HIDA/ERCP</td>
<td>None</td>
</tr>
<tr>
<td>M/80b</td>
<td>2003</td>
<td>Yes</td>
<td>Normal</td>
<td>Clips, 2 + 1</td>
<td>1</td>
<td>3</td>
<td>ERCP</td>
<td>ERCP + stent</td>
</tr>
<tr>
<td>F/34</td>
<td>2003</td>
<td>No</td>
<td>Ductotomy Sutures</td>
<td>+ 2 clips</td>
<td>1</td>
<td>3</td>
<td>CT/UGI/HIDA/ERCP</td>
<td>CT-guided drain/ERCP + stent</td>
</tr>
<tr>
<td>F/70</td>
<td>2005</td>
<td>No</td>
<td>Normal</td>
<td>Clips, 2 + 1</td>
<td>0</td>
<td>3</td>
<td>CT</td>
<td>Exploratory laparotomy + tie</td>
</tr>
<tr>
<td>F/48</td>
<td>2006</td>
<td>Yes</td>
<td>Short</td>
<td>Endoloop</td>
<td>1</td>
<td>1</td>
<td>ERCP</td>
<td>ERCP + stent</td>
</tr>
<tr>
<td>F/49</td>
<td>2006</td>
<td>Yes</td>
<td>Short</td>
<td>Sutures</td>
<td>1</td>
<td>1</td>
<td>ERCP</td>
<td>ERCP + stent</td>
</tr>
<tr>
<td>F/32</td>
<td>2007</td>
<td>Yes</td>
<td>Short</td>
<td>Clips, 2 + 1</td>
<td>1</td>
<td>1</td>
<td>HIDA/ERCP</td>
<td>ERCP + stent</td>
</tr>
</tbody>
</table>

Abbreviations: CD, cystic duct; CDSL, cystic duct stump leak; CT, computed tomography; ERCP, endoscopic retrograde cholangiopancreatography; HIDA, cholescintigraphy; IOC, intraoperative cholangiography; JP, Jackson-Pratt; POD, postoperative day; UGI, upper gastrointestinal.

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**Table 2. Presenting Symptoms in 12 Patients With CDSLs**

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Patients, No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain</td>
<td></td>
</tr>
<tr>
<td>Right upper quadrant</td>
<td>5 (42)</td>
</tr>
<tr>
<td>Left upper quadrant</td>
<td>1 (8)</td>
</tr>
<tr>
<td>Epigastric</td>
<td>1 (8)</td>
</tr>
<tr>
<td>Subtotal</td>
<td>7 (58)</td>
</tr>
<tr>
<td>Nausea</td>
<td>5 (42)</td>
</tr>
<tr>
<td>Bilious drain output alone</td>
<td>5 (42)</td>
</tr>
<tr>
<td>Vomiting</td>
<td>2 (17)</td>
</tr>
<tr>
<td>Peritoneal signs</td>
<td>1 (8)</td>
</tr>
<tr>
<td>Fever</td>
<td>1 (8)</td>
</tr>
<tr>
<td>Anorexia</td>
<td>1 (8)</td>
</tr>
<tr>
<td>Respiratory failure</td>
<td>1 (8)</td>
</tr>
</tbody>
</table>

Abbreviation: CDSL, cystic duct stump leak.

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**Table 3. Imaging Techniques Used to Diagnose CDSLs**

<table>
<thead>
<tr>
<th>Diagnostic Imaging</th>
<th>Total, No. (%)</th>
<th>Diagnostic Bile Leak, No. (%)</th>
<th>Diagnostic CDSL, No. (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERCP</td>
<td>10 (83)</td>
<td>10 (83)</td>
<td>10 (83)</td>
</tr>
<tr>
<td>CT</td>
<td>5 (42)</td>
<td>5 (42)</td>
<td>2 (17)</td>
</tr>
<tr>
<td>Cholescintigraphy</td>
<td>5 (42)</td>
<td>4 (33)</td>
<td>2 (17)</td>
</tr>
<tr>
<td>UGI series</td>
<td>1 (8)</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Abbreviations: CDSL, cystic duct stump leak; CT, computed tomography; ERCP, endoscopic retrograde cholangiopancreatography; UGI, upper gastrointestinal.
PATHOGENESIS

On reviewing the available literature, we found 276 CDSLs reported in 227,386 LCs (0.12%) (Table 4). It has been hypothesized that emergency LC for acute cholecystitis would be associated with a higher incidence of CDSL because inflammatory changes may lead to a more challenging dissection. This has not always been shown to be true. In one large series from 1996, 46.6% of CDSLs occurred in acute cholecystitis. In the present series, only 1 CDSL occurred in this setting.

Numerous theories abound regarding the etiology of CDSLs. The most commonly discussed theory is displacement of a surgical clip from the CD stump. It has become common practice to place at least 2 clips on the proximal side of the CD for insurance. Despite this, it is often because, when presented with a short CD, the surgeon anticipated the risk of postoperative leak.3 Indications included an edematous CD, after repair of an inadvertent ductotomy, and emergency LC for gangrenous cholecystitis.1 All were assumed to pose a high risk of postoperative bile leak. If a patient is believed to be at risk for a postoperative CDSL, appropriate drain placement for a postoperative bile leak is suggested. This idea is further supported in another study3 in which 50% of patients with CDSLs required excessive electrocautery for intraoperative bleeding.

Ischemic necrosis caused by devascularization of the CD has also been implicated.1,3,4,17 In one article,17 a pseudoaneurysm of the right hepatic artery caused by traumatic dissection was implicated as causing a CDSL. To avoid disrupting blood flow from minor perforating vessels and to prevent ischemia, it has been suggested that the cystic artery be divided distally, closer to the gallbladder.

Finally, it has been hypothesized that retained CBD stones can lead to excess pressure in the biliary tree, leading to either perforation of the CD or displacement of the surgical clips. This is rare and has been implicated in only 3% to 5% of CDSLs in the largest series.1,3

PRESENTATION

The average time to detection of a CDSL is 3 to 4 days from the date of operation.3,4,13 The most common presenting symptom is abdominal pain, typically in the right upper quadrant (76%-78%). Nausea and vomiting are also common (35%), followed by fever (18%-27%).3,4,13

The present series varies somewhat from the literature in that 5 patients presented with no symptoms other than bilious output from intraoperatively placed drains. Half of the patients in this series had drains placed, most often because, when presented with a short CD, the surgeon anticipated the risk of postoperative leak.3 Indications included an edematous CD, after repair of an inadvertent ductotomy, and emergency LC for gangrenous cholecystitis.1 All were assumed to pose a high risk of postoperative bile leak. If a patient is believed to be at risk for a postoperative CDSL, appropriate drain placement may help minimize symptoms and expedite diagnosis. These risk factors include aberrant duct morphologic features, a challenging dissection, poor intraoperative visualization, and critical illness.

Elevated WBC count has been described in up to 68% of patients with CDSLs.3 In the present series, 9 patients (79%) presented with a WBC count higher than 12,000/µL. Of the other 3 patients, 1 had 21% bandemia and an-
other was critically ill and likely unable to generate an appropriate WBC count.

Liver function test results are highly variable in CDSLs. One major series showed the direct bilirubin level to be elevated to greater than 1.5 mg/dL (to convert to micromoles per liter, multiply by 17.104) in 29% of patients with CDSLs. Aspartate aminotransferase, alanine aminotransferase, and alkaline phosphatase levels were elevated in 56%, 68%, and 67% of patients, respectively, in another series.

IMAGING

Any patient presenting after LC with right upper quadrant pain or nausea and vomiting should be assessed by ultrasonography. Ultrasonography is useful for screening for biloma or ascites or to rule out CBD injury or retained stones. However, it cannot detect the site of the bile leak. In one large study, ultrasonography correctly identified abnormalities in 24 of 24 patients with CDSLs. These results are uncommon, and it can be expected that the results might seem more like those of Braghetto et al, who reported that ultrasonography found only 2 of 13 leaks before postoperative day 4. When ultrasonography was repeated after postoperative day 5, all the patients had positive findings. Numerous other publications have reported that early ultrasonography for bile leaks is inaccurate.

Cholescintigraphy and CT may also be used. Although both are good at detecting bile leaks and bilomas, respectively, neither can pinpoint the exact location of bile extravasation. Computed tomography has been described to be almost 100% sensitive in detecting leaks, whereas cholescintigraphy is closer to 90% sensitive in detecting leaks. Although there is the possibility that a carefully interpreted cholescintigram can show a CDSL, these results are highly unreliable without a corroborating ERCP or magnetic resonance cholangiopancreatogram (MRCP).

The most successful imaging modality for correctly diagnosing CDSLs is ERCP. This study enables the physician to identify the precise location of the leak, allowing one to tailor treatment to the specific leak encountered. In one series, of 30 CDSLs were correctly diagnosed via ERCP. In numerous smaller studies, all CDSLs that underwent ERCP were accurately diagnosed. Endoscopic retrograde cholangiopancreatography is also the primary treatment modality in most postoperative biliary leaks, diminishing delay in therapy once the diagnosis has been confirmed.

Another imaging modality that has proven utility in CDSLs is MRCP. It has been found to be 95% sensitive and 100% specific in identifying bile leaks. In the same series, MRCP pinpointed the exact site of leakage in 14 of 20 patients. Although this is comparable to ERCP, MRCP offers none of the therapeutic advantages associated with ERCP. One area in which MRCP possesses an advantage over ERCP is when a bile leak occurs above a biliary obstruction. In this situation, MRCP is preferable because its contrast accumulates in an antegrade, rather than a retrograde, manner. Also, MRCP should be used instead of ERCP when there is concern for a patient's ability to tolerate anesthesia.

TREATMENT

As previously mentioned, endoscopic treatment of CDSLs has quickly become the standard of care. A variety of techniques have been used, including sphincterotomy, sphincterotomy with stenting, and endoscopic nasobiliary drain placement. These techniques are hypothesized to be beneficial because bile will flow via the path of least resistance. If the physician can provide a lower-resistance path, such as a stented CBD, bile will preferentially flow into the duodenum rather than out the CD. Diversion of the biliary flow provides the opportunity for the CD to heal spontaneously. This has been documented to be effective in numerous series. Wise Unger et al treated 47% of their CDSLs endoscopically, with a 94% cure rate by 1996. Likewise, Woods et al had treated 47% of their leaks up to 1994 in this manner, with a 100% cure rate.

Several research groups had previously advocated use of the endoscopic nasobiliary drain via the 1990s. These tubes, however, were found to be irritating, could easily be displaced from their desired location, and required prolonged hospitalization. By watching outputs and performing daily cholangiograms via these drains, it was shown that most diverted CDSLs spontaneously sealed quickly, usually within a week.

It is now common practice to perform a sphincterotomy and to stent the CBD, because we know that a well-drained CDSL will spontaneously close quickly, it enables one to perform a definitive procedure, to monitor the patient in the hospital for a brief stay, and to discharge the patient when symptoms resolve. Stents are typically removed after 4 to 8 weeks.

Another possibility is ERCP with sphincterotomy (EST) and no endoprosthesis placement. Although stents are indicated if there is a stricture of the CBD, theoretically, in normal CBDs, it should be sufficient to open the papilla to enable biliary drainage. There have yet to be any prospective randomized studies comparing EST with and without stent to stenting with and without EST for CDSLs. There is, however, a large series that compared the 3 options for all types of biliary leaks. Kaffes et al found that, in patients treated endoscopically for all types of biliary leaks, stent alone or with EST was superior to EST alone.

Radiologically guided drainage of the biloma has also been used in treating CDSLs. Although it is possible to treat the CDSL primarily with a percutaneous drain, we suggest that this be reserved as an adjunctive therapy or for patients who cannot undergo the stresses of an ERCP. Spontaneous closure of the CD has been reported to take as long as 6 to 8 weeks when treated in this manner. This procedure is useful for immediate evacuation of biloma and can be used in an acutely decompensating patient as a temporizing measure until definitive treatment can be achieved.

Another less invasive treatment that can be used is percutaneous transhepatic biliary drainage. This has been demonstrated to be effective in CDSLs in small series, but literature on the topic is minimal. In one study, the procedure was effective 88% of the time at closing bile leaks, but the mean length of stay in these patients was 33 days, and they had a 35% complication.
rate. Stents can also be passed percutaneously over a wire.\textsuperscript{20} This treatment has fallen out of favor since the advent of ERCP-directed stents. One may consider percutaneous transhepatic biliary drainage in patients who may not be amenable to ERCP due to illness or to ampullary obstruction or in those with complicated anatomy, for example, after Roux-en-Y gastric bypass.

Reexploratory surgery for biliary leaks should be reserved only for the patient whose condition fails to improve after other treatment modalities have been exhausted. Neither laparoscopy or laparotomy are benign procedures in this setting, and both are associated with high morbidity (22%-37%) and mortality (3%-18%).\textsuperscript{31} Despite the risks, operative intervention is a highly effective method of stemming a CDSL and has been shown to be 83% to 100% successful in the largest CDSL series.\textsuperscript{3,4}

Avoiding intervention has been advocated for a few patients with very mild CDSLs. In the series by Wise Unger et al.,\textsuperscript{3} they observed 2 of 58 patients who had successful drainage from intraoperatively placed drains. One of 17 patients in the study by Woods et al\textsuperscript{4} was also successfully observed without intervention. Observation should be reserved for stable patients with minimal symptoms, and they should be closely counseled on when to return to the emergency department.

Deaths do occur after CDSL, usually unrelated to the leak itself. One of 12 patients in the present study and 2 of 58 patients in the study by Wise Unger et al\textsuperscript{3} were critically ill and died of causes unrelated to leakage after treatment. For the rest, definitive treatment is usually achieved.

Cystic duct stump leaks are an uncommon complication of LC. They occur after emergency or elective LCs and often involve abnormal CDs. Given an abnormal CD, CDSL may be avoided by limiting the use of clips and instead using an endoloop or suture, perhaps combined with a harmonic ligature. It may also be necessary to leave the CD open and to leave a T tube or drain in, followed by postoperative ERCP. Finally, it may also be helpful to leave a drain in intraoperatively and to observe the patient for a day or 2 longer than usual.

If a patient has symptoms of abdominal pain (particularly in the right upper quadrant), nausea, or vomiting during the 3 to 4 days after LC, CDSL should be included in the differential diagnosis. This differential diagnosis may also include leaks from a variety of other places in the biliary tree or from the gallbladder fossa as well as postoperative hemorrhage, inadvertent enterotomy, CBD injury, and retained stones. In the case of a CDSL, the WBC count will likely be elevated, with or without liver enzyme elevation, and the hematocrit level will be stable. An ultrasonogram may show fluid collection in the right upper quadrant. Regardless of whether the ultrasonographic findings are positive, the next step should be to obtain a CT scan to evaluate any collections and to rule out nonbiliary causes. Cholescintigraphy may also be performed if CT proves to be inconclusive.

If a bile leak is still suspected, the patient should be scheduled for ERCP to evaluate the location of the leak. If a CDSL is found, a sphincterotomy should be performed and a stent placed, with care taken to evaluate for retained CBD stones, which should be removed. If the patient’s symptoms do not improve within 2 to 3 days of this procedure or if the patient is critically ill, CT-guided percutaneous drainage should be performed. Patients should recover well from this complication and should have no lingering symptoms. If the patient does not respond, surgical exploration may be necessary.

After 20 years of performing LCs, CDSLs still occur with the same frequency as they have always occurred. The greatest accomplishment in this period has been the advancement of numerous minimally invasive treatment modalities. The CDSLs can be treated promptly, with minimal morbidity and mortality and with shorter hospital stays.

**CONCLUSIONS**

**REFERENCES**


