Gallbladder Disease

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Abstract
The incidence of pediatric gallbladder disease continues to increase with changing risk factors in children. The most common etiology for gallbladder disease is cholelithiasis, which can be secondary to hemolytic or nonhemolytic causes. Gallstones can result in various presentations, including symptomatic cholelithiasis, acute cholecystitis, choledocholithiasis, cholangitis, or biliary pancreatitis. Other acalculous gallbladder pathology is also being diagnosed with increasing frequency in children. These acalculous conditions include gallbladder hydrops, acalculous cholecystitis, biliary dyskinesia, and gallbladder polyps. Each of these conditions can be differentiated with an appropriate diagnostic work-up consisting of a thorough history and physical examination, laboratory evaluation, and a focused radiographic work-up. Ultimately, the management will be dictated by the condition and treatment options and may include antibiotics, endoscopic retrograde cholangiopancreatography, laparoscopic cholecystectomy, or a combination of these modalities. The variations in presentation, multiple related conditions, and increasing frequency necessitate that all pediatric providers feel comfortable with the diagnosis and management of gallbladder disease in children.

Keywords
Gallbladder · Cholecystectomy · Choledocholithiasis · Cholelithiasis · Cholangitis · Cholecystitis · Biliary Dyskinesia

Introduction
The frequency of gallbladder disease in children is increasing with a resultant increase in the number of cholecystectomies performed (Rothstein and Harmon 2016). Many countries have observed an increase in the prevalence of pediatric gallstones and cholecystectomy with increasing childhood obesity (Greer et al. 2018). In the United States, the estimated number of cholecystectomies performed in children has risen from approximately 5500 in 1997 to nearly 8500 in 2009 (HCUPnet 2013). This increasing incidence of gallbladder disease in children correlates with changes in the most common etiologies and risk factors for biliary disease in children (Mehta et al. 2012).

Diagnostic Work-Up
The initial history and physical examination will often provide enough information to raise the suspicion of a gallbladder etiology for the child’s symptoms. Common presenting symptoms include right upper quadrant abdominal pain, nausea, and vomiting. Laboratory tests including a complete blood count (CBC), liver function tests (LFTs), and pancreatic enzymes (amylase/lipase) are often appropriate. An elevation in the white blood cell count (WBC) may indicate an inflammatory process, while an elevation in the serum bilirubin or alkaline phosphatase may indicate a biliary obstructive process. Imaging studies can be especially helpful. The most common radiographic studies are ultrasonography (US), hepatobiliary iminodiacetic acid (HIDA) scan, and magnetic resonance cholangiopancreatography (MRCP).
Ultrasonography

US is the preferred initial radiographic study in the work-up of suspected gallbladder disease and documents the presence or absence of gallstones, gallbladder wall thickening, and/or pericholecystic fluid (Fig. 1). Additionally, the common bile duct (CBD) size, the presence of CBD stones, the liver, and the pancreas can be evaluated. The sensitivity and specificity of US to detect gallstones and acute cholecystitis is over 90% in adults (Oddsdottir 2005). However, in children, this has not been studied as extensively, and some reports indicate the sensitivity may be as low as 82% (Tsai et al. 2013). Regardless, US is the best initial imaging study in a child with suspected gallbladder disease.

HIDA Scan

A HIDA scan should be obtained in children that do not have gallstones on US, but do have symptoms suggestive of biliary disease. The HIDA scan uses $^{99m}$-technetium-labeled iminodiacetic acid derivatives to assess cystic duct patency and gallbladder function. A nonvisualized gallbladder after intravenous injection of the radiolabelled marker, with prompt filling of the CBD and duodenum, is an indication of cystic duct obstruction (Fig. 2). This finding is highly diagnostic of acute cholecystitis, with a sensitivity and specificity approaching 95% (Oddsdottir and Hunter 2005). In a HIDA scan with normal gallbladder filling, a cholecystokinin (CCK) analogue infusion can then be used to calculate the gallbladder ejection fraction. A low gallbladder ejection fraction (< 35%) is diagnostic of biliary dyskinesia.

MRCP

A MRCP is a useful imaging study for complicated gallbladder disease with suspected biliary obstruction or pancreatic involvement. This is a noninvasive test that can accurately evaluate the bile ducts and pancreatic ducts, with the added benefit of avoiding radiation. It has a sensitivity of 95% and specificity of 89% in detecting choledocholithiasis (Liu et al. 2001). However, sedation or anesthesia may be required to obtain an optimal study, especially in younger children.

Fig. 1 (a, b) Ultrasound images in the long and transverse direction which show pericholecystic fluid (white asterisk), gallstones layering in the gallbladder (black asterisk), and acoustic shadowing in a 12-year-old with acute abdominal pain and cholecystitis. Sludge is seen anterior to the gallstones. The gallbladder wall is thickened due to the inflammation and measures 4.4 mm.
Gallstone-Related Conditions

Gallbladder disease in children and adults is most commonly secondary to gallstones. The prevalence of gallstones in the pediatric population ranges from 0.13% to 1.9% (Svensson and Makin 2012; Wesdorp et al. 2000). The exact prevalence varies by country, but overall has increased over time. The increasing prevalence is considered to be multifactorial, including the increased use of abdominal US, changes in the modern diet, and increasing childhood obesity.

The etiology of the gallstones can be classified into hemolytic or nonhemolytic causes. Hemolytic cholelithiasis results from excess bilirubin found in increased hemolytic states, while nonhemolytic cholelithiasis results from a variety of causes leading to gallstone formation.

Gallstone Formation

Gallstones form from an imbalance in the concentration of bilirubin, bile salts, phospholipids, and cholesterol that result in the precipitation of solutes and stone formation. This primarily results in four types of gallstones in children: cholesterol, black pigment, calcium carbonate, and brown pigment stones. Cholesterol stones primarily contain cholesterol (70–100%), with variable amounts of bile pigments and calcium. Black pigment stones are primarily associated with hemolytic disease and total parental nutrition (TPN). Calcium carbonate stones are more common in children than adults, and are associated with systemic illness and transient cystic duct obstruction. Brown pigment stones are quite rare and are associated with bacterial biliary tract infections (Poffenberger et al. 2012; Svensson and Makin 2012).

Hemolytic Cholelithiasis

Historically, hemolytic cholelithiasis was the most common etiology for gallstones in children. Although nonhemolytic cholelithiasis is becoming more frequent, hemolytic cholelithiasis remains a significant source of gallstones. The most common hemolytic disorders leading to gallstone formation are sickle cell disease (SCD), hereditary spherocytosis, and thalassemia.

The overall incidence of cholelithiasis in patients with SCD is approximately 50%. In children with SCD, the incidence of cholelithiasis increases with age, with approximately 30% of children having cholelithiasis by the age of 10. However, almost 50% of sickle cell patients found to have cholelithiasis are asymptomatic (Gumiero et al. 2008). Elective laparoscopic cholecystectomy should be considered in patients with symptomatic cholelithiasis, or in patients in whom symptomatology cannot be differentiated from a sickle cell crisis. Additionally, an incidental cholecystectomy may be appropriate in asymptomatic patients who are undergoing an abdominal operation for other reasons. However, due to the significant risk of postoperative complications in patients with SCD, prophylactic cholecystectomy is not currently recommended in asymptomatic patients, though this issue is somewhat controversial.
Sickle cell patients are at a higher risk for postoperative complications including sickle cell events, transfusion complications, and even death after cholecystectomy. These patients often undergo preoperative blood transfusion to achieve a hemoglobin level of 10.0 g/dL to decrease the risk of postoperative complications (Haberkern et al. 1997).

Hereditary spherocytosis is another hemolytic disease commonly associated with cholelithiasis. The overall incidence of cholelithiasis in this population ranges from 43% to 63%; however, it is uncommon before 10 years of age (Bates and Brown 1952). Those patients with symptomatic cholelithiasis should undergo cholecystectomy, and patients that are scheduled for an elective splenectomy should have an abdominal US to determine if a concomitant cholecystectomy should be performed for cholelithiasis.

The other common hemolytic disorder associated with cholelithiasis is thalassemia. However, the incidence of cholelithiasis in these patients has significantly decreased due to the use of hypertransfusion regimens that decrease the production of the fragile red blood cells.

Nonhemolytic Cholelithiasis

Nonhemolytic cholelithiasis is increasing in frequency, and the etiology is often believed to be secondary to changes in the enterohepatic circulation. In neonates and infants, the most common cause of nonhemolytic cholelithiasis is the use of TPN (King et al. 1987; Matos et al. 1987; Roy and Belli 1985). Approximately 43% of children receiving long-term TPN develop cholelithiasis (Komura et al. 1993). The mechanism behind TPN-related cholelithiasis is not well understood; however, bile stasis secondary to the lack of enteral stimulation and changes in bile composition caused by the amino acid infusions are speculated to play a role. Other factors that also contribute to cholelithiasis in this population include septicemia, dehydration, chronic furosemide therapy, short bowel syndrome, and ileal resection for necrotizing enterocolitis (El-Shafie and Mah 1986; Manji et al. 1989; Quigley et al. 1993).

In older children, the etiology of nonhemolytic cholelithiasis becomes more similar to the adult population. The most common causes include the use of oral contraceptives, cystic fibrosis, pregnancy, obesity, sepsis, and ileal resection. Reversible cholelithiasis, or biliary pseudolithiasis, has also been described in patients receiving ceftriaxone; however, the majority of these patients are asymptomatic or have resolution of the stones with cessation of therapy (Alemayehu et al. 2014).

Symptomatic Cholelithiasis

Cholelithiasis in the pediatric population is more likely to be symptomatic at presentation when compared to adults with gallstones (Svensson and Makin 2012). These patients are characterized by recurring attacks of pain, and often are found to have chronic cholecystitis on histological study. The described pain is secondary to intermittent obstruction of the cystic duct by a gallstone that results in a progressive increase in tension in the gallbladder wall.

Clinical Presentation

The most common presenting symptom is abdominal pain that is predominantly in the right upper quadrant, and less frequently in the epigastric region. The pain is often severe, episodic, and may develop after a fatty meal. This may be accompanied by nausea and vomiting. Typically, the patient will describe discrete attacks followed by periods that are pain free. Physical examination may be unremarkable or demonstrate mild right upper quadrant abdominal tenderness during episodes of pain.

Diagnosis

US will demonstrate gallstones or gallbladder sludge without any secondary signs of pathology (gallbladder wall thickness, pericholecystic fluid, or biliary ductal dilatation) (see Fig. 1). If
laboratory studies are obtained, the CBC, LFTs, and pancreatic enzymes are often normal.

Management
Patients with symptomatic cholelithiasis should undergo an elective laparoscopic cholecystectomy. The primary reason is to prevent gallstone-related complications including acute cholecystitis, choledocholithiasis, biliary pancreatitis, and cholangitis. The exception may be infants under 3 years of age. The management of these younger patients should be individualized. In infants that have been on prolonged TPN, there have been reports of spontaneous resolution of gallstones. Therefore, it is reasonable to observe these patients, in the absence of complications, for approximately 6–12 months following cessation of TPN and initiation of enteral feeding.

Acute Cholecystitis

Acute cholecystitis is most often secondary to gallstones. The typical inciting event is obstruction of the cystic duct by a stone, which then leads to gallbladder distention and inflammation. The inflammation results in edema of the gallbladder wall and can lead to secondary bacterial contamination.

Clinical Presentation
The pain associated with acute cholecystitis is similar to the pain described with symptomatic cholelithiasis, except that it is often more severe and persistent. Additionally, the patient may be febrile and complain of nausea, vomiting, and/or anorexia. On physical exam, the patient usually has reproducible right upper quadrant tenderness and a Murphy’s sign, which is inspiratory arrest with deep palpation of the right subcostal region.

Diagnosis
US will demonstrate gallstones (unless acalculous acute cholecystitis is present), gallbladder wall thickening, and pericholecystic fluid. Laboratory evaluation will usually reveal a moderate leukocytosis and normal LFTs, although a mild elevation of LFTs and pancreatic enzymes may be present. In cases where the diagnosis is not clear after US, a HIDA scan may be helpful in diagnosing acute cholecystitis. A gallbladder that fails to fill is indicative of a cystic duct obstruction, and is diagnostic of acute cholecystitis (see Fig. 2). Meanwhile, a normal HIDA scan excludes acute cholecystitis.

Management
The initial management of patients with acute cholecystitis includes intravenous fluids and antibiotics. This is followed by semi-urgent laparoscopic cholecystectomy or an interval cholecystectomy scheduled approximately 6–8 weeks after resolution of the acute episode. Several studies in adults have demonstrated that delayed cholecystectomy is associated with more gallbladder-related complications (recurrent cholecystitis, choledocholithiasis, or pancreatitis) and that early intervention is more cost-effective and results in quicker recovery times (Gurusamy et al. 2010; Lo et al. 1998). A recent study reported that chronic cholecystitis is underappreciated with 45% of the 170 patients presenting with acute symptoms and 55% of patients presenting with chronic symptoms (Blackwood and Grabowski 2017).

Choledocholithiasis

Common bile duct stones can be categorized as primary stones that form in the bile ducts, or the more common secondary stones that form within the gallbladder and pass through the cystic duct into the CBD. The incidence of choledocholithiasis increases with age, and is not very common in the pediatric population.

Clinical Presentation
The pain associated with CBD stones is usually similar to the biliary colic experienced by patients with symptomatic cholelithiasis. There may also be associated nausea and vomiting. On physical
examination, the patient may have mild right upper quadrant or epigastric tenderness, and there may be associated scleral icterus if the stone is causing biliary obstruction. If the stone is impacted, the patient may progress to develop jaundice.

**Diagnosis**

Similar to other gallstone-related conditions, the radiographic work-up begins with US. This test is useful to determine the presence of gallstones and in detecting biliary ductal dilatation, which may be located in the CBD or the more proximal hepatic ducts. An adjunct test that is helpful for confirmation or, in unclear cases, of choledocholithiasis is an MRCP. The MRCP provides detailed evaluation of the biliary system while avoiding radiation. Laboratory studies commonly demonstrate an elevated serum bilirubin, alkaline phosphatase, and transaminases.

**Management**

There are a number of management strategies available for treating patients with choledocholithiasis (Mah et al. 2004; Newman et al. 1997; Shah et al. 2001; Zargar et al. 2003). The most common strategies include preoperative endoscopic retrograde cholangiopancreatography (ERCP), laparoscopic CBD exploration at the time of cholecystectomy, and postoperative ERCP. Early ERCP offers diagnostic confirmation of choledocholithiasis and the added advantage of a therapeutic option with sphincterotomy and stone extraction; however, the availability of a provider to perform the ERCP in a child varies by institution. Often the choice of management is determined by the surgeon’s comfort with laparoscopic CBD exploration and the availability of pediatric ERCP. With the infrequency of choledocholithiasis in children, some recommend that patients undergo preoperative ERCP with sphincterotomy and stone extraction. If this is successful, then the surgeon can proceed with a routine laparoscopic cholecystectomy. However, if the preoperative ERCP is unsuccessful in extracting the stone, then the surgeon can plan for a common duct exploration at the time of the cholecystectomy.

**Cholangitis**

Cholangitis, which is an ascending bacterial infection, is one of the potential complications associated with CBD stones. Biliary obstruction secondary to choledocholithiasis may lead to bacterial contamination of the bile and subsequently ascending cholangitis.

**Clinical Presentation**

Patients with acute cholangitis classically present with fever, right upper quadrant pain, and jaundice, which is also known as Charcot’s triad. This may progress to include confusion and septicemia (known as Reynolds pentad) with a delayed presentation; however, this is more commonly found in the elderly population than in children. The severe right upper quadrant tenderness found on physical exam is similar to what is found with acute cholecystitis.

**Diagnosis**

The diagnosis of acute cholangitis is initially a clinical diagnosis based on history, physical exam findings, and laboratory studies. The laboratory evaluation will commonly reveal a leukocytosis and elevated serum bilirubin, alkaline phosphatase, and transaminases. The suspicion of cholangitis can be confirmed by US that shows the gallstones and dilated biliary ducts. Further radiographic imaging is typically not necessary.

**Management**

The initial management of acute cholangitis includes intravenous fluid resuscitation and antibiotics. After stabilizing the patient, urgent biliary decompression is usually required. In these patients, ERCP can be diagnostic and therapeutic through stone extraction and sphincterotomy.

**Biliary Pancreatitis**

A second potential complication of choledocholithiasis is obstruction of the pancreatic duct leading to biliary pancreatitis. This can be secondary to an impacted stone, or more commonly, a
Transient obstruction that was caused by a gallstone passing through the ampulla.

Clinical Presentation
These patients will often have similar presenting symptoms to other gallstone-related conditions with right upper quadrant and epigastric abdominal pain, nausea, and vomiting. It is much less common for patients to have associated fevers or jaundice.

Diagnosis
The diagnosis of biliary pancreatitis is based on an elevation of pancreatic enzymes on laboratory evaluation and the presence of gallstones. If there is no prior history of gallstones, then US may still be helpful for further evaluation. The remainder of the laboratory studies including WBC, serum bilirubin, and transaminases is often normal.

Management
These patients are usually managed with intravenous fluids and bowel rest until resolution of the acute pancreatitis. After the acute episode has resolved, the patient should undergo laparoscopic cholecystectomy during the initial hospitalization. Delayed cholecystectomy after discharge leads to a higher readmission rate and may result in an increase in the total length of hospitalization (Knott et al. 2012).

Acalculous Conditions
All gallbladder pathology is not related to gallstones. In the pediatric population, acalculous conditions including gallbladder hydrops, acalculous cholecystitis, biliary dyskinesia, and gallbladder polyps are being diagnosed more frequently. The increasing incidence of some of these diagnoses is believed to be secondary to the rise in the number of critically ill children.

Gallbladder Hydrops
Hydrops of the gallbladder is characterized by acute distention and edema in the wall of the gallbladder without evidence of gallstones, infection, or congenital anomalies. This is most often associated with severe sepsis or shock. Gallbladder hydrops has also been reported in association with Kawasaki’s disease due to a transient obstruction of the cystic duct or to increased mucus secretion by the gallbladder resulting in poor emptying (Bishop and Kao 1991; Chamberlain and Hight 1970; Choi and Sharma 1989; Edwards et al. 1985; Egritas et al. 2007). Most cases of hydrops resolve with conservative management. If there is progression of symptoms with increasing gallbladder distention on serial US, or evidence of a gangrenous gallbladder, then cholecystectomy may be necessary.

Acalculous Cholecystitis
Acalculous cholecystitis, similar to hydrops, is most frequently found in critically ill patients with severe sepsis, shock, burns, or trauma. Patients have often been on prolonged TPN leading to bile stasis, gallbladder distention, and potential ischemia. A combination of these factors leads to gallbladder wall edema and the potential for bacterial colonization. US is usually the initial diagnostic test; however, a nonvisualized gallbladder on a HIDA scan can be used for diagnosis in unclear cases. Initial management includes intravenous antibiotics and fluids. The decision regarding timing of cholecystectomy should be made based on the condition of the patient. Placement of a percutaneous cholecystostomy tube may be considered in unstable patients.

Biliary Dyskinesia
Biliary dyskinesia is an increasingly common diagnosis and reason for cholecystectomy in children (Al-Homaidhi et al. 2002; Carney et al. 2004; Halata and Berezin 2008). The condition is believed to result in poor gallbladder contractility that leads to bile stasis, microscopic bile crystallization, and mucosal irritation. These patients typically present with biliary colic symptoms and have no evidence of gallstones on US. Also,
patients have often undergone additional investigation to exclude another etiology. The diagnosis is usually made based on the calculated gallbladder ejection fraction determined by a HIDA scan with CCK infusion. A low ejection fraction (<35%) is diagnostic of biliary dyskinesia. Laparoscopic cholecystectomy is the treatment of choice and results in symptom resolution in approximately 80% of patients. Evaluation of the gallbladder specimen reveals that the majority of these patients have histopathologic evidence of chronic cholecystitis (Misra et al. 1991).

Gallbladder Polyps

Gallbladder polyps are rare in children; however, the increased use of US has resulted in greater identification of these lesions. Although long-term follow-up is not available for these patients, it is currently advisable to proceed with laparoscopic cholecystectomy for symptomatic children or patients with a polyp ≥1 cm in size (Stringel et al. 1997).

Laparoscopic Cholecystectomy

The laparoscopic approach is recognized as the standard method for cholecystectomy in children. The advantages of laparoscopy over the open approach include decreased postoperative pain, reduced length of hospital stay, improved cosmesis, and reduced overall convalescence. The procedure is performed under general anesthesia with endotracheal intubation; however, it does not require nasogastric tube or urinary catheter insertion.

Four-Port Technique

The patient is placed supine on the operating room table with two video monitors situated at the head of the table. The operating room table should be suitable for fluoroscopy if an intraoperative cholangiogram is planned. A 10-mm incision is made in the umbilicus, through which a 10-mm cannula is inserted into the abdominal cavity, and abdominal insufflation is initiated. Pneumoperitoneum is established, and a 10-mm 45° telescope connected to a camera is inserted through the umbilical cannula. The epigastric port is the main working site, and a 5-mm cannula is placed under direct visualization. On rare occasion, a 10-mm cannula may be necessary at this site to introduce a 10-mm endoscopic clip to completely occlude the cystic duct in larger patients.

Two additional ports are used for retraction of the gallbladder. The location of the two additional incisions depends on the patient’s age and size. The right lower abdominal stab incision is created with a No. 11 blade under direct visualization, and a locking, grasping forceps is introduced for retraction of the gallbladder superiorly over the liver by the assistant. The second stab incision is created in the right upper abdomen, and a non-locking, grasping forceps is inserted for lateral retraction of the infundibulum of the gallbladder by the operating surgeon. These two instruments are usually 5-mm instruments, but 3-mm instruments can be used in smaller and thin children (Fig. 3). Two additional 5-mm cannulas can be placed at these sites instead of making stab incisions; however, there can be a significant reduction in charges by eliminating these cannulas (Ostlie and Holcomb 2003). Once the cannulas are placed based on the patient’s size, the remaining principles of the procedure are similar to those used in adults.

The operating room table is then adjusted to place the patient in steep reverse Trendelenburg and a left-dependent position. This helps improve exposure by allowing the adjacent viscera to fall away from the operative area. Additionally, the infundibulum is retracted laterally to position the cystic duct in more of a 90° orientation to the CBD, rather than its usual oblique or even parallel orientation (Fig. 4a). This parallel orientation may result in incorrect identification of the cystic and common bile ducts resulting in injury to the common duct.

The initial goal in the dissection is to adequately expose the cystic duct and artery. This requires exposure of Calot’s triangle, which can be attained by lysing adhesions between the
duodenum, stomach, and infundibulum. Once the anatomy is clear, the cystic duct can be ligated with 5-mm clips. Two clips are placed on the cystic duct approximately 5 mm from its insertion into the common duct (Fig. 4b). One or two additional clips are placed on the cystic duct near the infundibulum, and then the cystic duct is divided. If the anatomy is unclear, the duct is larger than expected, or there is concern for biliary obstruction on preoperative studies, then a cholangiogram is performed prior to ligating the duct. After the cystic duct is divided, the cystic artery is ligated and divided in a similar fashion. Once these two structures are divided, the gallbladder is detached from the liver bed in a retrograde manner using either a right-angled hook, spatula, or endoscopic scissors attached to electrocautery (Fig. 5). Prior to completely detaching the gallbladder from the liver bed, the area of dissection is inspected for adequate hemostasis.

Once the gallbladder is completely separated, the telescope is moved to the epigastric 5-mm port, and the gallbladder is removed through the umbilical port. If the gallbladder cannot be extracted easily, then the umbilical fascial opening is extended to accommodate removal of the gallbladder without rupture and spillage of stones and bile. The abdomen is then reinspected for hemostasis and irrigated if there was any bile spillage during the procedure. The cannulas are then removed under direct visualization and the umbilical fascia is closed. The fascia of the 5-mm port site is re-approximated in smaller children; otherwise the stab incisions and 5-mm port site only require skin closure. The patients are then discharged from the hospital the same day or the next morning.

Single-Site Technique

Single-site umbilical laparoscopic surgery (SSULS) is being utilized more frequently for common surgical procedures like cholecystectomy (Seifarth et al. 2017; Raboe et al. 2019). When compared to traditional laparoscopic surgery, the only advantage of SSULS may be cosmesis.

For single-site laparoscopic cholecystectomy, a 2-cm umbilical incision is made and a SILS port (Covidien, Inc., Norwalk, CT) or TriPort (Olympus America Inc., Center Valley, PA) is inserted (Fig. 6). The SILS port is a foam port with three channels through which the telescope and instruments are introduced. A fourth instrument can then be introduced for gallbladder retraction directly through the umbilical incision, next to the foam port. The SILS port also has a separate channel for insufflation. The TriPort is designed for three instruments, but a fourth 3-mm instrument can be inserted through one of the insufflation channels. For these procedures, a 30 or 45° long telescope is used to give the operating surgeon greater working space. The grasping instrument that is used to retract the dome of the gallbladder over the liver edge is introduced at approximately the 9 o’clock position in the SILS or TriPort. From this point, the remainder of the procedure proceeds in a similar fashion to the traditional four-port laparoscopic cholecystectomy. However, after the gallbladder is
completely detached, the specimen is exteriorized through the umbilicus along with the large port. The umbilical fascia is then closed in an interrupted or continuous fashion, and the umbilical skin edges are re-approximated. The patients are then discharged home, like the traditional four-port laparoscopic cholecystectomy patients, the same day or the next morning (Fig. 7).

Complications

Postoperative complications following laparoscopic cholecystectomy are most common in children with hemolytic disease, and these are secondary to manifestations of the underlying disease. Outside of this population, the main complications associated with laparoscopic cholecystectomy include CBD injury, bile leak, and infections.

The most significant complication is injury to the common duct. The rate of ductal injury seems to be decreasing with greater experience; however, in the adult population 1 patient per 1000 laparoscopic cholecystectomies continues to require ductal reconstruction. There are no publications discussing the rate of ductal injury in children, but the rate is thought to be lower based on the fact that far less children present with the severe inflammation commonly found in the adult population. Regardless, any surgeon performing a laparoscopic cholecystectomy should be familiar with the potential complications and how to manage them.

If a ductal injury is recognized at the time of operation, then the injury should be repaired via an open procedure, and there should be a low threshold to perform a hepaticojejunostomy. Biliary injuries that result in ductal obstruction or delayed strictures can be temporized with percutaneous transhepatic drainage. Definitive repair or reconstruction for these injuries should be performed at a center with a large experience in biliary reconstruction.

Bile leak is a complication that usually presents in the first 1–2 postoperative weeks. The most common reason for a postoperative bile leak...
after a laparoscopic cholecystectomy is a leak from the cystic duct stump or the gallbladder fossa (ducts of Luschka). The location of the leak can be confirmed with an ERCP. During the same procedure, a sphincterotomy should be performed with stent placement. The majority of leaks will resolve secondary to the change in pressure in the biliary system with preferential drainage via the common duct.

Infectious complications are less common following laparoscopic cholecystectomy. The most common reason for intra-abdominal infections is spilled gallstones. Therefore, any spilled stones should be removed at time of the initial procedure to decrease the likelihood of infectious complications.

Fig. 6 This photograph shows a SILS port (Covidien Inc., Norwalk CT) (a) and a TriPort (Olympus America Inc., Center Valley, PA) (b) which are being used for a single-site umbilical laparoscopic cholecystectomy. Note the fourth instrument (solid arrow) placed alongside the SILS port which is used for cephalad retraction of the gallbladder. In the TriPort, a 3-mm instrument (dotted arrow) can be inserted through one of the insufflation channels for the same purpose.

Fig. 7 These two photographs depict the postoperative appearance in a child undergoing a four-port laparoscopic cholecystectomy (a) and a single incision laparoscopic cholecystectomy (b). On the right, the girl’s belly-button ring has been removed. (From Holcomb et al. 2014)
Conclusions and Future Directions

As gallbladder-related disease continues to increase in frequency in children, it is important that all pediatric providers feel comfortable with the diagnosis and management of these conditions. A significant amount can be learned from the adult experience, and there is an increasing body of literature with a focus on children; however, the experience of many pediatric surgeons is still limited. Continued evaluation and research into the changing trends in pediatric gallbladder disease will lead to improved outcomes.

Cross-References

- Biliary Atresia
- Congenital Biliary Dilatation
- Pancreatic Disorders

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