Percutaneous Imaging-guided Abdominal and Pelvic Abscess Drainage in Children

Debra A. Gervais, MD • Stephen D. Brown, MD • Susan A. Connolly, MD • Sherry L. Brec • Mukesh G. Harisinghani, MD • Peter R. Mueller, MD

Percutaneous imaging-guided drainage is the first-line treatment for infected or symptomatic fluid collections in the abdomen and pelvis, in the absence of indications for immediate surgery. The technology and expertise needed to perform percutaneous abscess drainage are widely available and readily adapted for use in the pediatric population. Catheter insertion procedures include the trocar and Seldinger techniques. Imaging guidance for drainage is most commonly performed with ultrasonography (US), computed tomography, or US and fluoroscopy combined. Abscesses in locations that are difficult to access, such as those deep in the pelvis, subphrenic regions, or epigastric region, can be drained by using the appropriate approach—transrectal, transgluteal, intercostal, or transhepatic. Although the causes of abscesses in children differ slightly from those of abscesses in the adult population, the frequency of successful treatment with percutaneous abscess drainage in children is 85%–90%, similar to that in adults. With expertise in imaging-guided drainage techniques and the ability to adjust to the special needs of children, interventional radiologists can successfully drain most abscesses and obviate surgery. Successful adaptation of abscess drainage techniques for pediatric use requires attention to the specific needs of children with respect to sedation, dedicated resuscitation and monitoring equipment, avoidance of body heat loss, minimization of radiation doses, and greater involvement of family compared with that in adult practice.

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Introduction
Imaging-guided percutaneous drainage of abdominal and pelvic abscesses was initially developed and used in adults. However, because the successful treatment of abscesses with percutaneous drainage either obviated surgery altogether or facilitated surgery by providing a clean operative field, the technique was soon adapted for use in the pediatric population (1–4). This article reviews the indications for and contraindications against percutaneous abscess drainage, the specific needs of pediatric patients during the procedure, catheter insertion techniques, use of imaging modalities for guidance, methods of catheter fixation and management, techniques for draining abscesses in difficult locations, postdrainage imaging, common causes of organ-specific abscesses, and reported results of percutaneous abscess drainage in children.

Indications and Contraindications
Although fluid collections have diverse origins, the purposes of percutaneous intervention in all such collections may be classified in one or more of the following three categories: to obtain a fluid sample for diagnosis, to completely drain the fluid from an abscess or symptomatic collection, or to treat a recurrent collection by instilling a sclerosing agent (1). With respect to diagnosis, aspirated fluid can be sent for laboratory analysis to determine whether it is benign or malignant. Microbiologic analysis may reveal an organic cause of infection, but when it does not, a cell count performed on the fluid may help confirm the presence of white blood cells and, thus, infection. A positive result of aspirate culture may provide additional guidance with respect to antibiotic choice, through susceptibility testing of the culture. In some cases, laboratory analysis of a specimen may reveal the cause of the abscess; for example, a high creatinine level helps confirm a diagnosis of urinoma, and a high bilirubin content helps confirm a diagnosis of biloma or bile leak.

With respect to treatment, abscesses generally require a combination of either percutaneous or surgical drainage and antibiotics for complete cure, since antibiotics do not reach sufficient concentrations within abscess cavities. Exceptions are very small abscesses of 1–3 cm in diameter, which sometimes resolve with antibiotic therapy alone. In these cases, a period of observation and waiting may be appropriate. To obtain material for culture and susceptibility testing, needle aspiration may be performed. Infection is not the only indication for drainage. Symptoms such as pain or pressure from a large noninfected fluid collection, or obstruction of the bowel or ureter, are also indications for drainage. Patients with abscesses under pressure benefit from the immediate decompression provided through drainage. Finally, the percutaneous drainage catheter also may be used as a conduit for infusing a sclerosing agent into a recurrent collection.

Contraindications for percutaneous treatment are relatively few. The main ones are uncorrectable coagulopathy, lack of safe percutaneous access, and inability of the patient to cooperate. For practical purposes, the absence of a safe percutaneous path is the only factor that prohibits percutaneous abscess drainage, since in most instances coagulopathy can be corrected to allow drainage. The presence of bowel near the abscess may preclude percutaneous abscess drainage (Fig 1). Abscesses located near or between bowel loops are not amenable to percutaneous catheter drainage and may require surgery if the patient experiences symptoms of peritonitis. However, in the absence of acute peritonitis, needle aspiration of an interloop abscess can be performed to obtain material for culture. Transection of the bowel with a small (19–22 gauge) needle is generally safe. However, transgression of the colon should be avoided, as the colonic flora will contaminate the specimen and may cause infection in the fluid collection.
Other structures through which catheter placement is contraindicated include the large blood vessels and organs such as the spleen and pancreas. Patient cooperation can generally be ensured with the assistance of an anesthesiologist, if need be.

**Specific Needs of Children**

Physicians, nurses, and technologists in pediatric hospitals are attuned to the needs of children, but the interventional radiology team in a general hospital must remember that children in the interventional radiology suite have specific needs. These needs include an appropriate level of sedation, dedicated equipment for monitoring and resuscitation, avoidance of body heat loss, minimization of radiation doses, and greater involvement of parents and family compared with that in adult practice. Young children require deep sedation or general anesthesia during interventional procedures. Sedation is a continuum with four recognized stages: anxiolysis (mild sedation), moderate sedation (so-called conscious sedation), deep sedation, and general anesthesia. The induction of deep sedation requires specific training and is generally performed either by anesthesiologists or by nurses or radiologists who have undergone that training (5–7). Competence in the delivery of deep sedation includes the ability to restore the patient from a condition of general anesthesia to deep sedation if an unintended transition to the deeper level takes place. A plan of sedation is established during the preprocedural assessment of the patient, and the methods used for the delivery of sedation must comply with the hospital policies (6,7). Intraprocedural monitoring and documentation of physiologic parameters (blood pressure, pulse, and blood oxygen saturation) is necessary, as is intermittent assessment of airway patency (6,7). The deepest sedation is needed during the most painful part of the procedure, whereas more moderate sedation may be used during preparation and while the catheter is being secured.

Intravenous pentobarbitol (2–3 mg per kilogram of body weight, titrated to a maximum dose of 6 mg per kilogram of body weight), midazolam (0.05 mg per kilogram of body weight, titrated to a maximum dose of 0.15 mg per kilogram), and fentanyl citrate (1 mcg, titrated to a maximum dosage of 3–4 mcg per kilogram of body weight per 20 minutes) are typically used for deep sedation (5–7). Recently, intravenous ketamine (2 mg per kilogram of body weight) has been introduced as an effective alternative to general anesthesia for interventional radiologic procedures in selected pediatric patients, in whom it has been administered under the radiologist’s supervision (8,9). Atropine sulfate (0.01 mg per kilogram of body weight) or glycopyrrolate (0.005 mg per kilogram of body weight) may be administered intravenously as an adjunct to ketamine, to decrease tracheobronchial and salivary secretions that result from ketamine (9). The use of ketamine may result in nightmares and hallucinations in adolescent patients and therefore is generally restricted to younger patients (9). If ketamine is used in older children, intravenous midazolam may be added to reduce the frequency of nightmares (8).

If sedation is performed by an anesthesiologist, intravenous propofol may be used to achieve deep sedation with rapid onset and rapid recovery. Certification in either pediatric advanced life support or a combination of basic life support, airway education, and sedation education is mandatory for nurses and physicians who administer deep sedation in children.

The interventional radiology suite must be equipped with blood pressure cuffs, oral airways, endotracheal tubes, face masks, and venous lines of the various sizes appropriate for use in children (6). In addition, because children’s bodies have a higher surface area-to-volume ratio and therefore lose heat more quickly than those of adults, all body parts that need not be exposed for the procedure should be covered. The use of heating lamps, blanket warmers, and warm US gel can help to limit heat loss. Because children vary in size, various amounts of radiation will be needed to obtain images of sufficient quality to guide percutaneous intervention. If computed tomography (CT) is used to guide abscess drainage, the lowest possible tube current and scanning time are used. For fluoroscopically guided interventions, the use of pulsed fluoroscopy should be considered if the means are available. Gonadal shields also should be used if possible. Standard techniques for decreasing the patient’s overall radiation exposure—for example, minimization of the distance between the image intensifier and the patient, as well as of the magnification power, collimation, and number of spot film images acquired—also should be used. The capture of fluoroscopic images with the photograph-and-store option is an effective strategy for reducing the number of spot film images that must be acquired.
Catheter Insertion Techniques

There are two methods for introducing a catheter into an abscess, both of which start with the insertion of a needle into the abscess cavity. Each method has its proponents, as well as its advantages and disadvantages. Operator preferences are usually a matter of personal experience.

**Trocar Technique**

The trocar technique involves a catheter mounted on a sharp trocar and inserted into the abscess in tandem with a guiding needle (Fig 2). The accurate placement of the guiding needle is of the utmost importance to ensure the safety of this technique and the accurate positioning and deployment of the catheter. The needle length should be chosen so that several centimeters extend outside the skin while the needle is securely positioned within the abscess. The external portion of the needle serves as an accurate guide for catheter placement. When the guiding needle is in the correct position, a small incision is made in the skin alongside the needle, and blunt dissection is performed. The catheter, mounted on the trocar, is then advanced in perfect parallel with the guiding needle to a premeasured depth. Even if the shape of the abscess is affected by respiratory or other motion, the external portion of the guiding needle will indicate the appropriate path and angle of entry into the abscess. Advantages of this technique include the ability to rapidly deploy the catheter, which is essential if the temporal window for sedation is nearing its end. Disadvantages include the difficulty of repositioning a catheter that has been deployed suboptimally on the first pass.

**Figure 2.** Imaging-guided drainage of an appendiceal abscess with use of the trocar technique in an 11-year-old male patient. (a–c) Axial CT images obtained with oral and intravenous contrast material show a thick-walled abscess (arrow in a), a guiding needle placed in the abscess (arrow in b), and a 10-F drainage catheter (black arrow in c) deployed parallel to the guiding needle in the abscess (white arrow in c), which has been decompressed.
Seldinger Technique

The Seldinger technique (Fig 3) involves the insertion of a hollow needle into the abscess cavity and the placement of a guide wire through the needle to create a percutaneous path for a drainage catheter. After the guide wire is inserted, the needle is withdrawn and the catheter is placed over (ie, around) the wire and inserted into the abscess. The percutaneous deployment of 8–14-F catheters requires the use of 0.035- or 0.038-inch wires. The needle puncture can be performed with a needle system that accommodates these wires (generally, 18-gauge angiographic needles or 19-gauge needles sheathed in 5-F catheters) or with a “skinny” (21- or 22-gauge) needle that accommodates a 0.018-inch wire. In the latter case, a dilator-and-sheath system is used either to exchange the 0.018-inch wire for a 0.035- or 0.038-inch wire (Fig 3) or to insert a 0.035- or 0.038-inch working wire while the 0.018-inch wire is left in place as a safety wire. Advantages of the Seldinger technique include the ability to direct the wire to the precise location desired for catheter deployment. Precise positioning is especially necessary in large abscesses, such as those that occur in the subphrenic region, and in locations in which access is tightly restricted. Disadvantages of the technique include the difficulty of

Figure 3. Imaging-guided drainage of an appendiceal abscess with use of the Seldinger technique in a 12-year-old patient with Crohn disease. (a) Axial CT image shows a large abscess (solid arrows) with a thick enhancing wall. At this axial level, the proximity of the bowel (open arrows) precludes an anterior percutaneous approach. However, inferior to this level, a small anterior projection of the abscess was readily accessed with US guidance (not shown). The bowel directly anterior to the abscess at this level was inflamed, and its appearance is affected by partial-volume averaging. (b, c) Fluoroscopic spot film images show the sheath system (b) used to direct a working wire (arrow) into the largest and farthest cephalic part of the abscess after placement of a needle with US guidance, and the dilated catheter (c) deployed over the wire. Part of the catheter is seen in duplex, an artifact caused by catheter motion during pulsed fluoroscopy for dose reduction.
working with wires in confined spaces, and the multiple steps involved in dilation. In addition, when dilators and wires are used with CT guidance, any buckling or kinking of the wire can be problematic. Leakage from small fluid collections around the wire during needle removal and dilations may substantially reduce operating space in the abscess and make catheter placement more difficult. Tissue elasticity is typically high in young children, and the insertion of the dilator or catheter into the abscess is difficult even in the best of circumstances; the implement may be deflected from the abscess wall and merely displace the fluid collection instead of penetrating it.

**Imaging Modalities**

The most straightforward imaging guidance modality for abscess drainage in children is ultrasonography (US). US allows real-time observation of the abscess and the catheter, without exposure of the patient to ionizing radiation. In large and readily accessible abscesses, deployment of the catheter by using the trocar technique with real-time US observation is the simplest and fastest way to achieve percutaneous drainage. However, if US depicts only part of an abscess or if more precise catheter positioning is required because of the proximity of adjacent structures, US must be supplemented with fluoroscopy for guidance of catheter deployment. Fluoroscopy is used to monitor wire manipulations in catheters placed with the Seldinger technique. Limitations of US include its inability to depict the entire extent of an abscess in a deep location such as the pelvis. In addition, an abscess that is partially obscured by bowel air can be difficult to localize, and an abscess that contains air may be difficult to see or impossible to differentiate from bowel at US. CT is free from these limitations (Fig 4). CT guidance can be performed either with standard incremental acquisition of a few contiguous axial images in the area of interest or with CT fluoroscopy (10–12).

**Catheter Fixation and Management**

Most radiologists use two means of catheter retention: an internal retention mechanism and an external fixation device. For internal retention, most radiologists use locking pigtail catheters. A string that courses through the catheter is fixed in place near the hub of the catheter; this “pigtail”
prevents inadvertent catheter withdrawal. The string is made in such a way that it will break under excessive tension or pressure, thus ensuring that the catheter will not rupture inside the patient, although inadvertent catheter removal may result. Other specially designed external fixation devices have been developed to obviate the need to suture the catheter to the patient’s skin. Catheters may be taped or sewn to a device that adheres to skin. This method avoids the skin irritation caused by sutures, as well as the need for suture removal. For very young children, however, even the detachment of a simple adhesive device may be painful, and an adhesive removal solution may be useful.

The abscess cavity is decompressed at the time of drainage with direct suction by using a syringe attached to the catheter. Some operators use a method analogous to surgical lavage and irrigate the abscess cavity with 10–15-mL aliquots of 0.9% saline to encourage further drainage of thick debris. Irrigation of the abscess, however, must be performed with a lesser volume of fluid than that previously drained from the abscess, to avoid an increase in intracavitary pressure with resultant bacteremia and sepsis.

After the catheter is secured in place in the decompressed abscess, the catheter should be flushed every 8–12 hours with 5–10 mL of saline solution to clear the tube of any adherent plugs or encrustations that might cause blockage. The active participation of the interventionalist in hospital rounds will help to ensure that the catheter is flushed regularly (13). In addition, patient rounds provide an opportunity to monitor catheter output, assess the clinical course, and observe any changes in the appearance of the drained fluid (13,14). Active management by the interventional radiologist can enhance the success of drainage and minimize catheter-related problems (13). The catheter position should be assessed to ensure that the catheter is not withdrawing from the abscess, and the access site and dressing should be carefully examined. Difficulty in flushing a catheter may indicate a clog. If the abscess is incompletely drained, a clogged catheter will have to be exchanged for a new catheter. Changes in the character of the drained fluid may be the first indication of a fistula, and further imaging may then be indicated. If a fistula is suspected and no sepsis is present, an abscessogram may be obtained via catheter for signs of communication with structures such as the bowel, pancreatic and biliary ducts, or genitourinary system. In the presence of sepsis, this examination is deferred so as not to exacerbate sepsis. The interventional radiologist also is actively involved in deciding the time of catheter removal.

**Drainage in Difficult Locations**

With an unobstructed percutaneous pathway to the abscess and clear depiction of the abscess at US, placement of a catheter is straightforward. However, abscesses in some locations may pose special challenges.

It may be difficult to access fluid collections deep in the pelvis, because of anterior bowel, bladder, and uterus; lateral bones and blood vessels; and posterior bones. In such abscesses, percutaneous access with routine anterior or lateral approaches is often impossible. If an abscess is close to the rectum, a transrectal approach may be used. The transrectal approach (Fig 5) has proved very successful for draining appendiceal abscesses located posterior to the bladder (15–17). Dedicated endoluminal US transducers equipped with specialized hardware may be used with this approach to guide the needle or catheter into the appropriate position. In some pediatric patients, however, the rectal vault may be too small to allow insertion of the US transducer, or the patient may not tolerate it. In such patients, transrectal drainage can still be performed with US guidance by using an anterior approach, a routine surface transducer, and bladder distention to create an acoustic window. The operator positions the catheter while observing the real-time US images. Either the trocar or the Seldinger technique may be used. When considering use of the transrectal approach, which is not sterile, the interventionalist should assess the
Figure 5. Imaging-guided drainage of an appendiceal abscess with the Seldinger technique and a transrectal approach in a 12-year-old female patient. (a) US image shows a large pelvic abscess (solid arrows) and the computer-generated path (open arrows) the needle will follow during its insertion into the abscess with the aid of a guide mounted on the US transducer. (b) US image shows the sheathed needle (open arrow), which has been inserted into the abscess (solid arrows). (c) US image shows a guide wire (arrows) positioned in the abscess. (d, e) Fluoroscopic images (e at a higher magnification than d) show the wire and catheter during placement. (f) Axial CT image obtained 5 days later shows that complete drainage has been achieved.
patient's overall clinical condition to determine whether infection is very likely present in the fluid collection; the goal is to avoid inducing infection in a sterile fluid collection. Transrectal catheters, though their presence may seem awkward at first, are well tolerated by most pediatric patients and permit them to ambulate and use the bathroom as they normally would.

The transgluteal approach (Fig 6) through the greater sciatic foramen is an alternative approach to deep pelvic abscesses (18,19). Initially described by Butch et al (18), the transgluteal approach requires CT guidance and patient positioning in either the prone or the decubitus position. Butch et al cited a higher incidence of pain (approximately 20% of patients) with this approach (18), and some therefore recommend that the approach not be used in children. However, Gervais et al (19) have shown the transgluteal approach to be reasonably well tolerated by children. The choice of transrectal versus transgluteal access to a deep pelvic abscess is often determined by operator preference. The transgluteal approach has the advantage of allowing percutaneous access to abscesses located farther cephalad. In addition, use of the transgluteal approach is strongly favored in abscesses in which infection is uncertain, because this approach allows drainage while using strict sterile technique.

**Figure 6.** Imaging-guided drainage of an appendiceal abscess with use of the tandem trocar technique and a transgluteal approach in a 6-year-old male patient. (a) Axial CT image shows an abscess (arrows) deep in the pelvic cavity, a location in which an anterior percutaneous approach is precluded because of proximity to the bowel. (b) Axial CT image obtained with the patient prone shows the placement of a guiding needle (straight arrow) through the greater sciatic foramen and into the abscess. A medial approach was used to avoid impingement on the sciatic nerve, which courses through the lateral aspect of the foramen (curved arrow). (c) Axial CT image shows a catheter (arrows) that has been inserted alongside the needle.
Subphrenic Abscesses
Subphrenic abscesses may develop after surgery or trauma (Fig 7). A left subphrenic abscess, for example, may occur after splenectomy, and a right subphrenic abscess may be related to liver trauma or liver transplantation surgery. When possible, the abscess is drained with a subcostal approach. If there is no possible subcostal percutaneous path to an abscess, intercostal access may be necessary (20). Intercostal access is safest with the most caudal and anterior approach possible, because the anterior pleural reflection is farther cephalad than the posterior reflection. Most patients who undergo intercostal subphrenic abscess drainage do not develop pleural complications, but all patients should be carefully monitored for such occurrences (20,21). Ideally, subphrenic abscess drainage should be performed by using US guidance to position a needle in the most caudal aspect of the fluid collection, with the needle tip pointed cephalad to allow the subsequently placed wire to migrate cephalad beneath the diaphragm. The catheter then should be deployed with its tip just below the diaphragm.

Epigastric Abscesses
The posterior epigastric region may be difficult to access with an anterior approach because of the stomach, with a lateral approach because of the liver and spleen, and with a posterior approach because of bone and kidneys. In very young or small children, a paucity of abdominal fat may further limit access. In older children with more abdominal fat, anterior approaches often are used (Fig 8), but other possible approaches include a posterior approach lateral or medial to the kidneys. CT guidance is extremely valuable for percutaneous drainage of abscesses in this region, because of the depth of the location and its proximity to vital structures. A transhepatic route may be used that transgresses the periphery of the liver (22). More central transgression of the liver should be avoided because of the large vessels and bile ducts. The spleen, because of its vascularity, also is not generally transected to reach another target. Likewise, the normal pancreas is not typically transgressed, because of the risk of pancreatitis.
Postdrainage Imaging: Challenges and Pitfalls

Many pediatric patients need no further imaging after percutaneous abscess drainage if the clinical course improves and catheter output declines to less than 10 to 20 mL daily. This is especially true in children with appendiceal abscesses. However, persistent fever, pain, or leukocytosis after percutaneous abscess drainage suggests that further imaging may be needed. CT is most commonly used to monitor the adequacy of drainage, as well as the development of new abscesses. If CT images show that the abscess is completely drained, a decision to remove the catheter may be made, depending on the presence or absence of continued drainage. However, if CT images show incomplete resolution of the abscesses despite optimal catheter positioning, then catheter patency should be reassessed with a 5- to 10-mL saline flush. If the catheter is patent and well positioned but the abscess persists, the catheter should be exchanged for a larger catheter (Fig 9). Locking
pigtail catheters as large as 14 F are available. In general, the smallest catheter that should be placed initially is 8 or 10 F, since pus is viscous and will not drain effectively otherwise.

Adjuvant thrombolytic therapy may be used to break down fibrin and facilitate drainage (23). Streptokinase in a dose of 120,000 units and tissue plasminogen activator in a dose of 2 to 10 mg may be administered in normal saline solution. Although there is little reported experience with intracavitary tissue plasminogen activator, abundant anecdotal evidence that accumulated when urokinase was commercially unavailable, from 1998 to 2002, supports its use. Doses of tissue plasminogen activator have not yet been standardized and vary among institutions. The volume of normal saline used may be as much as 50 mL, but it must be adjusted according to the size of the abscess and the volume of fluid drained. A 200- to 300-mL abscess in an older child will accommodate a 50-mL instillation, but a 30-mL abscess in a younger child will not. The volume instilled should be less than the volume of abscess contents already removed, so as not to place the abscess contents under excessive pressure and risk sepsis. The thrombolytic agent is left inside the abscess for 20 to 30 minutes and is then allowed to drain. Treatment twice daily for 3 days is generally effective. CT after a 3-day course may be used to evaluate the effectiveness of thrombolytic therapy and to guide further management.

In some patients with persistent or recurrent symptoms, CT may show that the catheter has been displaced and is either no longer in the abscess or remains in the abscess but in a position suboptimal for drainage. In these situations, the catheter must be repositioned. CT also may depict new and completely separate fluid collections that must be drained before the patient’s clinical condition will improve.

In some patients, a fistula may be suspected. The presence of a fistula may be indicated by the underlying disease process or the character of the drained fluid. Conditions such as Crohn disease or pancreatic duct injuries, which may occur after surgery in the left upper abdominal quadrant, are likely to be associated with fistulas. In addition, the presence of a fistula may be signaled by a change in the appearance of the drained fluid. In the initial period of drainage, most abscesses yield purulent fluid. However, after 2 or 3 days, most of the pus will have drained, and if a fistula is present, the fluid that follows it will have entered the abscess cavity via the fistula. The drainage volume may actually increase at this point, and the appearance and viscosity of the fluid will change as a result of its different origin. Fistulas can arise in the gastrointestinal tract, the genitourinary tract, the biliary system, or the pancreatic duct. When a fistula is suspected, a sinogram may be useful for diagnosis and localization. If the suspected fistula is in the bowel, CT may be performed with oral contrast material to confirm the diagnosis (Fig 10). Prolonged drainage may allow a fistula to close, but in some cases surgery may be necessary. In many situations, adjunctive procedures short of open surgery may facilitate fistula healing. For example, in patients with infected bilomas from trauma or iatrogenic causes, sphincterotomy with endoscopic biliary stent placement may be performed to facilitate internal drainage of bile and minimize bile leakage into the abscess cavity. Likewise, in patients with urinomas formed by posttraumatic urine leaks, a ureteral stent or a percutaneous nephrostomy catheter may be placed to divert flow away from the urinoma and facilitate closure of the fistula. In patients with a high-output enteral fistula, prolonged parenteral nutrition and exclusion of oral nutrition may be necessary. Abscess recurrence after
Figure 10. Unsuccessful drainage of multiple abscesses in a 15-year-old female patient with Crohn disease after sigmoid colon resection and anastomosis creation. (a, b) Axial CT images obtained to determine the source of postoperative fever show fluid collections (straight arrows in a) just above and posterior to the bladder (curved arrow in a) and in the paracolic gutters (arrows in b). Because the enhanced peritoneum indicated inflammation, the fluid had to be sampled for testing or drained. (c–e) Axial CT images show the insertion of a needle (arrows in c), guide wire (arrows in d), and 10-F catheter (arrows in e) for drainage of the fluid near the bladder with the Seldinger technique. (Fluid in the paracolic gutters was drained with the trocar technique.) Despite triple antibiotic therapy and drainage of all fluid collections, the fever did not resolve. (f–h) Axial CT images obtained with instillation of rectal contrast material show enhancement and distention of the cavities that contain the two most caudal catheters (straight arrows in f and g), as well as contrast material flowing into the peritoneum (curved arrows in g) and extending cephalad to the subhepatic space (curved arrows in h). Massive anastomotic leak was diagnosed, and the patient underwent anastomotic revision.
successful drainage is rare; it is found in less than 5% of patients (Fig 11). In some patients, repeated percutaneous drainage may be successful, but other patients may eventually require surgery. In rare cases, drainage failure may result from misdiagnosis. Many conditions might cause transient leukocytosis and fever, symptoms that could lead to the misinterpretation of CT findings as abscesses. However, minimal fluid drainage and little change in the appearance of the lesion on images should prompt consideration of other diagnoses, such as low-density tumors (Fig 12). Tumors, it must be remembered, also may become infected, and percutaneous abscess drainage is indicated also for treatment of tumor abscesses. In these abscesses, the catheters may have to remain in place indefinitely unless the underlying tumor resolves.

**Figure 11.** Recurrent abscess in a 6-year-old female patient with appendicolith. (a) Axial CT image obtained 1 week after initial transrectal drainage shows only the catheter (arrow) and no residual fluid, a finding that, with the patient’s improved clinical status and low catheter output, led to the removal of the catheter. (b) Axial CT image at a level more cephalad than a shows an appendicolith (arrow). (c) Axial CT image, obtained when the patient returned with fever and pain 2 weeks after catheter removal, shows a recurrent abscess (arrows) that may be secondary to the appendicolith.

**Organ-Specific Abscesses and Their Causes**

Peripancreatic fluid is a common CT finding in patients with pancreatitis and does not require intervention in most cases (24). Pancreatitis in children is commonly the result of trauma but is idiopathic in an estimated 30% (25); medications are another frequent cause of pancreatitis. A standardized classification system has been developed for fluid collections associated with pancreatitis, in part to help guide therapy (26). Acute peripancreatic fluid collections are small, generally have a triangular shape, and are associated with acute
pancreatitis (25). In general, acute collections are not infected. However, if superinfection of a peripancreatic fluid collection is suspected, percutaneous imaging-guided needle aspiration may be performed to obtain a specimen for culture (Fig 13). By definition, a pancreatic abscess is any peripancreatic fluid collection that is infected.

Figure 12. Drainage failure due to misdiagnosis of a pelvic lesion in a 6-year-old female patient transferred from an outside hospital for treatment. (a) Axial CT image from the outside hospital shows an apparent pelvic abscess (arrows), in which transrectal drainage was subsequently performed. (b) Axial contrast-enhanced CT image obtained because of scant drainage 4 days after the procedure shows irregularly enhanced contents and no change in the size of the apparent abscess, which was subsequently diagnosed as a dysgerminoma.

Figure 13. Fluid collection in a 6-year-old female patient with pancreatitis. (a) Axial CT image shows a peripancreatic fluid collection (arrows) that extends caudad in the abdomen and pelvis, in a location in which percutaneous drainage is indicated only for an infected abscess. Because pancreatitis may cause fever, leukocytosis, and peripancreatic fluid accumulation even without the presence of infection, needle aspiration was performed and Gram stains were analyzed to determine whether complete drainage was necessary. (b) CT fluoroscopic image shows needle placement (arrows) in a retroperitoneal fluid collection in the paranephric space. Three other fluid collections (not shown) also were aspirated. Gram stains showed no white blood cells or organisms, and drainage therefore was unnecessary.
In infected fluid collections, percutaneous drainage is indicated (Fig 14). Alternatively, the abscess may be surgically drained. A pancreatic pseudocyst requires 4 to 6 weeks to form, and most resolve spontaneously (27). Many are asymptomatic. Drainage is indicated only if the patient is symptomatic or demonstrates signs of bowel or biliary obstruction. Pancreatic necrosis also may result in collections of material with the attenuation of fluid at CT. This necrotic material, however, is very viscous and often does not drain completely via catheter. If the area of necrosis is not infected, then the recommended treatment is supportive care. If the area becomes infected, then surgery is indicated. In some cases, the necrotic tissue liquefies and is then amenable to catheter drainage.

Pyogenic hepatic abscesses are rare (<1% incidence) in children, and their origin is usually hematogenous. They are most common in children who are immunocompromised, but they can occur also after portoenterostomy or umbilical vein catheterization. Gallbladder disease also may result in hepatic abscesses. Small abscesses may respond to antibiotics without drainage, and drainage is typically reserved for very large abscesses or those that do not respond to antibiotic therapy alone (28). Entamoeba histolytica is the most common cause of hepatic abscesses worldwide. Diagnosis is based on the results of serologic testing, and amoebic abscesses are generally treated with metronidazole alone, without percutaneous or surgical drainage. Percutaneous drainage is performed, however, if pyogenic superinfection of an amoebic hepatic abscess is suspected (29). It also may be performed in an abscess that is under extreme pressure, to prevent rupture and discharge of the abscess contents into the chest cavity or peritoneum (29).

Splenic abscesses (Fig 15) are even rarer than hepatic abscesses. Most are immunosuppression associated, are very small, and do not require catheter drainage. Large splenic abscesses, how-

**Figure 14.** Imaging-guidance drainage of multiple abscesses in a 10-year-old renal transplant patient with pancreatitis and bowel fistula. (a) Axial CT image shows two catheters placed in partially drained abscesses (arrows). (b) Axial CT image at a level caudad to a shows a third abscess that contains oral contrast material (arrows), a finding that signifies a bowel leak. (c) Sinogram helps confirm the communication of the abscess with the bowel and depicts a fistula (arrows) that is probably secondary to bowel wall digestion by pancreatic enzymes. Although pancreatic abscesses often communicate with the pancreatic duct, no contrast enhancement of the duct is evident in this case. The fistula healed after prolonged drainage (2 months), and surgery was avoided.
ever, may be treated with drainage (30). Reports of successful drainage in infected hematomas subsequent to splenic salvage surgery have been published, in parallel with the increasingly conservative management of splenic trauma (31).

Renal abscesses may develop as a complication of pyelonephritis or nephrolithiasis, or they may be hematogenous (32–34). Superinfection of an existing renal cyst, however, is rare in children. As with hepatic and splenic abscesses, small renal abscesses may respond to antibiotics alone, whereas larger abscesses require drainage (32,33).

Outcomes of Percutaneous Abscess Drainage in Children

The American College of Radiology has reported an 80% success rate for percutaneous abscess drainage in adults, with success defined as complete drainage with no further procedures required (1). Although the literature about percutaneous drainage in children is more limited, the available data suggest similar outcomes (2–5,16,17,19). Complications occur in less than 5% of pediatric patients, and major complications occur in less than 1%. In the English-language literature, the largest study of abscess drainage in children is that by Jamieson et al (17), who reported 59 drainage procedures (34 percutaneous, 25 transrectal) and five needle aspirations for treatment of appendiceal abscesses in 46 children. Only four of the 46 (9%) experienced no improvement after abscess drainage and intravenous administration of antibiotics. In reports of percutaneous abscess drainage in children, appendicitis is the most commonly cited cause of abscess (2–5,16,17,19).

Reported complications of percutaneous drainage in children are rare. Jamieson et al (17) reported a single colonic fistula that healed after prolonged drainage. Towbin et al (3) reported two complications among nine drainage procedures; one patient developed sepsis after drainage, and another developed a small pleural fistula that resolved without treatment. Stanley et al (2) reported no complications in 13 pediatric patients, and vanSonnenberg et al (4) reported one episode of pulmonary hemorrhage and one case of pericatheter oozing.

Conclusions

Imaging-guided percutaneous drainage is a safe and effective treatment for abscesses in children. Interventional radiologists may use US, fluoroscopy, and CT for guidance of catheter placement in numerous locations in the abdomen and pelvis. Physicians, nurses, and technologists in the interventional suite should be trained to address the specific needs of pediatric patients. After catheter placement, the performance of daily hospital rounds and the judicious use of follow-up imaging will help to optimize patient outcomes. Exchange or repositioning of the catheter, or insertion of an additional catheter, as well as adjuvant thrombolytic therapy, may be needed to achieve complete drainage.
References


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