American College of Radiology
ACR Appropriateness Criteria®
Radiologic Management of Infected Fluid Collections

Variant 1: **Patient with right lower quadrant abdominal pain, fever, and leukocytosis for 7 days. Physical examination shows no peritoneal signs. CT scan shows a thin-walled fluid collection, greater than 3 cm, adjacent to the cecum, nonvisualization of the appendix, and an appendicolith. Imaging findings are highly suspicious for appendicitis. Treatment includes antibiotics.**

Procedure	Appropriateness Category
Conservative management only	Usually Not Appropriate
Surgical drainage	May Be Appropriate
Needle aspiration	May Be Appropriate
Percutaneous catheter drainage followed by delayed surgery	Usually Appropriate
Percutaneous catheter drainage only	Usually Appropriate

Variant 2: **Patient with a history of left hemicolectomy 2 months ago for colon carcinoma. Two weeks after placement of a drain into an abdominal abscess; the patient presents with abdominal pain and fever. Drain output is 25 cc per day and the collection is unchanged in size by CT. Treatment includes antibiotics.**

Procedure	Appropriateness Category
Catheter upsizing	Usually Appropriate
Continued antibiotics and drain removal	Usually Not Appropriate
Continued antibiotics and drainage (no change in care)	May Be Appropriate
Intracavitary thrombolytic therapy and drainage	Usually Appropriate
Laparoscopic drainage	May Be Appropriate
Open surgical drainage	May Be Appropriate

Variant 3: **Patient who is an intravenous drug abuser presents with fever and tachycardia and on imaging is found to have 2 noncommunicating splenic abscesses accessible percutaneously through a 1 cm rim of normal splenic tissue. Treatment includes antibiotics.**

Procedure	Appropriateness Category
Conservative management only	Usually Not Appropriate
Needle aspiration	May Be Appropriate
Percutaneous catheter drainage only	Usually Appropriate
Splenectomy	Usually Appropriate

Variant 4: **Patient with abdominal pain radiating to the back 5 weeks after hospitalization for acute pancreatitis. Afebrile. CT scan shows a walled-off collection in the body of the pancreas indenting a broad portion of the body of the stomach, affecting the gastric outlet. The collection is percutaneously accessible with a 3-cm window. MR cholangiopancreatography shows a patent pancreatic duct.**

Procedure	Appropriateness Category
Conservative management only	Usually Not Appropriate
Endoscopic cystgastrostomy	Usually Appropriate
Percutaneous catheter drainage only	May Be Appropriate
Percutaneous needle aspiration	May Be Appropriate
Surgical cystenterostomy	May Be Appropriate

Variant 5: **Patient with a 2 week history of cough, fever, and foul-smelling sputum. Worsening condition despite a full course of broad-spectrum antibiotics. Sputum cultures negative. CT scan shows a right lower lobe abscess. Treatment includes antibiotics.**

Procedure	Appropriateness Category
Another course of antibiotics and postural drainage	May Be Appropriate (Disagreement)
Needle aspiration	Usually Not Appropriate
Percutaneous catheter drainage only	May Be Appropriate
Surgery	May Be Appropriate

Variant 6: **Patient with a 3 week history of pneumonia, fever, dyspnea. Worsening condition despite a full course of broad-spectrum antibiotics. CT scan shows a loculated pleural collection with overlying pleural thickening (empyema). Treatment includes antibiotics.**

Procedure	Appropriateness Category
Another course of antibiotics and postural drainage	Usually Not Appropriate
Needle aspiration	Usually Not Appropriate
Open decortication	May Be Appropriate
Percutaneous catheter drainage with administration of thrombolytic therapy	Usually Appropriate
Video-assisted thoracic surgery decortication	Usually Appropriate

Variant 7: **Woman of childbearing age with abdominal pain, fever, and leukocytosis. Marked tenderness on pelvic examination. CT scan shows a walled-off, probable tubo-ovarian abscess (TOA) greater than 3 cm. Treatment includes antibiotics.**

Procedure	Appropriateness Category
Conservative management only	May Be Appropriate
Endoscopic US-guided drainage	May Be Appropriate
Surgical/laparoscopic drainage	May Be Appropriate
Transabdominal needle aspiration	May Be Appropriate
Transabdominal percutaneous catheter drainage	Usually Appropriate
Transgluteal needle aspiration	May Be Appropriate
Transgluteal percutaneous catheter drainage	Usually Appropriate
Transrectal needle aspiration	May Be Appropriate
Transrectal percutaneous catheter drainage	Usually Appropriate
Transvaginal needle aspiration	May Be Appropriate
Transvaginal percutaneous catheter drainage	Usually Appropriate

Variant 8: **Patient with recent endoscopic retrograde cholangiopancreatography and sphincterotomy now with 3 weeks of worsening right upper quadrant pain, fever, jaundice, and malaise. CT scan reveals 2 liver abscesses greater than 3 cm. MRCP demonstrates no biliary obstruction or stones. Treatment includes antibiotics.**

Procedure	Appropriateness Category
Continued conservative management	May Be Appropriate
Needle aspiration	May Be Appropriate
Percutaneous catheter drainage only	Usually Appropriate
Percutaneous catheter drainage with conversion to percutaneous biliary drain	May Be Appropriate
Surgical management	May Be Appropriate

Variant 9: **Patient presents to the emergency department with 5 days of progressive ankle swelling and 2 days of fever. An ultrasound was obtained given the diffuse soft-tissue swelling around the ankle which revealed a subperiosteal abscess. Treatment includes antibiotics.**

Procedure	Appropriateness Category
Continued conservative management	Usually Not Appropriate
Needle aspiration	May Be Appropriate
Percutaneous catheter drainage only	May Be Appropriate
Surgical drainage	Usually Appropriate

RADIOLOGIC MANAGEMENT OF INFECTED FLUID COLLECTIONS

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Summary of Literature Review

Introduction/Background

Radiologic management strategies are often preferred therapeutic options for infected fluid collections throughout the body [1]. The current literature demonstrates high clinical success rates with low complications, especially when compared with more invasive therapies, in particular open surgical drainage (OSD), which has high associated morbidity and mortality. However, physiologic and anatomic factors may render radiologic management less optimal compared with alternative therapies. Such factors include collections without a safe percutaneous approach, collections refractory to radiologic management, and collections with a more favorable endoscopic drainage option. In the past decade, endoscopic, laparoscopic, and multidisciplinary approaches have been described, and those approaches should be considered when applicable to reduce procedure risk, improve clinical success, avoid external catheter placement, and improve patient comfort.

Overview of Diagnostic Imaging Options

Detection and evaluation of fluid collections is typically accomplished with CT or ultrasound (US) in patients with signs and symptoms of infection. Routine imaging of postoperative patients should be discouraged because postoperative fluid collections are commonly present and may not be infected. US is fast and provides more detailed evaluation of the internal structure and composition of complex collections. US is more limited in the evaluation of collections deep within the soft tissues or adjacent to the loops of bowel than CT or MRI, and it fails to penetrate intracavitary, pulmonary, or enteric gas. Therefore, US is more commonly used to screen for superficial or large fluid collections and collections within or adjacent to solid organs. CT provides the advantage of detecting deep collections, and the use of intravenous (IV) and oral contrast can help distinguish collections from adjacent vasculature or bowel. CT is usually the first-line modality in patients with fever of unknown origin. Multidetector CT scanners with sagittal and coronal reformatting can help distinguish collections from adjacent structures.

Overview of Therapeutic Options

The choice of imaging guidance for draining fluid collections varies with body habitus, presence of adjacent structures, size and location of the collection, and presence of intracavitary or enteric gas. The choice of treatment options for a given collection may vary among operators and depends on size, location, and clinical presentation. Options include antibiotics coupled with supportive measures such as bowel rest and hyperalimentation, needle aspiration for drainage or to hone antibiotic coverage, percutaneous catheter drainage (PCD), PCD with thrombolytic therapy, endoscopic drainage, immediate surgery, or delayed surgery.

Two basic techniques are available for PCD: the Seldinger technique and the trocar technique [2]. For percutaneous aspiration and drainage, success thresholds of 95% and 85% have been recommended [3]. Choice of technique is primarily operator preference, though the trocar technique has been advocated for endocavitary drain placement to avoid the risk of loss of access during the process of serial dilation, a complication associated with the Seldinger technique. Although a safe window to the collection is required for drainage, techniques such as hydrodissection [4,5] and alternative approaches such as transhepatic drainage of abdominal collections [6,7] have been described to improve technical success rates.

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Discussion of Procedures by Variant

Variant 1: Patient with right lower quadrant abdominal pain, fever, and leukocytosis for 7 days. Physical examination shows no peritoneal signs. CT scan shows a thin-walled fluid collection, greater than 3 cm, adjacent to the cecum, nonvisualization of the appendix, and an appendicolith. Imaging findings are highly suspicious for appendicitis. Treatment includes antibiotics.

Percutaneous Catheter Drainage Only

For mature abscesses associated with appendicitis, an initial combination of PCD, antibiotics, bowel rest, and (on occasion) hyperalimentation has been advocated. In a retrospective review of 80 cases, nonoperative management was associated with a significantly lower rate of complications and a significantly shorter hospital stay compared with operative management [8]. In addition, PCD has shown to result in rapid clinical improvement in children with intra-abdominal infections secondary to perforated appendicitis [9].

PCD is advocated for larger collections with a reported efficacy ranging from 70% to 90% [10,11]. Peritoneal signs, active hemorrhage, lack of maturation of the abscess wall, and anatomic constraints have been suggested as contraindications to PCD [12]. The timing of abscess drainage is still open to debate with no clinical trials available that identify an optimal time period for drainage. However, timely drainage is of clear clinical benefit [2]. The highest success rates have been achieved for abscesses resulting from recent laparotomy [11,13,14], and, as a result, PCD with antibiotics is usually the only treatment required for this entity. For diverticular abscesses, a retrospective review of 218 patients showed that PCD with antibiotics obviated the need for subsequent colectomy in 85% of cases [15].

Percutaneous Catheter Drainage Followed by Delayed Surgery

Some disagreement exists in the literature regarding the need for subsequent ("interval") appendectomy after successful PCD [16]. In a study of 1,012 patients with appendicitis, Kaminski et al [16] evaluated the need for PCD and the subsequent need for interval appendectomy after successful PCD. On initial presentation, the vast majority of patients with appendicitis underwent emergent surgery, although a strategy of avoidance of open surgery in both simple and complicated cases of appendicitis has continued to evolve since this publication. If nonoperative management was successful, 80% of patients were cured without surgery. The push for conservative management, including PCD, rather than acute appendectomy for patients with appendicitis complicated by abscess or phlegmon is supported by a meta-analysis of 1,572 patients in 17 studies showing significant reductions in complication rates [17]. Factors that were associated with receiving an interval appendectomy after antibiotics and PCD include recurrent appendicitis, age ≤13, and treatment with antibiotics alone [18]. However, approximately 25% of patients with appendiceal abscess fail PCD and require operative intervention [19]. Risk factors for PCD failure in patients with appendiceal abscess include patient complexity, female gender, and earlier drainage [19]. Drainage failure is associated with longer hospital stays but no increase in patient mortality [19].

For mature abscesses associated with Crohn disease, an initial combination of PCD, antibiotics, high-dose steroids, bowel rest, and (on occasion) hyperalimentation has been advocated [20] to reduce the failure rate of PCD, temper the acute infection, and allow for surgical resection under more sterile, elective conditions [21]. When surgery is required, preliminary PCD has been shown to reduce postdrainage complications and the ultimate need for stomal creation [22]. Some patients (33%–50%) will ultimately require surgical drainage or resection [23,24], but most authors still advocate a first-line trial of PCD if technically possible. In a study of 25 patients with Crohn disease, PCD performed an average of 37 days before surgery significantly reduced the rate of severe, postoperative septic complications, such as anastomotic leak, intra-abdominal abscess, and fistula [25]. Published studies on the benefit of initial PCD to reduce the rate of postoperative septic complications demonstrate conflicting results, and the benefit of PCD for this purpose remains unclear [25,26].

Needle Aspiration

For the management of small (<3 cm) collections [2], most authors advocate a trial of antibiotics alone with consideration given to needle aspiration to hone antibiotic coverage for persistent cases [27,28]. This approach uses follow-up imaging and repeat aspiration if the collection does not resolve [2].

Conservative Management Only

For the management of small (<3 cm) collections [2], most authors advocate a trial of antibiotics alone with consideration given to needle aspiration to hone antibiotic coverage for persistent cases [27,28]. This approach uses follow-up imaging and repeat aspiration if the collection does not resolve [2].

Surgical Drainage
Abdominal abscesses are most often the result of diverticulitis, appendicitis, Crohn disease, and recent laparotomy. When possible, OSD is avoided because of a high rate of morbidity and mortality [29,30]. A recent retrospective study has demonstrated that early appendectomy compared with conservative nonsurgical management with subsequent appendectomy results in lower hospital costs and less health care utilization [31].

Variant 2: Patient with a history of left hemicolectomy 2 months ago for colon carcinoma. Two weeks after placement of a drain into an abdominal abscess; the patient presents with abdominal pain and fever. Drain output is 25 cc per day and the collection is unchanged in size by CT. Treatment includes antibiotics.

Catheter Upsizing
Persistence of fluid collections despite PCD may be the result of factors such as complex loculations and septations; fistulization of the cavity to the enteric, biliary, genitourinary, pancreatic, or bronchial systems; the presence of neoplastic tissue; and communication of the cavity to the lymphatic system. Depending on the reason for incomplete drainage, options may include catheter manipulation, catheter upsizing, diversion of upstream obstructions, or surgical drainage—both open and laparoscopic. A study of second PCD of recurrent intra-abdominal and pelvic abscesses reported a secondary drainage rate of 4.9% [32]. In a retrospective study of 82 abscesses that were refractory to PCD and clinical management, catheter exchange resulted in clinical success without surgery in 76.8% of cases [33].

Intracavitary Thrombolytic Therapy and Drainage
Fibrinolysis of complex, multiseptated fluid collections refractory to PCD by intracavitary instillation of fibrinolytic agents, such as tissue plasminogen activator, has been reported [34-36].

Available reports are limited in number, and often small but high rates of clinical success have been demonstrated retrospectively for abdominal and pelvic abscesses [34] as well as organizing hemothorax and empyema [36]. Case reports have even demonstrated success in the fibrinolytic treatment of refractory, complex splenic abscesses [37]. In a prospective study of 100 patients with abdominal abscesses randomized to regular instillation of sterile saline versus urokinase during catheter drainage, the urokinase group had no increase in complication rate [38]. However, in a smaller prospective, randomized study of 20 patients with complicated intra-abdominal abscesses, patients receiving intracavitary alteplase showed a 72% clinical success rate compared with 22% for patients receiving sterile saline [39]. Rates of bleeding complications using intracavitary recombinant tissue plasminogen activator have been low to zero for pelvic, abdominal, and chest collections, except for a 33% rate of pleural hemorrhage noted for intrapleural recombinant tissue plasminogen activator for patients on anticoagulation [36].

Enteric or biliary fistulas have been treated with a variety of therapies with varied success, though a recent series of 11 cases treated with *n*-butyl cyanoacrylate glue within the cavity and fistula tract resulted in 100% clinical success [40].

For persistent sterile collections such as cysts, lymphoceles, and seromas, a number of reports describe high rates of success in shortening the period of catheterization by intracavitary instillation of sclerotherapy agents such as ethanol, doxycycline, or tetradecyl sulfate [41].

Laparoscopic Drainage
Laparoscopic drainage has been shown to be an effective option for complicated abdominal abscesses. A retrospective study of 7 patients demonstrated successful drainage in all patients without recurrent abscess formation and no complications [42]. A reported advantage of laparoscopic drainage is direct visualization of purulent material and the ability to explore the abdominal cavity [43].

Open Surgical Drainage
Previous studies have estimated that approximately one-third of abdominal abscesses may not be amenable to PCD [44]. There is a paucity of literature that has studied the indications for OSD versus laparoscopic drainage versus PCD. As such, the decision to pursue OSD should be made based on prior management, patient characteristics, and location. If a persistent intra-abdominal abscess is due to another underlying process that requires surgical management (ie, bowel perforation), OSD may be the best approach. OSD is often a complementary approach to PCD. PCD may be the initial approach for complex abscesses in patients with multiple comorbidities in order to better optimize them for eventual elective OSD [45].

PCD of an infected or fluid-filled tumor may be inadvertent or intentional. For good surgical candidates, tumor resection is typically performed. For poor surgical candidates, the period of catheterization may be markedly

prolonged or indefinite [46]. Despite this finding, patients with infected, inoperable tumors at risk for systemic infection may opt for PCD.

Continued Antibiotics and Drainage (No Change in Care)
On occasion, PCD fails to resolve the associated fluid collection despite these measures. In such circumstances, the benefit of PCD may be to limit the hematogenous or local spread of infection and improve the acute clinical presentation, thereby preparing the patient for an elective, single-step surgical procedure. This treatment algorithm has been described for appendicitis and Crohn disease [23]. For cases of fistulization of the abscess cavity to enteric, biliary, genitourinary, pancreatic, or bronchial systems, PCD may be successful with prolonged catheterization [47,48].

Continued Antibiotics and Drain Removal
Removal of the drain with continued treatment with antibiotics alone for a persistent collection is not appropriate management. Criteria for drain removal includes resolution of signs of infection, catheter output <10 to 20 cc, and resolution of the abscess on repeat imaging [2]. Depending on the reason for incomplete drainage, options may include catheter manipulation, catheter upsizing, diversion of upstream obstructions, or surgical drainage, both open and laparoscopic as discussed above.

Variant 3: Patient who is an intravenous drug abuser presents with fever and tachycardia and on imaging is found to have 2 noncommunicating splenic abscesses accessible percutaneously through a 1 cm rim of normal splenic tissue. Treatment includes antibiotics.

Percutaneous Catheter Drainage Only
Current data on the management of splenic abscesses are relatively sparse, and treatment choices, even within a single institution, are often variable [49,50]. Splenic abscesses were considered to be surgical cases as recently as the 1990s, but a number of small, retrospective series [51,52] have readdressed this issue, some advocating the benefits of PCD for solitary, simple collections and splenectomy for multiple collections. In a retrospective study of 18 children with splenic abscesses, IV antibiotics were administered to all patients, and 10 underwent PCD for the inclusionary threshold of an abscess diameter >3 cm. The clinical response rate was 100% [53]. Preservation of splenic function is maintained by the use of PCD techniques, and this should be attempted where possible and safe. PCD does carry a risk of hemorrhage if a nontarget puncture occurs; thus, in these cases in which there is no favorable window for intervention, splenectomy is often performed [50].

Splenectomy
There is a wide range of reported failure rates of PCD for splenic abscess (14.3%–75%) [54]. As such, splenectomy for splenic abscess is still commonly performed, especially for patients with complex or multiple splenic abscesses [55]. Splenectomy is also indicated if there is no window for PCD or if the patient is at high risk of bleeding [50]. Another option for splenic preservation is laparoscopic drainage, which has been successfully attempted in pediatric patients, though there is a paucity of data on this approach [50].

Needle Aspiration
Needle aspiration is often pursued as part of the diagnostic workup [54,56]. A small series of patients treated with needle aspiration alone demonstrated that this approach is safe and effective for some patients with bacterial splenic abscesses. The authors suggested that percutaneous aspiration may aid in nonoperative healing or alternatively may be a technique to temporize patients who are not yet medically optimized for surgery [54].

Conservative Management Only
Cases of splenic abscess management with antibiotics alone do exist [55,57]; however, intervention (either surgical or PCD) is often required given the high mortality from untreated sepsis [57].

Variant 4: Patient with abdominal pain radiating to the back 5 weeks after hospitalization for acute pancreatitis. Afebrile. CT scan shows a walled-off collection in the body of the pancreas indenting a broad portion of the body of the stomach, affecting the gastric outlet. The collection is percutaneously accessible with a 3-cm window. MR cholangiopancreatography shows a patent pancreatic duct.

A significant amount of confusing terminology is used when discussing pancreatitis, including acute and subacute fluid collections. Operators are urged to adhere to standards such as the revised Atlanta classification when describing such collections [58]. Under the revised Atlanta classification system, four distinct collection subtypes exist based on the presence or absence of pancreatic necrosis and time since the onset of pancreatitis (acute within 4 weeks of pancreatitis onset; chronic after >4 weeks of pancreatitis onset) [59,60]. Non-necrotic collections are

termed acute peripancreatic fluid collections and pseudocysts (chronic). Necrotic collections are termed acute necrotic collections and walled-off necrosis (chronic) [59]. The use of the term pancreatic abscess is discouraged. Instead, any of the subtypes of pancreatic collections under the revised Atlanta criteria can become infected. Infected pancreatic collections are associated with a high rate of mortality and are drained emergently.

Endoscopic Cystgastrostomy
A randomized comparative trial demonstrated that endoscopic approaches are associated with shorter hospital stays and greater patient-reported mental and physical outcomes when compared with surgical drainage [61]. High rates of clinical success have been reported using endoscopic techniques [62,63], which may be optimal for more central collections and those abutting the greater curvature of the stomach.

Percutaneous Catheter Drainage Only
PCD generally requires a prolonged period of drainage in these patients compared with abscesses in other locations, but high rates of eventual success have been reported [64]. Complete occlusion of the main pancreatic duct central to the pseudocyst may lead to failure of PCD and necessitate use of surgical or endoscopic marsupialization to the bowel. When compared with endoscopic approaches, PCD has similar clinical success rates for symptomatic pseudocysts, but PCD is associated with higher rates of reintervention, longer length of hospital stay, and increased number of follow-up abdominal imaging studies [65]. A study of patients with acute necrotic collections and walled-off necrosis demonstrated that early and late PCD results in similar efficacy and safety profiles [66]. In addition, persistent organ failure is the most common indication for PCD in patients with acute necrotic collections, and suspected infection is the most common indication for PCD in patients with walled-off necrosis [66].

For suboptimal surgical candidates, minimally invasive alternatives include endoscopic drainage or PCD [62,64,67,68]. PCD is typically used as a temporizing measure prior to surgery because cure rates range from 14% to 32% [67-69]. Large, complex collections involving the tail of the pancreas or those collections not in direct communication with the pancreas may be better treated by PCD.

Both renal and perirenal abscesses may otherwise require PCD, surgical drainage, or nephrectomy.

Surgical Cystenterostomy
Surgical drainage, both open and laparoscopic, is efficacious with reported pseudocyst recurrence rates between 2.5% to 5% [60]. Initial comparisons of surgical versus endoscopic drainage demonstrated similar success and complication rates; however, with the advent of newer endoscopic techniques, endoscopic approaches are the preferred approach.

Both renal and perirenal abscesses may otherwise require PCD, surgical drainage, or nephrectomy.

Conservative Management Only
Pancreatic pseudocysts may resolve spontaneously if they are small, stable, and sterile. Drainage is generally advocated for large (≥5 cm) pseudocysts; however, under the revised criteria, size alone does not warrant treatment [59] of rapidly enlarging, painful, obstructing, or infected pseudocysts. Techniques for drainage are multidisciplinary [64,70], and continued disagreement of the optimal use of these techniques leads to a variety of treatment algorithms for these patients.

Renal abscesses may be cured by medical treatment in over half of cases [71] and even up to 64% of cases [72].

Percutaneous Needle Aspiration
Needle aspiration of pancreatic cystic lesions is primarily a diagnostic tool [73,74]. Needle aspiration can help to distinguish benign pancreatic lesions, such as pseudocysts, from more aggressive cystic and solid pancreatic lesions. Needle aspiration is not routinely performed for therapeutic purposes for pancreatic collections.

Similarly, needle aspiration can also be used for diagnosis of renal and perirenal cystic lesions; however, there have been cases of needle aspiration of renal abscesses with successful results [75].

Variant 5: Patient with a 2 week history of cough, fever, and foul-smelling sputum. Worsening condition despite a full course of broad-spectrum antibiotics. Sputum cultures negative. CT scan shows a right lower lobe abscess. Treatment includes antibiotics.

Percutaneous Catheter Drainage Only
Parenchymal lung abscesses most often occur from aspiration of anaerobic oropharyngeal bacteria or from fungal organisms. Alcoholics, immunocompromised patients, and patients with bronchial obstruction are predisposed.

PCD and surgical resection or drainage are generally reserved for cases that persist or worsen despite antibiotics [76-78]. In a retrospective study of 40 patients with lung abscesses refractory to antibiotic therapy, complete resolution was achieved with PCD in 83% of patients, and the remainder required surgery [79]. Chest tube drainage of lung abscesses has been reported to be definitive in 84% of cases with a complication rate of 16% [80]. Complications of PCD include spillage of infection into other portions of the lung, bleeding, empyema, and bronchopleural fistula [76]. Endoscopic drainage of lung abscesses can also be attempted in patients with central abscesses, multiple comorbidities, and coagulopathies, but they carry the risk of spillage of infected material throughout the lung [76]. Mediastinal abscesses are most commonly the result of thoracic surgical procedures and usually require PCD. Though these cases may be technically challenging, one study showed low complication rates, technical success rates approaching or reaching 100%, and clinical success rates exceeding 90% without the need for surgery [81].

Surgery
Surgical resection of lung abscesses is required in approximately 10% of cases [76]. Indications for surgical resection include prolonged sepsis, hemoptysis, bronchopleural fistula, empyema, lung abscess persisting >6 weeks with antibiotic treatment, and suspected cancer [76]. For large abscesses, lobectomy may be required; however, segmentectomy can be performed if the entire abscess and necrotic lung tissue can be removed [82].

Another Course of Antibiotics and Postural Drainage
The majority of lung abscesses (typically >80%) are treated to resolution with antibiotics and conservative management [80,83]. PCD and surgical resection or drainage are generally reserved for cases that persist or worsen despite antibiotics [76-78].

Needle Aspiration
Needle aspiration can be performed for diagnostic fluid culture. However, the organism is usually determined by culture of sputum or blood and, less optimally, by culture of cavitary fluid obtained by needle aspiration or bronchoscopy. Optimal management should be determined based on the discussion above.

Variant 6: Patient with a 3 week history of pneumonia, fever, dyspnea. Worsening condition despite a full course of broad-spectrum antibiotics. CT scan shows a loculated pleural collection with overlying pleural thickening (empyema). Treatment includes antibiotics.

Percutaneous Catheter Drainage with Administration of Thrombolytic Therapy
Persistent, complex collections and organizing hemothoraces have been successfully treated with instillation of fibrinolytic agents [36,84]. However, a meta-analysis of fibrinolytic therapy concluded that there is not enough evidence to support the use of fibrinolytics routinely for empyemas [84,85].

Needle Aspiration
Needle aspiration (thoracentesis) can be performed for fluid culture [84]. However, the organism is usually determined by culture of sputum or blood and, less optimally, by culture of cavitary fluid obtained by needle aspiration or bronchoscopy. Thoracentesis alone is helpful in uncomplicated pleural effusions but is not recommended for the management of empyema [84,86].

Video-Assisted Thoracic Surgery Decortication
In later-stage empyema with extensive fibrous septa formation or scar formation, surgical management is often required, either video assisted or open decortication [87]. A recent meta-analysis compared video-assisted thoracic surgery (VATS) decortication with open decortication. The results suggested that the VATS approach is comparable to or slightly better than open decortication with regard to operative time, hospital stay, and overall morbidity and mortality. There was no difference between relapse rates between the 2 techniques [87]. However, the American Association for Thoracic Surgeons recommends VATS decortication as the first-line surgical approach in patients with stage II acute empyema [84].

Open Decortication
In later-stage empyema with extensive fibrous septa formation or scar formation, surgical management is often required, either video assisted or open decortication [87]. A recent meta-analysis compared VATS decortication with open decortication. The results suggested that the VATS approach is comparable to or slightly better than open decortication with regard to operative time, hospital stay, and overall morbidity and mortality. There was no difference between relapse rates between the 2 techniques [87]. However, the American Association for Thoracic

Surgeons recommends VATS decortication as the first-line surgical approach in patients with stage II acute empyema [84].

Another Course of Antibiotics and Postural Drainage
Although systemic antibiotics are required for the successful management of empyema, pleural drainage in some form must also be performed (eg, PCD and surgical decortication) [84,86]. Postural drainage would not be appropriate for the management of empyema.

Variant 7: Woman of childbearing age with abdominal pain, fever, and leukocytosis. Marked tenderness on pelvic examination. CT scan shows a walled-off, probable tubo-ovarian abscess (TOA) greater than 3 cm. Treatment includes antibiotics.

Transvaginal Percutaneous Catheter Drainage
Depending on location, pelvic fluid collections can be drained via the transabdominal, transgluteal, transrectal, transvaginal, transperineal, and transvesicular routes. The efficacy and safety of these routes have been established by a number of retrospective reports [88-94]. The choice of route for a given abscess varies among operators and institutions, with transrectal and transvaginal approaches used much more commonly in academic centers [95]. In general, reports have advocated the use of the most sterile route possible when aspirating or draining a potentially sterile collection. Using this rationale, the transabdominal and transgluteal routes would be preferable to the endocavitary routes for a potentially sterile collection. The transperineal route is most commonly used in patients after low anterior resection for rectal cancer [93]. Some disagreement exists in the literature regarding the level and incidence of significant or persistent pain when comparing the transgluteal and endocavitary routes. At a minimum, conscious sedation is required for these procedures. The route of transgluteal drainage through the greater sciatic foramen should be medial to the sciatic nerves and below the level of the piriformis muscle to prevent the complications of persistent pain [90] or injury to the gluteal arteries.

For women of reproductive age desiring pregnancy, if tubo-ovarian abscess (TOA) exists without intra-abdominal rupture, medical management and early drainage results in pregnancy rates of 32% to 63% compared with 4% to 15% with medical management alone [96,97]. The route and method of drainage depends on operator and patient preference, as well as individual anatomic considerations.

Transgluteal Percutaneous Catheter Drainage
See the transvaginal PCD discussion above. Depending on location, pelvic fluid collections can be drained via the transabdominal, transgluteal, transrectal, transvaginal, transperineal, and transvesicular routes. The efficacy and safety of these routes have been established by a number of retrospective reports [88-94]. The choice of route for a given abscess varies among operators and institution type, with transrectal and transvaginal approaches used much more commonly in academic centers [95]. In general, reports have advocated the use of the most sterile route possible when aspirating or draining a potentially sterile collection.

Transabdominal Percutaneous Catheter Drainage
See the transvaginal PCD discussion above. Depending on location, pelvic fluid collections can be drained via the transabdominal, transgluteal, transrectal, transvaginal, transperineal, and transvesicular routes. The efficacy and safety of these routes have been established by a number of retrospective reports [88-94]. The choice of route for a given abscess varies among operators and institution type, with transrectal and transvaginal approaches used much more commonly in academic centers [95]. In general, reports have advocated the use of the most sterile route possible when aspirating or draining a potentially sterile collection.

Transrectal Percutaneous Catheter Drainage
See the transvaginal PCD discussion above. Depending on location, pelvic fluid collections can be drained via the transabdominal, transgluteal, transrectal, transvaginal, transperineal, and transvesicular routes. The efficacy and safety of these routes have been established by a number of retrospective reports [88-94]. The choice of route for a given abscess varies among operators and institution type, with transrectal and transvaginal approaches used much more commonly in academic centers [95]. In general, reports have advocated the use of the most sterile route possible when aspirating or draining a potentially sterile collection.

For prostatic abscesses, the longstanding treatment method has been transurethral drainage, but recent small studies have demonstrated that guidance of needle aspiration or placement of small-bore pigtail catheters using transrectal US can shorten hospital stay [98] and provide a viable alternative.

Transvaginal Needle Aspiration
Early TOA aspiration (for simple collections) has been advocated to prevent prolongation of the disease and the potential associated loss of fertility [99]. Needle aspiration is also helpful for diagnosis. Fluid culture can be used to guide antibiotic management [99]. The choice of route for a given abscess varies among operators, institution type, patient habitus, and abscess location.

Transgluteal Needle Aspiration
See the transvaginal needle aspiration discussion above. The choice of route for a given abscess varies among operators, institution type, patient habitus, and abscess location.

Transabdominal Needle Aspiration
See the transvaginal needle aspiration discussion above. The choice of route for a given abscess varies among operators, institution type, patient habitus, and abscess location.

Transrectal Needle Aspiration
See the transvaginal needle aspiration discussion above. The choice of route for a given abscess varies among operators, institution type, patient habitus, and abscess location.

Conservative Management Only
Small TOAs tend to resolve with antibiotics alone [99]. In a retrospective study of 122 patients, nearly two-thirds of TOAs resolved with antibiotics and supportive care [100]. However, early aspiration (for simple collections) and drainage (for complex collections) have been advocated to prevent prolongation of the disease and the potential associated loss of fertility.

Surgical/Laparoscopic Drainage
Salpingo-oophorectomy and OSD may become necessary in refractory cases and may be more commonly required for TOAs of gastrointestinal rather than gynecological origin [101]. Rupture of a TOA is a surgical emergency that warrants immediate washout [102]. Laparoscopic drainage can also be performed [103].

Endoscopic US-Guided Drainage
When collections are inaccessible by all of these techniques, open surgical intervention may be avoided in some cases by endoscopic US-guided transrectal or transcolonic drainage without fluoroscopy [104,105].

Variant 8: Patient with recent endoscopic retrograde cholangiopancreatography and sphincterotomy now with 3 weeks of worsening right upper quadrant pain, fever, jaundice, and malaise. CT scan reveals 2 liver abscesses greater than 3 cm. MRCP demonstrates no biliary obstruction or stones. Treatment includes antibiotics.

Percutaneous Catheter Drainage Only
Hepatic abscesses may be treated differently depending on their size and etiology. Pyogenic abscesses most often result from portal venous seeding of diverticulitis and appendicitis, but they also may occur from obstruction of the biliary system, including the gallbladder. Pyogenic abscesses complicate 1.4% of hepatic artery embolization procedures [106]. Morbidity and mortality from pyogenic abscess may be increased in patients undergoing hepatic artery embolization who have a history of bilioenteric anastomosis or an incompetent sphincter of Oddi. Mortality is also high for abscesses associated with malignancy, though PCD is clinically successful in approximately two-thirds of such cases [107].

For pyogenic abscesses >4 to 5 cm in diameter, PCD or aspiration is often required [108]. PCD appears to be more effective than needle aspiration [109]. Clinical success may be influenced by the infecting organism. A study of 48 patients with unilocular hepatic abscesses >3 cm treated with PCD and antibiotic therapy demonstrated a success rate of 83% [108,110].

Percutaneous Catheter Drainage with Conversion to Biliary Drainage
Some hepatic abscesses may develop communication with the biliary system, resulting in bile leak. Currently, there are no guidelines for the management of liver abscesses with biliary communication [111]. In such cases, biliary drainage or diversion can be performed for hepatic abscesses that have ruptured into the biliary system [112]. Some studies have shown that hepatic abscesses with biliary communication do not heal with percutaneous abscess drainage alone, and biliary stenting or drainage was required to achieve complete cure [113]. A prospective study of endoscopic biliary drainage (ie, sphincterotomy plus either stent or nasobiliary drainage catheter placement) demonstrated successful healing on biliary fistula/bile leaks that resulted from hepatic abscess after therapy [111].

Most studies in the current literature utilize an endoscopic approach for biliary drainage [111-113]. Percutaneous biliary drainage can also be attempted for bile leak secondary to abscess rupture into the biliary system depending on institutional preference. A percutaneous approach may need to be taken if an endoscopic approach is not feasible. However, there is a paucity of data specifically about the efficacy of percutaneous biliary drainage for hepatic abscess rupture or fistulization into the biliary system.

Needle Aspiration
For pyogenic abscesses <3 to 5 cm in diameter, authors have advocated using antibiotics, either alone or in conjunction with needle aspiration [108,114,115], with excellent success rates.

Amebic abscesses have been shown to respond extremely well to antibiotics without intervention, regardless of size, but occasionally they require needle aspiration [114]. For hepatic echinococcal cysts, percutaneous and surgical treatment options are available. For single compartment cysts that are percutaneously accessible and not in communication with the biliary system, percutaneous aspiration injection and reaspiration therapy can be attempted, depending on medical treatment response and cyst size [116,117]. Briefly, percutaneous aspiration injection and reaspiration involves aspiration of cyst contents and injection of a scolicidal agent, followed by reaspiration of the cyst contents [116-118].

Surgical Management
In patients with large multiloculated hepatic abscesses, the success rate for PCD and antibiotic therapy was 33% versus 100% in patients who underwent surgical drainage [110]. PCD failure occurs in 15% to 36% of cases [119,120]. Predictors of PCD failure for hepatic abscesses include multiloculation, high viscosity or necrotic contents, and hypoalbuminemia [110,120,121]. Larger abscesses (>5 cm) or abscesses without a percutaneous approach may be best managed surgically [110,121]. However, surgical drainage of hepatic abscesses has a high mortality rate at 10% to 47% [108].

For cysts that are percutaneously inaccessible, complex, and communicate with the biliary structures, surgical cystectomy can be performed, depending on prior medical therapy and the patient's clinical status [116]. It is important to note that cyst rupture or spillage of cyst contents can result in anaphylaxis. In cases of cyst content spillage during surgical resection, immediate washout with hypertonic saline and a scolicidal agent must be performed [116].

Continued Conservative Management
For pyogenic abscesses <3 to 5 cm in diameter, authors have advocated using antibiotics, either alone or in conjunction with needle aspiration [108,114,115], with excellent success rates. Amebic abscesses have been shown to respond extremely well to antibiotics without intervention, regardless of size, but occasionally they require needle aspiration [114].

Variant 9: Patient presents to the emergency department with 5 days of progressive ankle swelling and 2 days of fever. An ultrasound was obtained given the diffuse soft-tissue swelling around the ankle which revealed a subperiosteal abscess. Treatment includes antibiotics.

Percutaneous Catheter Drainage Only
Percutaneous drainage of subperiosteal abscesses has been reported with mixed success, but overall there is a paucity of data supporting this approach [122].

Surgical Drainage
Subperiosteal abscess is a rare complication of pyogenic osteomyelitis that most often occurs in pediatric patients [123]. The primary management of these abscesses is surgical incision and drainage followed by antibiotic therapy [124]. It is important to note that most cases of subperiosteal abscess occur in the setting of acute sinusitis most commonly affecting the frontal sinus and mastoid. The primary management of these abscesses involving the sinuses or calvarium is surgical drainage and antibiotics [125].

Needle Aspiration
Needle aspiration can be performed for confirmation of diagnosis, but the subperiosteal abscess will often recur with needle aspiration alone [126]. There have been reports of successful treatment of subperiosteal abscess associated with acute mastoiditis with needle aspiration and antibiotics, but most published literature reports surgical management [127].

Continued Conservative Management
Drainage of subperiosteal abscesses is often required for proper management as discussed above.

Summary of Recommendations

- **Variant 1:** PCD followed by delayed surgery or PCD only is usually appropriate for a patient with right lower quadrant abdominal pain, fever, and leukocytosis for 7 days. The physical examination shows no peritoneal signs with a CT scan showing a thin-walled fluid collection, >3 cm, adjacent to the cecum, nonvisualization of the appendix, and an appendicolith. Imaging findings are highly suspicious for perforated appendicitis. Treatment includes antibiotics. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).
- **Variant 2:** Catheter upsizing or intracavitary thrombolytic therapy and drainage is usually appropriate for a patient with a history of left hemicolectomy 2 months prior for colon carcinoma. Two weeks after placement of a drain into an abdominal abscess, the patient presents with abdominal pain and fever. Drain output is 25 cc per day, and the collection is unchanged in size by CT. Treatment includes antibiotics. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).
- **Variant 3:** PCD only or splenectomy is usually appropriate for a patient who is an IV drug abuser presenting with fever and tachycardia. Imaging is found to have two noncommunicating splenic abscesses accessible percutaneously through a 1-cm rim of normal splenic tissue. Treatment includes antibiotics. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).
- **Variant 4:** Endoscopic cystgastrostomy is usually appropriate for a patient with abdominal pain radiating to the back 5 weeks after hospitalization for acute pancreatitis. The patient is afebrile with a CT scan showing a walled-off collection in the body of the pancreas indenting a broad portion of the body of the stomach, affecting the gastric outlet. The collection is percutaneously accessible with a 3-cm window, and the MR cholangiopancreatography shows a patent pancreatic duct.
- **Variant 5:** PCD only or surgery may be appropriate for a patient with a 2-week history of cough, fever, and foul-smelling sputum. The patient has a worsening condition despite a full course of broad-spectrum antibiotics. Sputum cultures are negative, with a CT scan showing a right lower lobe abscess. Treatment includes antibiotics. The panel did not agree on recommending another course of antibiotics and postural drainage for a patient in this clinical scenario. There is insufficient medical literature to conclude whether or not these patients would benefit from another course of antibiotics and postural drainage for this clinical scenario. Intervention in this patient population is controversial but may be appropriate.
- **Variant 6:** PCD with administration of thrombolytic therapy or VATS decortication is usually appropriate for a patient with a 3-week history of pneumonia, fever, and dyspnea. The patient has a worsening condition despite a full course of broad-spectrum antibiotics. CT scan shows a loculated pleural collection with overlying pleural thickening (empyema). Treatment includes antibiotics. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).
- **Variant 7:** Transabdominal PCD, transgluteal PCD, transrectal PCD, or transvaginal PCD is usually appropriate for a woman of childbearing age with abdominal pain, fever, and leukocytosis. The approach is dependent on the specific location of the pelvic collection, allowing for a safe window. There is marked tenderness on the pelvic examination and a CT scan shows a walled-off, probable TOA >3 cm. Treatment includes antibiotics. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).
- **Variant 8:** PCD only is usually appropriate for a patient with recent endoscopic retrograde cholangiopancreatography and sphincterotomy now with 3 weeks of worsening right upper quadrant pain, fever, jaundice, and malaise. A CT scan reveals 2 liver abscesses >3 cm and a MR cholangiopancreatography demonstrates no biliary obstruction or stones. Treatment includes antibiotics.
- **Variant 9:** Surgical drainage is usually appropriate for a patient presenting to the emergency department with 5 days of progressive ankle swelling and 2 days of fever. A US was obtained given the diffuse soft-tissue swelling around the ankle, which revealed a subperiosteal abscess. Treatment includes antibiotics.

Supporting Documents

The evidence table, literature search, and appendix for this topic are available at https://acsearch.acr.org/list. The appendix includes the strength of evidence assessment and rating round tabulations for each recommendation.

For additional information on the Appropriateness Criteria methodology and other supporting documents go to www.acr.org/ac.

Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

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