

Review Article

# Image-Guided Percutaneous Drainage for Intra-Abdominal Abscesses: Indications, Clinical Outcomes, and Comparison with Surgical Management

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## Abstract

Intra-abdominal abscesses represent a significant clinical challenge due to their heterogeneous etiologies, variable anatomical locations, and often nonspecific presentation. Their pathophysiology is driven by localized infectious or inflammatory processes that trigger an immune response, leading to tissue necrosis, pus formation, and encapsulation, which limits antibiotic penetration and frequently necessitates invasive source control. Etiologically, these abscesses commonly arise in postoperative settings, inflammatory bowel disease, appendicitis, diverticulitis, and abdominal trauma, with location-specific implications that influence both diagnosis and management. Diagnostic evaluation relies heavily on imaging, as clinical and laboratory findings alone lack sufficient specificity. Computed tomography remains the cornerstone modality due to its high sensitivity, detailed

anatomical resolution, and critical role in procedural planning, while ultrasound and magnetic resonance imaging serve as complementary tools in selected scenarios. Image-guided percutaneous drainage has become the preferred initial intervention for most intra-abdominal abscesses, offering high success rates, a favorable safety profile, and reduced morbidity compared with surgical management. Technical advances, including optimized access routes, pigtail catheters, fibrinolytic adjuncts, and large-bore mechanical aspiration devices, have expanded the effectiveness of percutaneous strategies, even in complex or refractory collections. Clinical outcomes consistently demonstrate high rates of abscess resolution, shorter hospital stays, and lower complication rates with percutaneous drainage relative to open surgery. Nevertheless, limitations exist, particularly in multiloculated, viscous, or necrotizing infections, where repeat interventions or surgical management may be required. Surgical approaches remain essential when percutaneous techniques fail or are contraindicated, with minimally invasive surgery preferred when feasible.

### **Key words**

Source control; Interventional radiology; Minimally invasive procedures; Abdominal sepsis; Clinical outcomes; Therapeutic decision-making.

### **Introduction**

Intra-abdominal abscesses represent a relevant cause of hospital admission and are frequently associated with common intra-abdominal inflammatory conditions such as diverticulitis and appendicitis [1]. Their clinical importance lies not only in their prevalence but also in their potential to progress toward severe local and systemic complications when diagnosis or treatment is delayed, highlighting the necessity for timely and effective therapeutic strategies [2].

Historically, the treatment of intra-abdominal abscesses relied primarily on surgical intervention, which was considered the definitive approach for source control. Over time, however, advances in diagnostic imaging and the development of interventional radiology techniques have progressively transformed this paradigm toward less invasive options. As a result, image-guided percutaneous drainage has emerged as a preferred modality, largely due to its association with lower morbidity and mortality when compared with open surgical management [3, 4].

The rationale for image-guided percutaneous drainage is grounded in its precision, safety, and demonstrated clinical effectiveness. The use of

imaging guidance, particularly computed tomography, enables accurate localization of abscess collections and controlled catheter placement, thereby minimizing injury to adjacent structures. In parallel, multiple studies have reported high technical and clinical success rates, reaching up to 97.9 percent in selected patient populations, which reinforces the reliability of this approach. The minimally invasive nature of the procedure also contributes to a favorable complication profile, with pain at the catheter insertion site being the most frequently described adverse effect [4, 5]. Furthermore, the technique demonstrates adaptability in complex clinical scenarios, including psoas muscle abscesses, where multimodal imaging guidance may enhance procedural success and overall outcomes [5]. Despite these advantages, radiation exposure remains a relevant consideration, particularly in patients with inflammatory bowel disease who may undergo repeated computed tomography examinations, underscoring the importance of balancing diagnostic and therapeutic benefits against cumulative radiation doses [6].

Beyond procedural aspects, several clinical considerations influence the overall management of intra-abdominal abscesses treated with percutaneous drainage. The role of microbiological cultures obtained during

drainage remains debated, as available evidence suggests that culture results lead to changes in antimicrobial therapy in only a minority of cases [1]. At the same time, technological advances continue to expand therapeutic options, with newer approaches such as large-bore mechanical aspiration providing potential alternatives in situations where conventional drainage proves insufficient, thereby reducing the need for surgical intervention [7]. Consistent with these developments, contemporary clinical guidelines emphasize early recognition and prompt, appropriate management of intra-abdominal infections, positioning image-guided percutaneous drainage as a cornerstone of the treatment algorithm [2].

The aim of this article is to analyze the role of image-guided percutaneous drainage in the management of intra-abdominal abscesses, focusing on its clinical indications, effectiveness, and outcomes in comparison with surgical approaches.

## **Methodology**

This article corresponds to a narrative review focused on the role of image-guided percutaneous drainage in the management of intra-abdominal abscesses, with particular emphasis on clinical indications, therapeutic outcomes, and its relationship to surgical approaches. The manuscript was developed through an interpretative synthesis of clinical practice considerations and contemporary scientific evidence, prioritizing conceptual coherence and clinical applicability rather than adherence to systematic review protocols or rigid methodological frameworks.

The analytical framework was constructed by examining how diagnostic imaging, abscess characteristics, patient clinical status, and interventional techniques converge in decision-making for source control. Particular attention was given to the interaction between abscess etiology, anatomical location, technical feasibility of percutaneous access, and

anticipated clinical outcomes. This approach allowed the therapeutic process to be addressed as a dynamic and multidisciplinary strategy, highlighting both the strengths and limitations of percutaneous drainage across diverse clinical scenarios.

Scientific literature published between 2021 and 2026 provided the contextual basis for this narrative analysis. Peer-reviewed articles indexed in PubMed, Scopus, and Web of Science were selectively reviewed to support key concepts related to image-guided drainage, including procedural techniques, success and failure rates, complication profiles, antimicrobial integration, and comparative outcomes versus surgical management. The selection of references was guided by their relevance to clinical practice and their contribution to understanding therapeutic effectiveness, while non-peer-reviewed sources, redundant publications, or studies lacking direct applicability to intra-abdominal abscess management were excluded.

To maintain thematic consistency and logical continuity throughout the manuscript, artificial intelligence-based tools were used solely as organizational support during manuscript preparation, facilitating the structured integration of clinical, radiological, and interventional perspectives. This narrative methodology enabled the presentation of a cohesive and clinically oriented overview, reinforcing the role of image-guided percutaneous drainage as a central component in the contemporary management of intra-abdominal abscesses.

## **Pathophysiology and Etiology of Intra-Abdominal Abscesses**

Abscess formation is a complex biological process that usually originates from an infectious or inflammatory insult capable of activating a localized immune response. This response is characterized by the recruitment and accumulation of neutrophils and other immune cells at the site of infection, leading to progressive tissue necrosis and pus formation. As

part of the host defense mechanism, the body attempts to contain the infectious focus by developing a fibrous capsule that surrounds the purulent material, which consists of dead cells, bacteria, and inflammatory debris [8]. While this encapsulation limits the spread of infection to adjacent tissues, it simultaneously creates a relatively isolated environment that reduces antibiotic penetration, rendering medical therapy alone insufficient in many cases and thereby necessitating mechanical drainage of the collection [9].

The etiological spectrum of intra-abdominal abscesses is broad and closely linked to underlying pathological or iatrogenic processes. Postoperative abscesses represent a frequent category and commonly arise following surgical procedures involving the gastrointestinal tract, where contamination or leakage of intestinal contents can promote localized infection [10]. Inflammatory conditions also play a significant role, particularly Crohn's disease, in which chronic transmural inflammation and bowel wall penetration substantially increase the risk of abscess development [11]. Infectious etiologies remain highly prevalent, with appendicitis and diverticulitis constituting leading causes; in these settings, perforation of the appendix or diverticula facilitates the formation of localized abscesses within the abdominal cavity [1]. In addition, traumatic mechanisms must be considered, as blunt or penetrating abdominal injuries, especially those involving solid organs such as the liver, can lead to tissue disruption followed by secondary infection and abscess formation [12].

The anatomical location of an intra-abdominal abscess has important clinical implications for both presentation and management. Hepatic abscesses often originate from biliary tract infections or hematogenous dissemination and are associated with considerable morbidity and mortality, particularly when diagnosis is delayed [13]. Pelvic abscesses frequently arise in the context of gynecological infections or as

complications of lower gastrointestinal surgical procedures, posing specific diagnostic and therapeutic challenges due to their proximity to pelvic organs [14]. Abscesses within the peritoneal cavity are commonly observed following abdominal surgery or perforated appendicitis and require meticulous management to avoid progression to diffuse peritonitis (Leandri et al., 2025). Finally, retroperitoneal abscesses are particularly challenging because of their deep anatomical location and close relationship with vital structures, factors that often delay diagnosis and complicate both percutaneous and surgical treatment strategies [15].

### **Diagnostic Evaluation**

The clinical presentation of intra-abdominal abscesses is often characterized by nonspecific signs and symptoms, which can complicate early recognition. Patients commonly present with fever, abdominal pain, and laboratory evidence of systemic inflammation, including leukocytosis; however, the intensity and combination of these findings vary considerably according to abscess location, extent of disease, and underlying patient conditions. As a result, the clinical picture alone is frequently insufficient to establish a definitive diagnosis. Laboratory investigations, such as a complete blood count and inflammatory markers, play a supportive role by reinforcing clinical suspicion, yet they lack diagnostic specificity and cannot reliably differentiate abscesses from other intra-abdominal inflammatory processes [16].

Given these limitations, imaging modalities are central to the diagnostic evaluation and subsequent management of intra-abdominal abscesses, as they not only confirm the presence of a collection but also guide therapeutic decision-making. Computed tomography is the most widely used imaging technique in this setting due to its high sensitivity and specificity, as well as its ability to provide detailed cross-sectional anatomical information essential for planning percutaneous drainage. In particular,

CT-guided drainage is favored when complex anatomy, interposed viscera, or adjacent critical structures limit the feasibility and safety of ultrasound guidance [3, 16].

Ultrasound remains an important diagnostic and interventional tool, especially during initial evaluation and in cases involving superficial abscesses. Its advantages include real-time visualization, absence of ionizing radiation, and the possibility of bedside application, which is particularly beneficial for critically ill patients. Nonetheless, its effectiveness is reduced for deep-seated collections because of limited tissue penetration and lower spatial resolution compared with computed tomography, resulting in lower overall success rates for ultrasound-guided drainage [5].

Magnetic resonance imaging is not routinely employed for abscess drainage but may provide added value in selected complex cases. Its superior soft tissue contrast can be advantageous in delineating intricate anatomical relationships, such as those encountered in psoas muscle abscesses, or in patients for whom computed tomography is contraindicated. In these situations, magnetic resonance imaging may complement other modalities by offering additional anatomical detail that informs therapeutic planning [5].

The selection of an imaging modality for intervention is ultimately determined by a combination of abscess characteristics, including location, size, and internal complexity. Computed tomography is generally preferred for deep or complex collections, whereas ultrasound is appropriate for more superficial abscesses when visualization is adequate [3]. Beyond imaging considerations, the decision to proceed with drainage is guided by clinical factors such as symptom burden and risk of complications. In practice, abscesses exceeding 3 centimeters in diameter or those associated with significant clinical manifestations typically warrant

interventional management rather than conservative treatment alone [4].

### **Image-Guided Percutaneous Drainage**

Image-guided percutaneous drainage is founded on technical principles that aim to achieve effective source control while minimizing procedural risk. Among available imaging guidance techniques, computed tomography is the most frequently used modality for guiding percutaneous catheter drainage, primarily because of its ability to provide high-resolution, multiplanar anatomical detail. This capability is particularly important when abscesses are located near viscera, vascular structures, or skeletal elements that may limit the feasibility or safety of ultrasound guidance [3, 4].

The selection of the access route represents a critical step in the procedure and is determined by abscess location, depth, and the relationship to adjacent organs and structures. An optimal pathway minimizes the risk of injury while ensuring adequate drainage of the collection. In most cases, catheters with a pigtail configuration are used, as their design promotes stable positioning within the abscess cavity and effective evacuation of purulent material [4].

Standard catheter-based drainage systems remain the cornerstone of percutaneous management for the majority of intra-abdominal abscesses. However, in selected cases characterized by complex anatomy, large volume, or dense purulent content, alternative technologies may be required to enhance drainage efficiency. Large-bore mechanical aspiration devices, such as the FlowTrieve Aspiration Catheter, have emerged as potential adjuncts in these scenarios, offering improved evacuation of viscous or organized collections when conventional catheters are insufficient [7].

The indications for percutaneous catheter drainage are closely linked to abscess characteristics and patient-related factors. The technique has demonstrated effectiveness in large

or complex abscesses, including those associated with diverticulitis and inflammatory bowel disease, where it has been shown to reduce hospital length of stay and improve clinical outcomes compared with conservative management alone [6, 17]. In addition, patient stability and the presence of comorbidities must be carefully evaluated prior to intervention. Although percutaneous drainage is generally considered safe, conditions such as coagulopathy or severe systemic illness require individualized risk assessment to ensure procedural safety [4]. Percutaneous drainage is also indicated when antibiotic therapy fails to achieve adequate resolution, as direct evacuation of infected material can significantly reduce bacterial burden and facilitate clinical recovery [18].

Despite its broad applicability, percutaneous catheter drainage has well-defined contraindications and limitations. Certain collections are not amenable to drainage, particularly those that are very small or located in anatomically inaccessible regions, where safe catheter placement cannot be achieved (Bonomo et al., 2024). Similarly, patients with uncorrected coagulopathy or anatomical constraints that preclude a safe access route may not be suitable candidates for this intervention [4]. Moreover, multiloculated abscesses or collections with highly viscous content present additional challenges, as standard catheter drainage may be insufficient. In such cases, alternative strategies, including intra-abscess antibiotic instillation, use of advanced aspiration devices, or surgical intervention, may be required to achieve effective source control [7, 18].

### **Clinical Outcomes of Percutaneous Drainage**

Percutaneous catheter drainage has consistently demonstrated high clinical success rates in the management of intra-abdominal abscesses. Reported outcomes indicate success rates of 93.7 percent and 97.9 percent in different patient cohorts, underscoring the effectiveness of this technique across a range of clinical settings [4].

In situations where conventional drainage proves inadequate, the adoption of advanced approaches has further expanded therapeutic success. Large-bore mechanical aspiration techniques have shown favorable results in refractory cases, achieving marked volume reduction or near-complete collapse of abscess cavities when standard percutaneous catheter drainage failed [7]. Similarly, in patients with infected walled-off necrosis, a modified percutaneous drainage strategy incorporating triple guidance resulted in significant reductions in abscess size and inflammatory markers within 48 hours, highlighting the potential for rapid clinical and radiological improvement when tailored techniques are applied [19].

The complication profile associated with percutaneous catheter drainage is generally favorable and supports its role as a first-line interventional strategy. The most frequently reported adverse event is localized pain at the catheter insertion site, which is typically mild and manageable with conservative measures [4]. In specific patient populations, such as individuals with Crohn's disease, percutaneous drainage has been associated with a lower incidence of surgical complications when compared with patients managed without drainage, further reinforcing its safety advantage in complex inflammatory conditions [11]. Moreover, studies evaluating the use of large-bore mechanical aspiration devices in complex abscesses have reported an absence of procedure-related complications, suggesting that these advanced techniques can be applied safely in selected cases [7].

Beyond clinical effectiveness and safety, percutaneous catheter drainage has demonstrated a favorable impact on hospitalization metrics. Its use has been associated with shorter hospital stays when compared with surgical management, reflecting faster clinical recovery and reduced procedural burden. The adjunctive use of fibrinolytic agents during percutaneous drainage has been shown to further decrease

hospitalization duration in adult patients by enhancing catheter efficacy and abscess resolution [20]. Long-term practice reviews spanning a decade have similarly indicated that percutaneous drainage facilitates quicker recovery and shorter hospital stays relative to conservative management alone [17].

The requirement for repeat interventions following percutaneous catheter drainage varies according to abscess complexity and the degree of initial response. In patients with Crohn's disease, the need for re-drainage has been reported more frequently among those undergoing percutaneous drainage, reflecting the recurrent and multifocal nature of abscess formation in this population [11]. Nevertheless, emerging techniques, including the use of large-bore aspiration devices, may mitigate the need for repeat procedures or subsequent surgical debridement in complex or refractory cases, thereby enhancing the overall durability of percutaneous management strategies [7].

### **Surgical Management of Intra-Abdominal Abscesses**

Operative intervention remains an essential component in the management of intra-abdominal abscesses when less invasive strategies are insufficient or inappropriate. Surgical treatment is typically indicated in situations where percutaneous drainage fails to achieve adequate source control or when abscesses exhibit complex characteristics, such as multiloculation, extensive organization, or association with necrotizing infections that require direct debridement [7, 8]. In specific clinical contexts, including pyogenic liver abscesses, surgery may be favored after unsuccessful image-guided drainage, particularly in the presence of multiloculated collections that limit effective catheter drainage [21]. Additionally, patients presenting with severe secondary peritonitis often require operative management, as surgical exploration allows comprehensive source control, removal of

infected material, and management of underlying perforations or ischemic segments [22].

Within surgical management, the choice between open and minimally invasive approaches is guided by disease severity, anatomical considerations, and patient stability. Minimally invasive strategies, including laparoscopic techniques and percutaneous interventions, have gained prominence due to their association with reduced morbidity and shorter recovery times when compared with traditional open surgery [4, 22]. These approaches are particularly advantageous in selected patients, offering effective source control while minimizing physiological stress. In contrast, open surgical techniques are generally reserved for scenarios in which minimally invasive methods are inadequate, such as cases involving extensive tissue necrosis, diffuse contamination, or the need for rapid and definitive source control. Evidence from infected necrotizing pancreatitis management further supports this paradigm, as minimally invasive approaches have been associated with lower in-hospital complication rates and reduced resource utilization compared with open procedures [22, 23].

Considerations of morbidity, mortality, and recovery further underscore the importance of surgical approach selection. Minimally invasive techniques are consistently associated with lower rates of postoperative complications and mortality, as demonstrated in studies of minimally invasive debridement for necrotizing pancreatitis, which report improved survival and fewer adverse events compared with open surgery [22]. Conversely, open abdomen techniques, although sometimes unavoidable, carry a higher risk of complications, including incisional hernias, infections, and prolonged hospital stays [24]. Recovery following open surgical intervention is typically more prolonged, often requiring increased healthcare resources and a higher likelihood of discharge to rehabilitation or long-term care facilities,

reflecting the greater physiological impact of these procedures [23].

### **Comparative Analysis; Percutaneous Drainage vs Surgical Approach**

Percutaneous catheter drainage has consistently demonstrated high effectiveness in the management of intra-abdominal abscesses and related fluid collections, with reported success rates supporting its role as a first-line interventional strategy. Clinical series have documented success rates of 93.7 percent and 97.9 percent across different patient groups, reflecting reliable abscess resolution in a broad range of clinical scenarios [4]. In the specific context of hepatic abscesses, percutaneous drainage has achieved a 100 percent technical success rate, although it has been associated with a greater need for repeat drainage sessions when compared with endoscopic ultrasound-guided drainage, highlighting differences in procedural durability rather than technical feasibility [24]. Similarly, percutaneous drainage has shown utility in the management of pancreatic necrosis, achieving a success rate of 56.6 percent in patients with organ failure; however, a subset of these cases still required subsequent surgical intervention, underscoring the limitations of percutaneous techniques in severe or advanced disease [25].

From a safety perspective, percutaneous catheter drainage is generally associated with a more favorable complication profile than surgical approaches. The most commonly reported adverse event is pain at the catheter insertion site, whereas serious complications occur less frequently [4]. When compared directly with endoscopic ultrasound-guided drainage, percutaneous drainage has been associated with a higher overall rate of adverse events, reported at 61 percent versus 17 percent, suggesting that procedure selection and anatomical considerations play an important role in minimizing complications [24]. Despite this variability, computed tomography-guided percutaneous drainage is widely regarded as a

safe intervention, offering lower morbidity and mortality rates than operative management in appropriately selected patients [3].

The impact of percutaneous catheter drainage on patient recovery and healthcare resource utilization further supports its clinical value. In general, percutaneous approaches are associated with shorter hospital stays and faster recovery when compared with surgical interventions. Although endoscopic ultrasound-guided drainage has demonstrated even shorter hospitalization and more rapid symptom resolution in some studies, it remains conceptually aligned with the minimally invasive principles underlying percutaneous drainage [24]. Broadly, minimally invasive strategies, including percutaneous drainage, have been linked to fewer in-hospital complications and reduced resource use relative to open surgical methods, reinforcing their role in contemporary management pathways [22].

Cost-effectiveness represents an additional advantage of percutaneous catheter drainage. Reduced length of hospitalization and lower complication rates translate into decreased overall healthcare costs when compared with open surgical approaches. Evidence from studies on pancreatic necrosis indicates that minimally invasive techniques, including percutaneous drainage, are associated with lower hospitalization expenditures than traditional surgery [22]. Moreover, adjunctive measures such as the use of fibrinolytic agents during percutaneous drainage can further shorten drainage duration and hospital stay, thereby enhancing cost-effectiveness, particularly in adult patient populations [20].

### **Special Clinical Scenarios**

Postoperative abscesses represent a frequent complication following abdominal procedures, including appendectomies and hepatobiliary surgeries, and pose a significant challenge in postoperative care. In this setting, percutaneous drainage is commonly employed as a first-line

intervention, offering a less invasive alternative to reoperation while achieving effective source control. Computed tomography-guided percutaneous drainage has been shown to be a safe and effective modality for managing postoperative fluid collections, with a reduction in morbidity and mortality when compared with surgical approaches [3]. In more complex postoperative abscesses where standard percutaneous techniques are insufficient, the use of large-bore mechanical aspiration devices has emerged as a viable alternative. Evidence demonstrates successful outcomes without procedure-related complications, supporting their role as an adjunctive option in refractory cases [7].

Intra-abdominal abscesses are also a common and clinically significant complication of inflammatory bowel disease, particularly Crohn's disease, in which chronic transmural inflammation predisposes patients to localized infectious collections. Percutaneous drainage plays a critical role in this population by potentially avoiding immediate surgical intervention, although the risk of abscess recurrence remains an important consideration. Studies have shown that the use of percutaneous drainage prior to surgery in patients with Crohn's disease is associated with fewer postoperative complications and a reduced need for stoma creation when compared with surgical management alone, highlighting its value as part of a staged treatment strategy [11]. In pediatric patients with Crohn's disease-related abscesses, anti-tumor necrosis factor therapy has been reported as both safe and effective, although concerns regarding infectious complications persist and necessitate careful patient selection and monitoring [23]. An additional challenge in inflammatory bowel disease is cumulative radiation exposure, as computed tomography-guided drainage may contribute to higher radiation doses, particularly in patients with severe disease who require repeated imaging and interventions [6].

Special considerations are also required when managing intra-abdominal abscesses in pediatric and immunocompromised patients. In children, treatment strategies must balance efficacy with minimization of procedural burden and hospitalization. Saline irrigation during percutaneous drainage has been shown to reduce the length of hospital stay, while the use of fibrinolytic agents increases drainage volume and may enhance abscess resolution [20]. In immunocompromised populations, emerging adjunctive therapies are being explored to optimize outcomes. Photodynamic therapy has demonstrated safety and feasibility as a complement to percutaneous drainage, offering a potential novel approach for abscess management without reported adverse safety outcomes, thereby expanding therapeutic options in this vulnerable group [28].

## Conclusions

Intra-abdominal abscesses arise from a complex interplay between infectious or inflammatory insults and host immune responses, leading to encapsulated collections that frequently limit antibiotic efficacy. Their heterogeneous etiologies and anatomical locations significantly influence clinical presentation, diagnostic challenges, and therapeutic decision-making, underscoring the need for individualized management strategies.

Image-guided percutaneous drainage has emerged as a cornerstone in the management of intra-abdominal abscesses, demonstrating high success rates, a favorable safety profile, and reduced hospitalization compared with surgical approaches. Advances in imaging guidance and drainage technologies have further expanded its applicability, even in complex or refractory cases, while careful patient selection remains essential to optimize outcomes.

Surgical intervention continues to play a critical role when percutaneous techniques are insufficient or contraindicated, particularly in cases of multiloculated abscesses, necrotizing

infections, or severe peritonitis. Overall, a stepwise, minimally invasive–first approach supported by accurate imaging, clinical assessment, and multidisciplinary collaboration offers the most effective framework for achieving source control, reducing morbidity, and optimizing healthcare resource utilization.

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