Section: Miscellaneous

Original Research Article

CLINICAL OUTCOMES OF ULTRASOUND-GUIDED PERCUTANEOUS DRAINAGE IN THE MANAGEMENT OF INTRA-ABDOMINAL COLLECTIONS: A COMPARATIVE ANALYSIS

Abhay Raina[1], Shalini Gandhi[2]

[1]*Assistant Professor, Department of Radiology, SKS medical college. Mathura, Uttar Pradesh, India*
[2]*Professor and HOD, Department of Physiology, NIIMS, Greater Noida, Uttar Pradesh, India*
[3]*Professor and HOD, Department of Physiology, Kalyan Singh government medical college, Bulandshahar, Uttar Pradesh, India*
[4]*Specialist, Department of Obstetrics and Gynaecology, DDU Hospital. New Delhi, India*

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Corresponding Author:
Dr. Abhay Raina,
Assistant Professor, Department of Radiology, SKS Medical College. Mathura, Uttar Pradesh, India.
Email: drabhayraina@yahoo.com

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ABSTRACT

Background: Intra-abdominal collections are a common cause of morbidity and sepsis in surgical practice. While open surgical drainage has traditionally been the standard of care, advances in imaging have made ultrasound-guided percutaneous drainage (USG-PD) an attractive minimally invasive alternative. This study aimed to evaluate the clinical outcomes of USG-PD and compare them with open surgical drainage in the management of intra-abdominal collections.
Materials and Methods: This prospective comparative observational study included 104 adult patients with radiologically confirmed intra-abdominal collections managed at a tertiary care hospital. Patients were allocated to either ultrasound-guided percutaneous drainage (USG-PD; n = 53) or open surgical drainage (SD; n = 51) based on clinical and radiological criteria. Baseline demographic and clinical characteristics, etiology and location of collections, procedural details, clinical outcomes, complications, and hospital course were analyzed and compared between the two groups.
Results: Baseline characteristics were comparable between the groups. Technical success of USG-PD was achieved in 96.2% of patients. Clinical success rates were similar in the USG-PD and SD groups (84.9% vs 84.3%; $p = 0.932$). The USG-PD group had significantly shorter procedure duration (28.4 ± 9.6 vs 78.6 ± 18.3 minutes; $p < 0.001$), shorter hospital stay (7.6 ± 3.1 vs 12.4 ± 4.8 days; $p < 0.001$), and faster defervescence (2.8 ± 1.3 vs 4.6 ± 2.1 days; $p < 0.001$). Overall complication rates were significantly lower in the USG-PD group (13.2% vs 31.4%; $p = 0.024$), with no surgical site infections observed following USG-PD.
Conclusion: Ultrasound-guided percutaneous drainage is a safe and effective first-line treatment for intra-abdominal collections, offering clinical outcomes comparable to open surgical drainage with the added benefits of reduced procedural time, shorter hospitalization, and fewer complications. Open surgical drainage should be reserved for selected cases with complex or inaccessible collections or failure of percutaneous management.
Keywords: Intra-abdominal abscess; Ultrasound-guided percutaneous drainage; Surgical drainage; Minimally invasive procedures; Clinical outcomes.

INTRODUCTION

Intra-abdominal collections, including abscesses, infected fluid collections, and postoperative or post-inflammatory localized fluid accumulations, represent a common and potentially life-threatening complication encountered in surgical and medical practice.[1] These collections may arise secondary to gastrointestinal perforations, appendicitis, pancreatitis, postoperative anastomotic leaks, trauma, or intra-abdominal malignancies. If not adequately treated, they can progress to systemic sepsis, multi-organ dysfunction, prolonged hospitalization, and increased mortality.[2]

Traditionally, surgical drainage was considered the definitive management for intra-abdominal collections.[3] However, open surgical intervention is associated with significant morbidity, including wound complications, postoperative pain, longer recovery time, and increased healthcare costs, particularly in patients with poor physiological reserve or multiple comorbidities.[4] With advances in imaging technology and minimally invasive techniques, image-guided percutaneous drainage has emerged as a preferred alternative to surgical drainage in appropriately selected patients.[5]

Ultrasound-guided percutaneous drainage (USG-PD) offers several advantages, including real-time visualization, absence of ionizing radiation, bedside feasibility, cost-effectiveness, and the ability to access superficial and moderately deep collections safely.[6] Ultrasound guidance allows precise needle placement, avoidance of vital structures, and continuous monitoring during catheter insertion, thereby reducing procedural complications.[7] This technique is especially valuable in resource-limited settings where access to computed tomography (CT) may be restricted.[8]

Percutaneous drainage has been shown to achieve high technical and clinical success rates, with reported success ranging from 70% to over 90% in various studies, depending on the etiology, size, loculation, and microbiological characteristics of the collection.[9] Clinical success is typically reflected by resolution of symptoms, reduction in collection size, improvement in inflammatory markers, and avoidance of surgical intervention. However, outcomes may be influenced by factors such as multiloculated abscesses, thick purulent contents, presence of enteric fistulae, underlying malignancy, or delayed presentation.[10]

Despite its widespread use, variability exists in patient selection, procedural techniques, catheter management protocols, and outcome assessment across different centers.[11] Moreover, data from developing countries remain limited, where delayed presentation, advanced disease, and mixed etiologies may affect clinical outcomes.[12] Evaluating the effectiveness, safety profile, and predictors of success or failure of ultrasound-guided percutaneous drainage in such settings is essential for optimizing patient care and establishing standardized treatment pathways.[12] Therefore, the present study was undertaken to assess the clinical outcomes of ultrasound-guided percutaneous drainage of intra-abdominal collections, focusing on technical success, clinical resolution, complication rates, and the need for subsequent surgical intervention. Understanding these outcomes will help reinforce the role of ultrasound-guided percutaneous drainage as a minimally invasive, effective, and safe modality in the management of intra-abdominal collections.

MATERIALS AND METHODS

Study Design and Setting: This was a prospective comparative observational study conducted in the Departments of Radiology and General Surgery at a tertiary care teaching hospital in India over a period of 12 months, from January 2024 to December 2024. The study aimed to evaluate and compare the clinical outcomes of ultrasound-guided percutaneous drainage (USG-PD) and open surgical drainage (SD) in the management of intra-abdominal collections. The hospital caters to both emergency and elective surgical cases and serves as a referral center for surrounding districts.

Study Population and Group Allocation: A total of 104 adult patients diagnosed with intra-abdominal collections were included in the study. Diagnosis was confirmed by ultrasonography in all cases, with contrast-enhanced computed tomography used selectively for complex or deep-seated collections. Patients were allocated into two treatment groups based on the primary drainage modality employed. Fifty-three patients underwent ultrasound-guided percutaneous drainage (USG-PD group), while fifty-one patients underwent open surgical drainage (SD group). Allocation was non-randomized and based on predefined institutional criteria, including hemodynamic stability, size and accessibility of the collection, presence of generalized peritonitis, and overall surgical risk.

Eligibility Criteria: Patients aged 18 years and above with a radiologically confirmed intra-abdominal collection measuring at least 3 cm in maximum diameter and associated with clinical signs of infection such as fever, abdominal pain, localized tenderness, leukocytosis, or sepsis were included. Both postoperative and spontaneous collections arising from infective, inflammatory, or traumatic etiologies were eligible. Patients with diffuse peritonitis requiring emergency laparotomy, ruptured hollow viscus, suspected hydatid disease, uncorrectable coagulopathy (INR >1.5 or platelet count <50,000/mm³), collections inaccessible by ultrasound due to bowel interposition, or those who declined consent were excluded.

Baseline Clinical and Radiological Assessment: All patients underwent detailed clinical evaluation, including assessment of vital parameters, abdominal examination findings, and systemic signs of sepsis. Laboratory investigations performed prior to intervention included complete blood count, serum electrolytes, renal and liver function tests, coagulation profile, and C-reactive protein levels. Ultrasonography was used to document the anatomical location, volume, internal echogenicity, septations, and proximity to adjacent organs. Collections were categorized based on site (hepatic, subhepatic, pelvic, paracolic, pancreatic, or postoperative) and nature (uniloculated or multiloculated).

Ultrasound-guided Percutaneous Drainage Procedure: Patients in the USG-PD group underwent drainage under real-time ultrasound guidance using either a low-frequency curvilinear probe for deep collections or a high-frequency linear probe for superficial collections. The procedure was performed under strict aseptic precautions, with local infiltration of 2% lignocaine at the puncture site. The safest percutaneous route was selected to minimize the risk of bowel, vascular, or solid organ injury. Access was obtained using the Seldinger technique in most cases, particularly for deep or multiloculated collections. Following confirmation of needle position by aspiration of purulent material, a guidewire was introduced and an 8–14 Fr pigtail catheter was placed. The catheter was connected to a closed drainage system and secured to the skin. Aspirated fluid was sent for Gram stain, aerobic culture, and antibiotic sensitivity testing.

Open Surgical Drainage Procedure: Patients in the SD group underwent open drainage under general or regional anesthesia in the operating theater. The surgical approach (midline laparotomy or localized incision) was determined by the site and extent of the collection. After entering the peritoneal cavity, the abscess cavity was identified, evacuated, and thoroughly irrigated with saline. Loculations were broken down manually, and necrotic tissue was debrided where present. Surgical drains were placed within the cavity and brought out through separate stab incisions. In cases where the collection was secondary to an underlying pathology such as bowel perforation, anastomotic leak, or necrosis, definitive surgical management was carried out simultaneously.

Post-procedural Management and Monitoring: All patients received empirical broad-spectrum intravenous antibiotics immediately after the procedure, which were later tailored based on culture sensitivity reports. Clinical parameters, including temperature, abdominal pain, drain output, and signs of sepsis, were monitored daily. Drain output volume and character were recorded every 24 hours. Follow-up ultrasonography was performed at 48–72 hours and subsequently as required to assess reduction in collection size and adequacy of drainage. Drains were removed once output was less than 10–20 mL per day for two consecutive days and imaging confirmed near-complete resolution of the collection.

Outcome Measures: Technical success was defined as successful placement of the drainage catheter with immediate evacuation of purulent material in the USG-PD group. Clinical success was defined as resolution of symptoms, normalization or significant improvement in laboratory markers, radiological resolution of the collection, and no requirement for additional surgical intervention. Treatment failure was defined as persistent or worsening sepsis, inadequate drainage, catheter blockage or displacement, need for repeat intervention, or conversion to surgical drainage. Procedure-related complications such as bleeding, bowel injury, wound infection, and drain-related issues were documented.

Follow-up: Patients were followed until discharge and subsequently in the outpatient department for a minimum duration of 4 weeks. During follow-up, patients were assessed for recurrence of collection, wound complications, and overall clinical recovery.

Statistical Analysis: Data were entered into a structured database and analyzed using SPSS software version 20.0. Continuous variables were expressed as mean ± standard deviation, while categorical variables were expressed as frequencies and percentages. Comparisons between the USG-PD and SD groups were performed using independent t-test or Mann–Whitney U test for continuous variables and chi-square test or Fisher's exact test for categorical variables. A p-value of less than 0.05 was considered statistically significant.

Ethical Approval: The study protocol was approved by the Institutional Ethics Committee prior to commencement. Written informed consent was obtained from all participants, and confidentiality of patient information was strictly maintained throughout the study.

RESULTS

A total of 104 patients with intra-abdominal collections were included, with 53 patients in the ultrasound-guided percutaneous drainage (USG-PD) group and 51 patients in the open surgical drainage (SD) group. The mean age of patients was comparable between the two groups (45.6 ± 14.2 years in USG-PD vs 47.9 ± 13.8 years in SD; p = 0.392), with a male predominance observed in both groups. The prevalence of comorbidities such as diabetes mellitus and hypertension did not differ significantly between groups. Clinical presentation at admission, including fever, leukocytosis, and sepsis, was also comparable, indicating baseline clinical homogeneity between the two treatment groups [Table 1].

Table 1: Baseline Demographic and Clinical Characteristics of Study Participants.

Variable	USG-PD (n = 53)	SD (n = 51)	p-value
	Frequency (%)/mean ± SD		
Age (years)	45.6 ± 14.2	47.9 ± 13.8	0.392
Age ≥ 60 years	11 (20.8)	13 (25.5)	0.564
Gender			
Female	19 (35.8)	18 (35.3)	
Male	34 (64.2)	33 (64.7)	0.954
Comorbidities			

Diabetes mellitus	16 (30.2)	18 (35.3)	0.573
Hypertension	14 (26.4)	15 (29.4)	0.728
Clinical and laboratory parameters			
Fever at presentation	41 (77.4)	44 (86.3)	0.248
Leukocytosis (>11,000/mm³)	38 (71.7)	40 (78.4)	0.432
Sepsis on admission	19 (35.8)	21 (41.2)	0.568

USG-PD: ultrasound-guided percutaneous drainage; SD: surgical drainage.

Postoperative collections constituted the most common etiology in both groups, followed by appendicular and hepatobiliary causes, with no statistically significant difference in etiological distribution between the groups ($p > 0.05$). The anatomical location of collections was also similar, with subhepatic/hepatic and pelvic collections being the most frequently encountered sites. The proportion of collections involving multiple intra-abdominal sites did not differ significantly between groups, suggesting comparable disease burden and complexity at presentation [Table 2].

Table 2: Etiology and Anatomical Distribution of Intra-abdominal Collections.

Variable	**USG-PD (n = 53)**	**SD (n = 51)**	**p-value**
	Frequency (%)		
Etiology			
Postoperative	21 (39.6)	19 (37.3)	0.808
Appendicular	12 (22.6)	14 (27.5)	0.560
Hepatobiliary	9 (17.0)	7 (13.7)	0.636
Pancreatic	6 (11.3)	5 (9.8)	0.802
Traumatic / Others	5 (9.4)	6 (11.8)	0.689
Location			
Subhepatic / Hepatic	18 (34.0)	16 (31.4)	0.777
Pelvic	14 (26.4)	15 (29.4)	0.728
Paracolic	10 (18.9)	11 (21.6)	0.727
Pancreatic bed	6 (11.3)	5 (9.8)	0.802
Multiple sites	5 (9.4)	4 (7.8)	0.758

USG-PD: ultrasound-guided percutaneous drainage; SD: surgical drainage.

The mean size of intra-abdominal collections was comparable between the USG-PD and SD groups (6.8 ± 2.4 cm vs 7.1 ± 2.6 cm; $p = 0.518$). However, multiloculated collections were significantly more frequent in the SD group compared to the USG-PD group (43.1% vs 28.3%; $p = 0.046$). The mean procedure duration was significantly shorter in the USG-PD group (28.4 ± 9.6 minutes) compared to the SD group (78.6 ± 18.3 minutes; $p < 0.001$). All USG-PD procedures were performed under local anesthesia, whereas all patients in the SD group required general or regional anesthesia [Table 3].

Table 3: Procedural Characteristics.

Variable	**USG-PD (n = 53)**	**SD (n = 51)**	**p-value**
	Frequency (%)/mean ± SD		
Collection size (cm)	6.8 ± 2.4	7.1 ± 2.6	0.518
Multiloculated collection	15 (28.3)	22 (43.1)	0.046
Duration of procedure (minutes)	28.4 ± 9.6	78.6 ± 18.3	<0.001
Local anesthesia	53 (100.0)	0 (0.0)	—
General/regional anesthesia	0 (0.0)	51 (100.0)	—

USG-PD: ultrasound-guided percutaneous drainage; SD: surgical drainage.

Technical success was achieved in 96.2% of patients undergoing USG-PD. Clinical success rates were comparable between the USG-PD and SD groups (84.9% vs 84.3%; $p = 0.932$). Although a higher proportion of patients in the SD group required repeat intervention, the difference was not statistically significant. The mean duration of hospital stay was significantly shorter in the USG-PD group compared to the SD group (7.6 ± 3.1 days vs 12.4 ± 4.8 days; $p < 0.001$). Patients undergoing USG-PD also demonstrated significantly faster resolution of fever, as reflected by shorter time to defervescence ($p < 0.001$) [Table 4].

Table 4: Clinical Outcomes and Hospital Course.

Outcome	**USG-PD (n = 53)**	**SD (n = 51)**	**p-value**
	Frequency (%)/mean ± SD		
Technical success	51 (96.2)	—	—
Clinical success	45 (84.9)	43 (84.3)	0.932
Need for repeat intervention	6 (11.3)	9 (17.6)	0.356
Conversion to surgery	5 (9.4)	—	—
Duration of hospital stay (days)	7.6 ± 3.1	12.4 ± 4.8	<0.001
Time to defervescence (days)	2.8 ± 1.3	4.6 ± 2.1	<0.001

USG-PD: ultrasound-guided percutaneous drainage; SD: surgical drainage.

Overall complication rates were significantly lower in the USG-PD group compared to the SD group (13.2% vs 31.4%; p = 0.024). Major complications were more frequently observed in the SD group (15.7% vs 3.8%; p = 0.038), with surgical site infections occurring exclusively in patients undergoing open drainage (p < 0.001). Minor complications such as catheter blockage or transient pain were infrequent and comparable between groups. Mortality was higher in the SD group; however, the difference did not reach statistical significance [Table 5].

Table 5: Complications and Mortality.

Complication	USG-PD (n = 53)	SD (n = 51)	p-value
	Frequency (%)		
Any complication	7 (13.2)	16 (31.4)	0.024
Minor complications†	5 (9.4)	8 (15.7)	0.329
Major complications‡	2 (3.8)	8 (15.7)	0.038
Wound infection	0 (0.0)	9 (17.6)	<0.001
Procedure-related bleeding	2 (3.8)	4 (7.8)	0.423
Mortality	1 (1.9)	3 (5.9)	0.309

USG-PD: ultrasound-guided percutaneous drainage; SD: surgical drainage; †Minor complications include catheter blockage, pain, or minor leakage; ‡Major complications include bowel injury, septic shock, or need for re-exploration.

DISCUSSION

The present prospective comparative study evaluated the clinical outcomes of ultrasound-guided percutaneous drainage (USG-PD) in comparison with open surgical drainage (SD) for intra-abdominal collections. The baseline demographic and clinical characteristics were comparable between the two groups, with no statistically significant differences in age (45.6 ± 14.2 vs 47.9 ± 13.8 years; p = 0.392), sex distribution, comorbidities, or severity of infection at presentation. This baseline comparability minimizes confounding and allows meaningful interpretation of outcome differences observed between the two drainage modalities.

Postoperative collections constituted the most common etiology in both groups (39.6% in USG-PD vs 37.3% in SD), followed by appendicular and hepatobiliary causes, reflecting the epidemiological pattern reported in Indian tertiary care settings in studies by Dhurve et al., and Wani et al.[13,14] Similar anatomical distribution of collections, with subhepatic/hepatic and pelvic locations being most frequent, further suggests that both groups had comparable disease burden and anatomical complexity at baseline. These findings are consistent with studies by Gavriilidis et al. and Fagenholz et al., who reported postoperative and appendicular abscesses as the predominant indications for percutaneous drainage.[15,16]

Although the mean size of collections was similar between the groups, multiloculated collections were significantly more common in the SD group (43.1% vs 28.3%; p = 0.046). This reflects a real-world clinical decision-making process, wherein complex and multiloculated abscesses are more often managed surgically due to concerns of incomplete drainage.[17]

Despite this, USG-PD achieved a high technical success rate of 96.2%, which is comparable to success rates of 90–98% reported in previous studies Agarwal et al., and Stan-Ilie et al.[18,19] The significantly shorter procedure time observed with USG-PD (28.4 ± 9.6 minutes vs 78.6 ± 18.3 minutes; p < 0.001) highlights the procedural efficiency and minimally invasive nature of ultrasound-guided techniques.

Clinical success rates were nearly identical in both groups (84.9% in USG-PD vs 84.3% in SD; p = 0.932), demonstrating that USG-PD is not inferior to open surgical drainage in achieving effective source control. Similar clinical success rates ranging from 80% to 90% for percutaneous drainage have been reported in multiple comparative studies by Maradi et al and Liu et al.[20,21] Importantly, patients undergoing USG-PD experienced significantly shorter hospital stay (7.6 ± 3.1 vs 12.4 ± 4.8 days; p < 0.001) and faster defervescence (2.8 ± 1.3 vs 4.6 ± 2.1 days; p < 0.001). These advantages are clinically meaningful and may be attributed to reduced surgical trauma, avoidance of general anesthesia, and lower postoperative inflammatory response.[22]

The complication profile strongly favored USG-PD. The overall complication rate was significantly lower in the USG-PD group (13.2% vs 31.4%; p = 0.024), with major complications occurring in only 3.8% of patients compared to 15.7% in the SD group (p = 0.038). Notably, surgical site infections were observed exclusively in the SD group (17.6%; p < 0.001), a finding consistently reported in earlier literature.[23,24] In contrast, complications following USG-PD were predominantly minor and catheter-related, such as blockage or transient pain, which are generally manageable without major intervention.[7]

Mortality was lower in the USG-PD group (1.9%) compared to the SD group (5.9%), although this difference did not reach statistical significance (p = 0.309). Similar trends have been reported in other studies by Politano et al., Wu et al., where mortality was more closely related to underlying sepsis severity and comorbid conditions rather than the drainage technique itself.[25,26] The lack of statistical significance in mortality differences in the present study may be due to the relatively small sample size.

From a pathophysiological perspective, USG-PD provides effective source control by continuous evacuation of infected material while preserving peritoneal integrity and minimizing tissue disruption.[27] Real-time ultrasound guidance allows accurate catheter placement, avoidance of adjacent viscera, and dynamic monitoring during the procedure, contributing to rapid clinical improvement and reduced systemic inflammatory response.[28] These advantages make USG-PD particularly valuable in elderly patients, those with multiple comorbidities, and in resource-limited settings where minimizing hospital stay and complications is crucial.[29]

Limitations: The present study has certain limitations that should be acknowledged. First, the non-randomized observational design may have introduced selection bias, as treatment allocation was based on clinical judgment and institutional protocols, with more complex and multiloculated collections preferentially managed surgically. Second, the study was conducted at a single tertiary care center, which may limit the generalizability of the findings to other healthcare settings. Third, the sample size, although adequate for comparative outcome assessment, may have been insufficient to detect statistically significant differences in less frequent outcomes such as mortality. Fourth, follow-up duration was relatively short, and late recurrence of intra-abdominal collections beyond the follow-up period could not be assessed. Finally, cost analysis and patient-reported outcomes were not evaluated, which could have provided additional insights into the overall benefit of ultrasound-guided percutaneous drainage.

CONCLUSION

Ultrasound-guided percutaneous drainage is a safe, effective, and minimally invasive modality for the management of intra-abdominal collections, with clinical success rates comparable to open surgical drainage. In the present study, USG-PD was associated with significantly shorter procedure time, faster resolution of infection, reduced hospital stay, and lower complication rates, particularly with complete avoidance of surgical site infections. These findings support the use of USG-PD as the preferred first-line intervention in hemodynamically stable patients with accessible intra-abdominal collections. Open surgical drainage should be reserved for patients with diffuse peritonitis, complex multiloculated collections, or failure of percutaneous management. Adoption of ultrasound-guided percutaneous drainage as an early treatment strategy can reduce surgical morbidity, optimize resource utilization, and improve patient outcomes, especially in resource-constrained tertiary care settings.

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