



Original Research Article

PROSPECTIVE EVALUATION OF ULTRASONOGRAPHY/CT-BASED MARKING ACCURACY AND MORPHOLOGICAL PREDICTORS (VOLUME, DEPTH, LOBE) FOR LIVER ABSCESS ASPIRATION OUTCOMES

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ABSTRACT

Background: Liver abscess is a common intra-abdominal infection in developing regions and often necessitates image-guided intervention in addition to antimicrobial therapy. Ultrasonography (USG) and computed tomography (CT) play a crucial role not only in diagnosis but also in procedural planning for percutaneous aspiration. Despite widespread use, aspiration outcomes vary, frequently resulting in dry taps or incomplete evacuation. This variability underscores the importance of understanding how imaging-based marking accuracy and morphological characteristics of abscesses influence aspiration success. The aim is to prospectively evaluate the accuracy of ultrasonography/CT-based surface marking and to assess morphological predictors—specifically abscess volume, depth, lobe involvement, and imaging-defined aspirability—in determining aspiration outcomes in patients with liver abscess.

Materials and Methods: A prospective observational study was conducted at Maharana Bhupal Government Hospital, affiliated with R.N.T. Medical College, Udaipur, from 2019 to 2021. Twenty-five patients with hepatic abscess undergoing interventional management were included. Detailed demographic, clinical, biochemical, and radiological data were collected prospectively. USG and/or CT were used to assess abscess morphology and to mark the aspiration site based on approach angle, depth, volume, and accessibility. Percutaneous aspiration was performed using a wide-bore comet tail needle (14–18G), and aspirated material was sent for microbiological analysis. Procedural outcomes were correlated with imaging-defined morphological parameters. Statistical analysis was carried out using Student's t-test and Chi-square test where appropriate.

Results: Most patients were males (96%), with the highest incidence in the 31–40-year age group (36%). Single-attempt aspiration was successful in 68.8% of cases, while all patients undergoing multiple attempts achieved successful aspiration. Abscess volume showed a clear influence on aspiration yield, with low success in collections <100 cc (33.3%) and higher success in volumes >100 cc. Depth had minimal impact on aspiration success, whereas imaging-defined aspirability emerged as the strongest predictor, with 100% success in aspirable abscesses compared to 58.3% in organized lesions. Aspiration alone was the predominant treatment modality (72%). Culture positivity was low (20%), and no mortality was observed.

Conclusion: Ultrasonography/CT-based marking accuracy is a key determinant of successful liver abscess aspiration. Morphological factors, particularly abscess volume and imaging-defined aspirability, are more predictive of aspiration outcomes than depth or lobe involvement. Incorporating detailed morphological assessment into procedural planning can optimize aspiration success and guide timely escalation of intervention.

Keywords: Liver abscess; Ultrasonography; Computed tomography; Percutaneous aspiration; Morphological predictors.

INTRODUCTION

Liver abscess remains a clinically important intrahepatic infection because delayed diagnosis or inadequate source control can rapidly progress to sepsis, rupture, pleuro-pulmonary extension, and other life-threatening complications. Contemporary classification broadly separates pyogenic and amoebic abscesses, but regardless of etiology timely imaging confirmation and a clear drainage strategy are central to outcome. Cross-sectional imaging (ultrasonography and CT) is now embedded in routine evaluation, not only to establish the diagnosis and anatomical relationships, but also to determine whether a cavity is sufficiently liquefied to yield pus, whether the trajectory is safe, and whether adjacent viscera or vascular structures constrain access. As a result, the procedural step of image-guided site marking (angle, depth, and target window) has become a practical determinant of whether aspiration yields pus or results in a dry tap.^[1] In endemic and resource-variable settings, liver abscess continues to generate substantial inpatient workload, with a predominance among adult males and frequent right-lobe involvement. Large contemporary series from northern India illustrate how liver abscess care is typically imaging-led and intervention-heavy, with many patients requiring percutaneous drainage strategies alongside antibiotics and supportive care. These cohorts also highlight that complications such as pleural effusion and rupture are not uncommon, reinforcing the need for early recognition and effective image-guided access planning. Within such real-world practice, the ability of ultrasonography and/or CT to guide accurate marking—so that the initial attempt enters the liquefied portion of the collection—becomes a clinically meaningful performance metric, because it affects technical success, downstream escalation to catheter drainage or surgery, and overall length of stay.^[2] Management has evolved from primarily operative approaches toward minimally invasive, image-guided interventions. Current practice integrates antibiotics with aspiration or catheter drainage depending on clinical status and abscess morphology, while reserving laparotomy for rupture, failure of percutaneous approaches, or complex multiloculated disease not amenable to safe access. Reviews emphasize that interventional radiology and improved peri-procedural care have reduced mortality compared with historical series, but outcomes remain heterogeneous due to variation in abscess stage (early phlegmon vs. liquefied cavity),

loculation, size, comorbidity burden, and access constraints imposed by depth or subdiaphragmatic position. These considerations underscore why a study focused on marking accuracy and morphological predictors is clinically relevant: aspiration success is not purely operator-dependent—it is strongly shaped by imaging-defined cavity characteristics and the feasibility of a safe, stable needle path.³ Among image-guided options, percutaneous needle aspiration (PNA) and percutaneous catheter drainage (PCD) are the two principal modalities, and comparative trials have explored which strategy offers higher primary success and fewer re-interventions. A key issue common to both approaches is that the first needle pass must reach the purulent component; when marking is imperfect or when the cavity is only partially liquefied, aspiration may be non-yielding despite technically correct needle placement within an inflamed mass. Randomized and comparative studies evaluating ultrasound-guided aspiration versus catheter drainage in liver abscesses have therefore drawn attention to procedural endpoints such as “successful aspiration,” need for repeat attempts, and conversion to catheter placement. In practical terms, the aspiration attempt is also an indirect audit of pre-procedure imaging interpretation (liquefaction, septations) and of the accuracy of the selected trajectory (depth and angulation).^[3,4] Evidence syntheses further support that outcomes depend not only on which percutaneous technique is used, but also on abscess morphology at presentation and on how well imaging guidance is operationalized at the bedside. A recent systematic review with trial sequential analysis comparing PCD and PNA reported clinically meaningful differences across several procedural and clinical endpoints, but also noted the importance of patient selection and abscess characteristics when interpreting aggregate effects. These findings motivate prospective designs that record imaging-derived parameters at the time of marking—particularly volume (or size), depth from skin, and lobe location—because they plausibly influence both technical yield (aspirate obtained) and clinical recovery (resolution, need for escalation). Within this context, a structured evaluation of marking accuracy using “aspiration yield” as a performance proxy becomes a pragmatic, patient-centered metric.^[5] Updated meta-analytic work incorporating randomized evidence continues to refine comparative expectations between catheter drainage and needle aspiration, while also highlighting that heterogeneity persists due to

varying definitions of success, differences in abscess size thresholds for intervention, and inconsistency in how imaging morphology is classified across studies. This reinforces a key methodological gap: many reports compare drainage modalities without granular documentation of the specific imaging determinants that govern whether aspiration is feasible, where the liquefied portion is located, and whether a safe window exists for a stable needle path. A prospective study that explicitly links ultrasonography/CT-based marking parameters (trajectory, depth, and intended cavity zone) to aspiration outcomes can therefore contribute by translating “imaging findings” into measurable procedural performance and by clarifying which morphological features most strongly predict success in everyday practice.^[6,7]

MATERIALS AND METHODS

A prospective observational study was undertaken at Maharana Bhupal Government Hospital (MBGH), affiliated with R.N.T. Medical College, Udaipur, encompassing patients admitted with hepatic (liver) abscess disease during 2019–2021 who received interventional treatment. The methodology was designed to evaluate the accuracy of ultrasonography/CT-based surface marking for aspiration and to assess morphological predictors—particularly abscess volume, depth parameters, and lobe involvement—in relation to aspiration outcomes.

Eligible patients were counselled regarding the objectives and scope of the study, and written informed consent was secured prior to inclusion. Information was gathered prospectively throughout the hospital stay. Clinical evaluation was supported by laboratory investigations and radiological confirmation, following which cases were classified as hepatic abscess disease. Patient-level details were captured comprehensively, including demographic profile, presenting symptoms and signs, biochemical reports, and imaging findings.

For each included patient, structured assessment focused on radiological morphology and procedural planning variables. Morphological predictors and related determinants were documented from imaging, including the number of abscess cavities, overall size, presence or absence of calcification, hepatic lobe location, and imaging-defined features relevant to aspiration feasibility. In addition, laboratory correlates such as total leukocyte count and liver function markers—serum bilirubin, alkaline phosphatase, and other liver function tests—were recorded to allow correlation with procedural and clinical outcomes.

Ultrasonography and/or CT scan were used to determine the aspiration plan and to mark the intended entry site. The marking process incorporated measurements required for procedural precision, including the intended approach angle,

estimated tract depth, abscess volume, and both minimum and maximum depth from the skin surface. After finalizing the imaging-based marking, aspiration was performed on the operating table according to the planned site, using a wide-bore comet tail needle (14–18G). The aspirate was collected aseptically and submitted for pus culture and sensitivity.

Procedures were carried out after obtaining informed risk consent from the patient and family members. Depending on clinical requirements, local or general anaesthesia was administered. The procedure field was prepared under strict aseptic conditions with povidone iodine and savlon, followed by sterile draping. Needle aspiration was then attempted using the comet tail needle (14–18G). After aspiration and sample dispatch for microbiology, sterile dressing was applied and the patient was transferred to the ward. The entire clinical course was documented, including pre-procedure preparation, intra-procedure observations, and post-procedure monitoring, to support evaluation of marking accuracy and the influence of morphological variables on aspiration outcomes.

Inclusion criteria comprised patients undergoing management for hepatic abscess disease, except those receiving only medical management. Patients diagnosed with extra-hepatic abscess disease were excluded.

Data were analysed using computer-based statistical software. Student’s t-test and Chi-square test were used wherever appropriate to test associations and determine statistical significance with calculation of p-values. Microsoft Word and Excel were utilized to prepare tables, charts, and graphical outputs.

RESULTS

[Table 1] (Baseline demographic profile): In this prospective cohort of 25 liver abscess patients, the age distribution demonstrated a clear predominance in early to mid-adulthood. The largest proportion of cases occurred in the 31–40 years group (9 patients; 36%), indicating that liver abscess requiring interventional management was most frequent in the fourth decade. The next highest contribution came from the 51–60 years group (5 patients; 20%), followed by 21–30 years (4 patients; 16%) and 41–50 years (3 patients; 12%), showing that most patients were clustered between 21 and 60 years. Extremes of age were uncommon: only one patient each (4% each) was present in the 11–20, 61–70, 71–80, and 81–90 year categories. Sex distribution showed a marked male predominance, with 24 males (96%) and only 1 female (4%), suggesting that, in this hospital-based sample, liver abscess requiring procedural management affected males overwhelmingly more than females.

[Table 2] (Aspiration attempts and yield as a proxy for marking accuracy):

Aspiration attempt patterns demonstrate how often a planned imaging-based approach translated into a successful aspirate yield. Among patients undergoing a single attempt (n = 16), aspiration was successful in 11 cases, whereas 5 cases resulted in dry tap, indicating that despite a planned entry based on ultrasonography/CT marking, no pus could be obtained in nearly one-third of the single-attempt subgroup. Importantly, no cases were recorded as “not attempted” in either category, indicating that these were genuine procedural attempts. In the multiple-attempt subgroup (n = 4), aspiration was successful in all 4 cases, with no dry taps.

[Table 3] (Morphological predictors and aspiration outcome): This table demonstrates the relationship between imaging morphology and aspiration success, thereby directly addressing morphological predictors of aspiration outcomes. Abscess volume showed the strongest visible gradient: aspiration success was lowest in small collections <100 cc, with only 2/6 (33.3%) successfully aspirated and 4/6 (66.7%) not aspirated, establishing small-volume collections as the most difficult to yield aspirate. In contrast, success improved markedly in the 100–500 cc category, where 9/11 (81.8%) were aspirated, and was highest in >500 cc abscesses with 7/8 (87.5%) aspiration success. With respect to depth, aspiration success remained consistently high in both strata. Lesions at 1–5 cm depth had an 80% success rate (8 aspirated, 2 not aspirated), while lesions >5 cm had a 72.7% success rate (8 aspirated, 3 not aspirated). This relatively modest difference suggests that deeper location did not drastically compromise aspiration yield in this cohort, likely reflecting appropriate planning of trajectory and use of imaging guidance. Regarding lobe involvement, the right lobe was the most commonly involved (n = 16), with aspiration success of 10/16 (62.5%), and 6/16 (37.5%) not aspirated. The left lobe group (n = 3) and both lobe involvement group (n = 6) showed 100% aspiration success (3/3 and 6/6 respectively). While this appears favorable for left/bilateral lesions, the subgroup sizes are small and therefore should be interpreted cautiously; however, it still suggests that certain anatomical locations may offer more straightforward access windows. The most decisive morphological discriminator was aspirability status on imaging. Abscesses labelled aspirable (n = 9) had 100% success (9 aspirated, 0 not aspirated), demonstrating that when the cavity was assessed as liquefied and accessible, aspiration was consistently effective. Conversely, non-aspirable/organised (n = 12)

abscesses had only 58.3% success (7 aspirated, 5 not aspirated), underscoring the technical limitation posed by thick, organized contents and supporting the practical value of explicitly documenting “aspirability” during pre-procedural imaging marking.

[Table 4] (Treatment pathways adopted): Treatment allocation reflects the real-world procedural strategy required for different clinical scenarios. The majority of patients underwent aspiration only (18/25; 72%), establishing percutaneous aspiration as the principal intervention in this cohort. Aspiration with ICD placement was required in 2 patients (8%), indicating that a subset had thoracic extension, pleuro-pulmonary involvement, or required adjunctive drainage for associated collections. Open drainage/excision via laparotomy was performed in 3 patients (12%), which typically suggests complicated abscess disease such as rupture, failure of percutaneous drainage, inaccessible location, or peritonitis requiring operative management. Only 1 patient (4%) was treated conservatively, implying that most cases were of sufficient size, symptom burden, or complexity to warrant intervention. Additionally, ICD placement alone in 1 patient (4%) indicates an instance where pleural drainage was required as the principal intervention, consistent with complications such as pleuro-peritoneal communication or significant pleural collection.

[Table 5] (Pus culture yield): Among 15 aspirate samples sent for microbiology, sterile/no growth results predominated, occurring in 12 samples (80%). This high proportion suggests frequent culture negativity, which can commonly occur due to prior antibiotic administration before aspiration, low organism burden, inadequate sampling volume, or fastidious organisms. Culture-positive results were relatively infrequent, with E. coli isolated in 2 cases (13.33%) and Citrobacter in 1 case (6.67%).

[Table 6] (Hospital stay by intervention category): Hospital stay data demonstrate a tendency toward longer admissions, particularly in patients requiring more invasive management. In the aspiration group (n = 20), only 6 patients were discharged within 0–10 days, whereas 14 patients required hospitalization for >10 days, indicating that even after percutaneous aspiration, ongoing antibiotic therapy, monitoring for residual cavity infection, persistent fever, or complications may prolong inpatient care. In contrast, all patients managed with laparotomy (n = 3) had hospital stay >10 days, with 0 patients discharged within the first 10 days.

Table 1: Baseline demographic profile (n = 25)

Variable	Category	Number	Percentage (%)
Age (years)	11–20	1	4.00
	21–30	4	16.00
	31–40	9	36.00
	41–50	3	12.00
	51–60	5	20.00
	61–70	1	4.00
	71–80	1	4.00
	81–90	1	4.00

Sex	Male	24	96.00
	Female	1	4.00

Table 2: Aspiration attempts and yield (procedural performance proxy for marking accuracy)

Attempt strategy	Aspirated (n)	Dry tap (n)	Not attempted (n)
Single attempt (n = 16)	11	5	0
Multiple attempts (n = 4)	4	0	0

Table 3: Morphological predictors and aspiration outcome (as per imaging-based subgroup totals)

Predictor domain	Category (n)	Aspirated (n)	Not aspirated (n)	Success rate (%)
Volume	<100 cc (6)	2	4	33.3
	100–500 cc (11)	9	2	81.8
	>500 cc (8)	7	1	87.5
Depth	1–5 cm (10)	8	2	80.0
	>5 cm (11)	8	3	72.7
Lobe	Right (16)	10	6	62.5
	Left (3)	3	0	100.0
	Both (6)	6	0	100.0
Aspirability	Aspirable (9)	9	0	100.0
	Non-aspirable/organised (12)	7	5	58.3

Table 4: Treatment pathways adopted (n = 25)

Treatment modality	Number of patients	Percentage (%)
Conservative	1	4.00
Aspiration only	18	72.00
Aspiration + ICD placement	2	8.00
Open drainage/excision (laparotomy)	3	12.00
ICD placement only	1	4.00
Total	25	100.00

Table 5: Pus culture yield (aspirated samples, n = 15)

Organism / report	Number	Percentage (%)
Sterile / no growth	12	80.00
E. coli	2	13.33
Citrobacter	1	6.67
Total	15	100.00

Table 6: Hospital stay by intervention category

Duration of stay (days)	Aspiration (n = 20)	Laparotomy (n = 3)
0–10	6	0
>10	14	3

DISCUSSION

The present prospective cohort (n = 25) demonstrated that liver abscess requiring interventional management clustered predominantly in early-to-mid adulthood, with the highest burden in the 31–40-year group (36%), and a marked male predominance (96%). This demographic pattern is directionally consistent with the Indian prospective data of Jana et al (2024), where most cases were between 21–40 years (53.3%) with male predominance (76.7%), reinforcing that liver abscess remains largely a disease of working-age males in endemic and resource-variable settings, likely reflecting exposure risks and late presentation to tertiary care.^[8] Clinically, abdominal pain (100%) and fever (80%) were the dominant presenting features in the current cohort, while jaundice was less frequent (16%), implying that biliary obstruction/communication or significant hepatic dysfunction was present only in a minority. Comparable symptom distributions are reported in large Indian series: Jindal et al (2021) observed abdominal pain in 86% and fever in 85.3% of patients, with jaundice in approximately 10.2%,

supporting the concept that systemic inflammatory features are common but not universal, and that jaundice represents a more selective subgroup often associated with complexity or larger disease burden.^[9]

A key operational objective of this study was to assess procedural yield as a proxy for marking accuracy and technical success. In the single-attempt subgroup (n = 16), aspiration yielded pus in 11 cases (68.8%) and resulted in dry tap in 5 cases (31.2%), whereas all patients subjected to multiple attempts (n = 4) were successfully aspirated (100%). This aligns with controlled interventional evidence: Singh et al (2013) showed that needle aspiration success increases with repeated sessions (30% after the first aspiration, 63% after the second, and 77% after the third), highlighting that an initial non-yielding attempt should not be interpreted as definitive failure—particularly when imaging suggests partial liquefaction or organized debris.^[10]

Morphological determinants in this cohort showed the most prominent gradient with abscess volume: aspiration success was lowest for <100 cc collections (33.3%), improving in 100–500 cc (81.8%) and >500

cc (87.5%). Although statistical association with volume was not significant in the first-article analysis ($p = 0.109$), the observed pattern is clinically intuitive and consistent with pooled interventional comparisons. Cai et al (2014) reported higher overall success for catheter drainage than needle aspiration (96.1% vs 77.8%), implying that smaller or less liquefied collections—where needle aspiration is technically limited by target size and cavity collapse—may benefit from alternative drainage strategies when repeated aspiration is non-yielding.^[11]

Beyond size, “aspirability” on imaging emerged as the most decisive discriminator in this cohort: lesions labelled aspirable had 100% success (9/9), while organized/non-aspirable lesions had only 58.3% success. This practical finding mirrors broader real-world management trends where percutaneous techniques are the mainstay, but modality selection depends on cavity characteristics and expected yield. In a European experience, Serraino et al (2018) reported that 66.7% of cases required image-guided procedures, with percutaneous drainage performed in 67% and needle aspiration in 11%, indicating that many centers preferentially escalate beyond single-pass aspiration when morphology predicts reduced yield—particularly in complex, organized, or septated abscesses.^[12]

Microbiological yield in this study was low, with sterile/no-growth cultures in 80% of aspirates (12/15), and only Gram-negative isolates recovered among positives (*E. coli* 13.33%, *Citrobacter* 6.67%). In contrast, large Asian datasets typically report higher culture positivity. Zhang et al (2019) noted that among patients with pus culture available (60.8%), 70.3% were culture-positive, and *Klebsiella pneumoniae* was the most common pathogen; blood cultures, when obtained, were positive in 26.5%. The discrepancy with our 80% sterile rate is plausibly attributable to pre-aspiration antibiotic exposure, sampling limitations in small-volume cavities, and reduced viability in partially treated infections—factors that can substantially depress culture yield despite active disease.^[13]

The high proportion of culture-negative aspirates is also contextualized by comparative outcome work. Liu et al (2023) reported culture-positive disease in 62.3% of patients (202/324), implying that a substantial minority remain culture-negative even in structured settings; within culture-positive cases, *Klebsiella pneumoniae* predominated (54.0%) with *E. coli* comprising a smaller proportion (9.9%). In our cohort, culture negativity was even more pronounced (80%), emphasizing that clinical response and imaging evolution should guide therapy when microbiology is unrevealing, and that culture-negative status does not exclude clinically significant abscess burden requiring intervention.^[14]

From a safety and outcome standpoint, this cohort had no mortality (0%), no hepatic failure, and no major surgical site infection, despite documented serious events such as intra-abdominal rupture (16%)

and pulmonary complications (8%). This favorable outcome profile compares well with population-based estimates. Losie et al (2021) reported 30-day mortality of 7.4% in pyogenic liver abscess and identified absence of abscess drainage among independent risk factors, supporting the inference that timely drainage/aspiration and escalation pathways likely contributed to the zero-mortality finding in our interventional cohort, even with a meaningful fraction of complicated presentations.^[15] Hospital stay in this cohort was prolonged for most patients: 70% of aspirated patients (14/20) stayed >10 days, and all laparotomy patients (3/3) stayed >10 days, reflecting the downstream impact of residual cavity issues, persistent fever, rupture, and the need for extended antimicrobial therapy and monitoring. Similar absolute lengths of stay are reported internationally; Zhou et al (2021) documented an average hospitalization duration of 15.72 ± 3.16 days in pyogenic liver abscess, reinforcing that even when image-guided drainage is technically successful, inpatient care may remain substantial due to systemic inflammation, comorbidity burden, and the time required for radiologic resolution and clinical stabilization.^[16]

CONCLUSION

The findings of this study indicate that ultrasonography/CT-based marking accuracy plays a central role in determining aspiration yield in liver abscess management. Morphological parameters—particularly abscess volume and imaging-defined aspirability—were more predictive of successful aspiration than lesion depth or lobe location. Smaller and partially organized abscesses were associated with lower aspiration success, while larger, liquefied collections consistently yielded pus. These results emphasize the importance of integrating detailed morphological assessment into procedural planning to optimize aspiration outcomes and guide timely escalation of intervention when required.

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