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Original Article

Analysis of factors affecting the diagnostic yield for microbiologic diagnosis from percutaneous abdominal abscess drainage

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Abstract
Introduction: This study aimed to investigate the factors influencing the diagnostic yield of microbiologic diagnosis obtained through percutaneous abdominal abscess drainage procedures. We analyzed the influence of diverse clinical, radiological, and pre-procedural factors on the success of microbiologic diagnosis in this context.
Methodology: A retrospective analysis of patients who underwent percutaneous abdominal abscess drainage was performed to assess the factors affecting the diagnostic yield for microbiologic diagnosis.
Results: A total of 174 patients undergoing percutaneous abdominal abscess drainage was included. The use of antibiotics during the procedure and the spread of the abscess to other organs significantly increased the likelihood of obtaining a positive culture. Specifically, antibiotic use during the procedure raised the risk by up to 3.30-fold (OR = 3.30, 95% CI 1.48–7.65, $p = 0.004$), while abscess spread to another organ increased the risk by approximately 1.87-fold (OR = 1.87, 95% CI 0.98–3.61, $p = 0.057$). Additionally, abscesses containing air and abscesses with an air-fluid level were more common in patients with positive culture results. Other factors, such as gender, age, malignancy prevalence, and surgical history, did not significantly impact culture results.
Conclusions: This study provides valuable insights into the factors affecting the diagnostic yield of microbiologic diagnosis from percutaneous abdominal abscess drainage. The findings underscore the importance of considering patient-specific variables and procedural aspects when planning and executing abscess drainage procedures. Further research can build upon these insights to develop evidence-based guidelines for optimizing the diagnostic yield of percutaneous abdominal abscess drainage procedures.

Key words: abscess; abdominal; drainage; culture; image-guided; percutaneous.

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Introduction
Intra-abdominal abscesses (IAA) are cystic collections of focally limited, suppurative inflammatory material located in the abdominal cavity. The primary treatment for IAAs includes antibiotic therapy; however, drainage of the abscesses is required in appropriate patients [1]. In recent years, percutaneous drainage (PD) has evolved significantly with the widespread use of imaging-guided PD procedures, because it can be performed with a shorter hospital stay and without general anesthesia [2]. PD provides drainage of the abscess and the causative microorganism can be detected by taking a sample from the pus. In this way, it allows for the identification of the pathogen and determination of specific treatment based on antibiotic susceptibility tests performed on the isolated pathogen [3]. Performing drainage on non-abscess sterile fluid collections can be an unwarranted intervention, adding unnecessary risk for the patient [4]. Accurate microbiological diagnosis plays a pivotal role in guiding targeted antimicrobial therapy and improving patient outcomes. However, the diagnostic yield of PD for microbiological identification remains subject to various factors that may influence the success of this essential procedure. While the procedure has demonstrated favorable outcomes in many cases, the variability in diagnostic yield warrants a comprehensive investigation of the factors influencing its success.

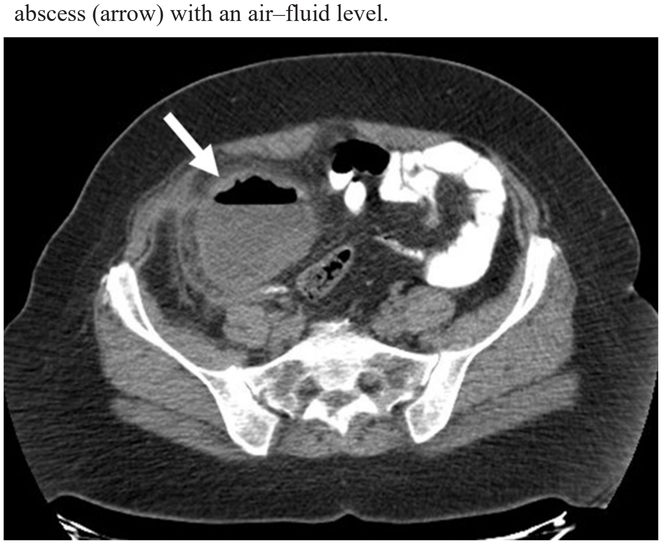
This research paper aims to delve into the multifactorial aspects affecting the diagnostic yield of image-guided drainage for microbiologic diagnosis of abdominal abscesses. Additionally, we will present a thorough analysis of the potential factors influencing the diagnostic yield, such as abscess characteristics in computed tomography (CT) and patient-specific variables. Understanding these factors is crucial in optimizing diagnostic accuracy, facilitating early and targeted antibiotic therapy, and ultimately reducing the burden of abdominal abscess-related complications.

Methodology

Study design, patient selection, and data collection

A retrospective study was conducted to analyze the factors affecting the diagnostic yield for microbiologic diagnosis from abdominal abscess PD. The study protocol was evaluated and approved by the relevant Pamukkale University review board (process number: E-60116787-020-406295). Patients who underwent PD for abdominal abscesses and had microbiologic analysis of the collected specimens were included in the study. Patients with incomplete medical records including abdominal CT images, without IAA, those who did not undergo microbiologic analysis, or cases with non-bacterial abscess etiologies were excluded (38 cases). Relevant demographic information, clinical history, and CT image characteristics of abscesses were collected from electronic medical records of patients who underwent PD for abdominal abscess in the Department of Interventional Radiology at our institution between January 2018 and January 2023. Surgery was investigated as a possible risk factor for developing IAA because it can cause contamination and fluid leakage. Abscess characteristics including size, location, number, density, wall thickness, surrounding inflammatory changes, capsular ring contrast uptake, abscess spread to another organ and, presence of gas or fluid-fluid levels of abscesses on CT imaging studies were recorded (Figure 1). Moreover, the use of antibiotics during the drainage procedure and the change in antibiotic treatment after culture results were noted.

Figure 1. A right lower quadrant abscess arising from the perforation of acute appendicitis was observed in a 44-year-old woman. The axial computed tomographic scan image shows the abscess (arrow) with an air–fluid level.



Sample collection and processing

The patients were screened to prevent bleeding complications prior to the procedure; and to ensure a serum platelet count of ≥ 50,000 µL or greater and an international normalized ratio of 1.5 or less. All drainage procedures were performed by radiologists in the Interventional Radiology Suite. Ultrasound and CT were used as imaging methods for guidance. The patients underwent drainage and sampling using 18 or 21-gauge Chiba needles. The samples were collected during the first puncture from each patient. The collected specimens were processed by the hospital's microbiology laboratory using standard laboratory techniques. The identification of isolated pathogens, including the presence of polymicrobial infections, was recorded. Antimicrobial susceptibility testing was performed to determine the sensitivity of isolated pathogens to various antibiotics. Furthermore, a secondary specimen was collected from patients exhibiting negative outcomes in the initial routine culture, specifically targeting tuberculosis and anaerobic bacteria.

Statistical analysis

Data obtained in the study were summarized using descriptive statistical methods. The median, minimum, and maximum values were calculated for continuous variables and presented in tables based on data distribution. Categorical variables were expressed as frequency and percentage. The normality of continuous variables was assessed using the Shapiro-Wilk, Kolmogorov-Smirnov and Anderson-Darling tests. The Pearson Chi-Square, Fisher's Exact Test, or Fisher Freeman Halton tests were used to determine differences between categorical variables grouped based on the expected observation numbers. When comparing the culture results, the Mann Whitney U test was preferred for continuous variables that did not show a normal distribution. Logistic regression analysis was used to determine factors affecting whether the culture development was positive or not. In the univariate analysis, the effect of each variable was evaluated separately. In the multivariate model, variables thought to be potentially effective were included. To check for multicollinearity in the model, the variance inflation factor (VIF) was evaluated and was observed to be within acceptable limits. Statistical analyses were performed using the Jamovi (version 2.3.28) and JASP

Table 1. Demographic and clinical variables in patients undergoing percutaneous abdominal abscess drainage.

Characteristics	Negative (n = 80)	Positive (n = 94)	*p* value
Gender J			
Male	45 (56.2)	52 (55.3)	0.999**
Female	35 (43.8)	42 (44.7)	
Age §	61.5 [16.0 - 84.0]	57.0 [18.0–91.0]	0.169*
Malignancy, *yes* J	38 (47.5)	37 (39.4)	0.354**
Surgery in the last one month, *yes* J	40 (50.0)	46 (48.9)	0.999**

J: n (%); §: median [Min.–Max.]; *: Mann-Whitney U test; **: Pearson Chi-square.

(version 0.17.2.3) software. A *p* value of < 0.05 was considered statistically significant in all analyses.

Results

We evaluated 174 patients who underwent percutaneous abdominal abscess drainage. Of these patients, 80 (45.9%) had negative culture results from the drainage fluid, while 94 (54.1%) had positive results. Of the patients with negative culture results, 56.2% were male and 43.8% were female; of those with positive results, 55.3% were male and 44.7% were female. The median age of patients with negative culture results was 61.5 years, while the median age was 57 years for those with positive results. Malignancy was detected in 47.5% of patients with negative results, while 39.4% of those with positive results had signs of malignancy. The proportion of patients with a surgical history in the previous month was 50% in the negative result group and 48.9% in the positive result group. Based on culture results, no statistically significant difference was determined between the groups in terms of gender, age, prevalence of malignancy, and surgical history in the previous month ($p > 0.05$ for each) (Table 1).

When examining abdominal abscess characteristics based on culture results, it was observed that abscesses that spread to other organs, contained air, and had an air-fluid level, were statistically more common in patients with positive culture results ($p = 0.040$, $p = 0.041$, and $p < 0.001$, respectively). No significant difference was detected between patients with negative and positive culture results in terms of abscess location, presence of visceral abscess, presence of multiple abscesses, number of abscesses, size, wall thickness, capsular ring contrast uptake, surrounding inflammatory changes, and abscess density ($p > 0.05$ for all) (Table 2).

In patients with positive culture results, antibiotic treatment was changed more frequently based on these results, while in patients with negative results, antibiotic treatment was changed less frequently ($p < 0.001$). It was determined that culture results were more often positive in patients receiving antibiotic treatment during drainage ($p = 0.003$). The use of a catheter during drainage was similar between patients with negative and positive culture results ($p = 0.178$) (Table 3).

According to the results of univariate logistic regression analysis (Table 4), the presence of abscess spread to another organ increased the risk of a positive culture result by approximately 1.97-fold ($p = 0.028$). The presence of antibiotic use during the procedure

Table 2. Comparison of characteristics of abdominal abscess according to cultures.

	Culture result		*p* value
	Negative (n = 80)	Positive (n = 94)	
Abscess location J			
Upper right dial	22 (27.5)	32 (34.0)	
Left top dial	13 (16.2)	16 (17.0)	
Bottom right	13 (16.2)	13 (13.8)	0.331**
Bottom left	10 (12.5)	4 (4.3)	
Multiple dials	22 (27.5)	29 (30.9)	
Visceral abscess, *yes* J	26 (32.5)	35 (37.2)	0.622**
Multiple abscesses, *yes* J	20 (25.0)	32 (34.0)	0.257**
Abscess number §	1.0 [1.0–7.0]	1.0 [1.0–10.0]	0.206*
Abscess size (volume mm^3) §	300150.0 [2340.0–7150000.0]	260392.5 [4500.0–6000000.0]	0.109*
Air in the abscess, *yes* J	26 (32.5)	46 (48.9)	**0.041****
Air-fluid level in abscess, *yes* J	0 (0.0)	37 (39.4)	**< 0.001****
Fluid level in abscess, *yes* J	2 (2.5)	5 (5.3)	0.454**
Abscess wall thickness (mm) §	3.0 [1.0–8.0]	3.5 [1.0–7.6]	0.178*
Abscess density (HU) §	13.0 [-7.0–55.0]	14.5 [-20.0–70.0]	0.875*
Capsular ring enhancement, *yes* J	71 (88.8)	86 (91.5)	0.726**
Inflammatory changes in surrounding tissues, *yes* J	58 (72.5)	79 (84.0)	0.095**
Abscess dissemination to another organ, *yes* J	36 (45.0)	58 (61.7)	**0.040****

J: n (%); §: median [Min.–Max.]; *: Mann-Whitney U test; **: Pearson Chi-Square/Fisher's Exact test/Fisher Freeman Halton test; **bold font:** statistically significant results.

Table 3. Comparison of the antibiotic regimen and catheter use associated with percutaneous abdominal abscess drainage procedure in the patient groups with negative and positive culture results.

	Culture results		
	Negative (n = 80)	**Positive (n = 94)**	***p* value**
Antibiotic regimen change after culture results, *yes* J	30 (37.5)	66 (70.2)	**< 0.001**
Antibiotherapy during the procedure, *yes* J	43 (53.8)	72 (76.6)	**0.003**
Catheter use, *yes* J	68 (85.0)	87 (92.6)	0.178

J: n (%); §: median [Min.-Max.]; **bold font:** statistically significant results.

increased the risk by 2.82-fold ($p = 0.002$). When the univariate results for other variables were examined, they were found to be not statistically significant ($p > 0.05$ for each).

According to the multivariate logistic regression model, only the presence of antibiotic use during the procedure increased the risk of a positive culture result by 3.30-fold ($p = 0.004$). The presence of abscess spread to another organ increased the risk by approximately 1.87-fold, and this result was borderline significant ($p = 0.057$), suggesting that it might be significant in a larger sample size or different studies. No significant results were obtained when evaluating the statistical results for other variables, ($p > 0.05$ for each).

Thus, the factors that significantly increased the risk of a positive culture result included presence of abscess spread to another organ, contained air, presence of air-fluid level, and the use of antibiotic during the procedure. The effects of other variables were not statistically significant.

Discussion

We sought to identify the key variables that significantly impacted the success of obtaining accurate microbiologic diagnoses by analyzing a retrospective cohort of patients who underwent PD for abdominal abscesses through microbiologic analysis of the collected specimens. Previous studies evaluated the diagnostic yield of IAA fluid collections and they found that several clinical and imaging characteristics were associated with positive culture result [4–7]. Our study's analysis revealed that abscesses that spread to other organs, contained air, and had an air-fluid level were the factors affecting the diagnostic yield from percutaneous abdominal abscess drainage. Patients presenting with organ-spreading abscesses that are often in advanced stages of disease progression and extend beyond the initial site of infection are likely to ease a polymicrobial milieu. Gas within a fluid collection was reported to be associated with a positive culture consistent with the current study [4,5,8].

Demographic and patient history factors such as gender, age, prevalence of malignancy, and surgical history in the previous month did not show a statistically significant difference in terms of culture results ($p > 0.05$ for each). Previous reports have shown that age and gender are not associated with a positive culture, which is consistent with the current study [5,6]. Surgical history may have a lower rate of infection since seromas or loculated ascites can be confused. However, in the present study, a surgical history in the previous month did not show a statistically significant difference in terms of culture results. Once again, abscess characteristics such as abscess location, presence of multiple abscesses, number of abscesses, size, wall thickness, capsular ring contrast uptake, surrounding inflammatory changes, and abscess density did not demonstrate a statistically significant difference in terms of culture results ($p > 0.05$ for each). Larger abscesses may be more likely to yield positive microbiologic results, possibly due to a higher microbial load and a greater likelihood of obtaining adequate specimen volumes. However, the current study's results show that there was no relationship between the size of abscesses and positive culture result. Wall thickness, capsular ring contrast uptake, and surrounding inflammatory changes of the fluid collections are related to fibrin and they represent a defense mechanism for localizing and limiting peritoneal infections [9]. However, the current study found that they were not associated with a positive

Table 4. Logistic regression results (univariate and multivariate) on factors that may influence culture outcomes.

Dependent variable: culture result	**OR (univariable)**	**OR (multivariable)**
Age	0.99 (0.97–1.01, $p = 0.243$)	0.99 (0.97–1.01, $p = 0.161$)
Malignancy, *yes*	0.72 (0.39–1.31, $p = 0.281$)	0.57 (0.29–1.11, $p = 0.103$)
Abscess number	1.12 (0.88–1.46, $p = 0.365$)	-
Abscess size	1.00 (1.00–1.00, $p = 0.247$)	1.00 (1.00–1.00, $p = 0.081$)
Abscess wall thickness	1.07 (0.88–1.31, $p = 0.498$)	-
Abscess spread to another organ, *yes*	1.97 (1.08–3.63, $\mathbf{p = 0.028}$)	1.87 (0.98–3.61, $p = 0.057$)
Antibiotics use during the procedure, *yes*	2.82 (1.48–5.45, $\mathbf{p = 0.002}$)	3.30 (1.48–7.65, $\mathbf{p = 0.004}$)
Catheter use, *yes*	2.19 (0.84–6.17, $p = 0.118$)	1.08 (0.33–3.67, $p = 0.903$)

OR: odds ratio; **bold font:** statistically significant results.

culture. Gee *et al.* [6] reported that a low Hounsfield Unit (HU) value (< 20) on CT scans, indicating the density of the abscess, was associated with successful outcomes. However, this finding is inconsistent with the present study.

The patients with positive culture results had their antibiotic treatment changed more frequently based on these results, compared to those with negative culture results ($p < 0.001$). The present study demonstrated that the antibiotic regimen was changed owing to culture results from IAA drainage (70%). The results of the current study are in agreement with a previous study [5]; however, it was inconsistent with the study of Asai *et al.* (30%) [10]. Accurate identification of causative pathogens enables targeted antibiotic therapy, minimizing the risk of antibiotic resistance and unnecessary use of broad-spectrum antibiotics [11]. Moreover, early and effective antimicrobial treatment based on microbiologic results is associated with improved patient outcomes, reduced hospital stay, and decreased healthcare costs [12]. The use of a catheter during drainage was similar between patients with negative and positive culture results. Additionally, the abscess size was found to be comparable between these groups.

The use of antibiotics during the drainage procedure significantly increased the likelihood of obtaining a positive culture result, and this was unexpected ($p = 0.004$). Some studies have recommended obtaining a sample from a fluid collection suspected of infection prior to antibiotic therapy owing to low culture yield [13–15]. McGillen *et al.* found a very high yield of positive cultures (74%), in spite of antibiotic treatment administered prior to the procedure [5]. They explained that the difference between reported values may be the result of the large variety of indications and locations for CT-guided drainage with diagnostic sampling. The present study's results are also in accordance with their study and there was a high yield of positive cultures (63%) in antibiotic therapy administered prior to the drainage [5]. Moreover, the diagnostic yield was lower in those who did not receive antibiotics in the current study. The difference in values from the previous report may be the result of the timing of antibiotics and the heterogeneity of the patient group. Although the clinical presentation may align with that of an abscess, microbial proliferation within the abscess contents can occur due to the ineffectiveness of antibiotics. Consequently, the process of drainage holds substantial importance for achieving efficacious therapeutic outcomes. It is imperative to ascertain the precise causative microorganism and administer the suitable antibiotics at the correct timing and dosage, as dictated by the antibiogram, to ensure optimal treatment.

Limitations of our study include its retrospective design, which may have introduced selection bias, and limited data availability. Patients who underwent drainage earlier in the course of the abscess development tended to have higher rates of successful microbiologic diagnosis. However, the exact timing of the drainage procedures was not available in the records. Additionally, the timing of antibiotic therapy can be significant as a risk factor, although it was not evaluated in the present study. The current study did not analyze the presence of a fistula as a risk factor. However, it was identified as a risk factor in a previous study [6].

Conclusions

This investigation sheds light on the crucial factors affecting the diagnostic yield for microbiologic diagnosis from percutaneous abdominal abscess drainage. The abscesses that contained air and had an air-fluid level, and abscesses that spread to other organs, emerged as key determinants of diagnostic success. Moreover, the use of antibiotics during the drainage procedure significantly increased the likelihood of obtaining positive culture result. Patients with positive culture results had their antibiotic treatment changed more frequently based on these results compared to those with negative results. These findings underscore the importance of optimizing procedural techniques, adhering to standardized microbiologic protocols, and recognizing the clinical significance of the diagnostic yield in guiding appropriate antimicrobial therapy. Further prospective studies with larger sample sizes are warranted to corroborate these findings and establish evidence-based guidelines for optimizing the diagnostic yield in percutaneous abdominal abscess drainage.

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Authors' contributions

MA, TS: wrote the manuscript; MA, HSA, MT, TD, UO, TS: data collection and curation; MA: analyzed the data. All authors reviewed the results and approved the final version of the manuscript.

Ethical approval

This study complied with the principles of the Declaration of Helsinki and was approved by Institutional Research Ethics Board of Pamukkale University School of Medicine.

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