ANNALS OF MEDICINE
2022, VOL. 54, NO. 1, 2269–2277
https://doi.org/10.1080/07853890.2022.2110612

ORIGINAL ARTICLE

OPEN ACCESS

Early percutaneous catheter drainage in protecting against prolonged fever among patients with pyogenic liver abscess: a retrospective cohort study

Yang Liu, Zexi Li, Anlei Liu, Jun Xu, Yi Li, Jihai Liu, Yecheng Liu* and Huadong Zhu*

Emergency Department, State Key Laboratory of Complex Severe and Rare Diseases, Peking Union Medical College Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College, Beijing, China

ABSTRACT

Background: Percutaneous catheter drainage (PCD) has been viewed as first-line treatment for pyogenic liver abscess (PLA), yet detailed guidance is lacking for best practice of PCD. This study investigated characteristics of patients with PLA who had received PCD, identified factors associated with prolonged fever, and aimed to evaluate the relationship between timing of PCD and clinical improvement.

Methods: This was a retrospective study of patients with PLA who had undergone PCD over a 7-year period. PCD performed when the liquefaction degree of abscesses was less than 30% and/or within 1 week after fever onset was defined as early PCD. Patients were grouped and analysed based on the timing of PCD (early vs. delayed). Factors associated with prolonged fever were also analysed using univariate and multivariate logistic regression.

Results: Among 231 patients with PLA, 81 treated with PCD were included in the study after exclusion. The size of abscesses ranged from 3.4 to 16 cm in diameter. Interestingly, the abscesses were predominantly multiloculated in this cohort (82.7%). The most common pathogen isolated from pus was *Klebsiella pneumoniae* (60.5%), followed by *Escherichia coli* (8.6%). The duration of fever was significantly shortened with early PCD as compared to delayed PCD intervention ($p = .042$). No statistical differences were found between the two groups with regard to catheter adjustment and salvage drainage. Maximum body temperature and diameter of abscess $>$ 7.5 cm were found to be associated with prolonged fever while early PCD was inversely related to prolonged fever. Multivariate analysis suggested that early PCD treatment was an independent protective factor of prolonged fever ($p = .030$).

Conclusions: Large abscesses with loculation could be successfully treated with PCD, and early PCD protected patients with PLA from prolonged fever. Our findings suggest that early intervention should be provided if PCD is indicated in clinical practice.

KEY MESSAGES

- Large abscesses and multiloculated abscesses can be treated with percutaneous catheter drainage.
- Early percutaneous catheter drainage is identified as a protective factor of prolonged fever among patients with pyogenic liver abscesses.
- Early intervention should be provided if percutaneous catheter drainage is indicated for pyogenic liver abscesses.

ARTICLE HISTORY
Received 15 May 2022
Revised 20 June 2022
Accepted 2 August 2022

KEYWORDS
Percutaneous catheter drainage; early; pyogenic liver abscess; prolonged fever; loculation

Background

Pyogenic liver abscess (PLA) has once been a potentially life-threatening disease, with mortality up to 31–65% [1]. The outcomes of PLA have improved dramatically over the past decades, as a result of timely diagnosis, effective antimicrobial therapy, development in intensive care and extensive application of percutaneous catheter drainage (PCD) [2]. Historically, PLA was treated with antibiotics and open surgery. Since first introduced in 1950s, PCD has been increasingly utilized in the management of PLA [3,4]. It can bridge the gap between conservative and operative treatment with minimally invasive, image-guided procedure, and has replaced surgery as first-line treatment for PLA [5]. Recent mortality rates have been decreasing and reported to be less than 10% as

CONTACT Yecheng Liu drliuyc@163.com; Huadong Zhu zhdpumch@outlook.com Emergency Department, State Key Laboratory of Complex Severe and Rare Diseases, Peking Union Medical College Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College, 1 Shuaifuyuan, Dongcheng District, Beijing, China
*These authors contributed equally to this work.

© 2022 The Author(s). Published by Informa UK Limited, trading as Taylor & Francis Group.
This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial License (http://creativecommons.org/licenses/by-nc/4.0/), which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

antibiotics and PCD have become the mainstay treatments for PLA [6–8]. Surgical drainage has then been reserved for those that have failed PCD [9].

Multiple studies have been conducted to analyse factors associated with outcomes and compare applications of different procedures, in pursuit of better evidence for PCD in treating PLA [10–13]. Generally, the size of liver abscess is used to determine choice of treatments in clinical practice. In cases of giant abscesses (larger than 10 cm), especially multiloculated lesions, it has been reported that PCD have high failure rate and incidence of complications [11,14,15]. However, recent studies have shown that PCD is as effective in treating large abscesses, regardless of loculation, indicating more extensive application of PCD [16–19]. Nevertheless, few have investigated detailed practice of PCD, including the optimal timing of the procedure [10]. In cases when abscesses are barely or partially liquified with a small fraction (in an immature form), there could be two options in performing PCD: to insert the drain and retain the tubing so that the abscess contents can get drained once they become liquified (early PCD), or to postpone PCD until the abscesses get fully mature (delayed PCD). It remains unclear whether immediate PCD should be recommended in terms of clinical improvement and interventional success rate.

In the present study, we reviewed clinical characteristics of patients with PLA who had received PCD, compared early PCD with delayed PCD, and investigated the factors associated with prolonged fever, which could contribute to better practice of PCD in treating PLA.

Methods

Study population

This was a retrospective cohort study conducted in Peking Union Medical College Hospital, a tertiary care hospital in Beijing, China. From December 2013 to December 2020, Medical records were reviewed from the hospital electronic database with the code K75.0, based on the International Classification of Diseases, 10th Revision. The diagnosis of PLA was based on clinical presentations, radiological manifestations and microbiological findings. Altogether, 231 patients were identified, among which 111 received PCD treatment. Since defervescence was a main indicator for clinical improvement, patients without fever in clinical course were excluded from this study. Other exclusion criteria included cases with amoebic liver abscesses, those missing important medical records, such as contrast-enhanced CT images, cases where the use of antibiotics was not appropriate or standardized, and patients who had got PCD prior to our hospital admission.

Data collection and definitions

Medical data were extracted and recorded, including demographic features, clinical characteristics, comorbidities, laboratory values, microbiological results, radiological manifestations, treatment procedures and efficacy. Laboratory values within 24 h of hospital admission were acquired for analysis. Radiological manifestations included abscess size, location, liquefaction degree, number of abscesses and presence of internal septations. Radiological characteristics were determined primarily by certified diagnostic radiologists and then verified by two experienced interventional radiologists (Figure 1).

Early PCDs referred to the PCDs performed when the liquefaction degree of abscesses was less than 30% and/or within 1 week after fever onset; the others were defined as delayed PCDs. As was determined by experienced radiologists, the degree of liquefaction with 30% was chosen as the cut-off; because in this case, the abscesses had started the process of

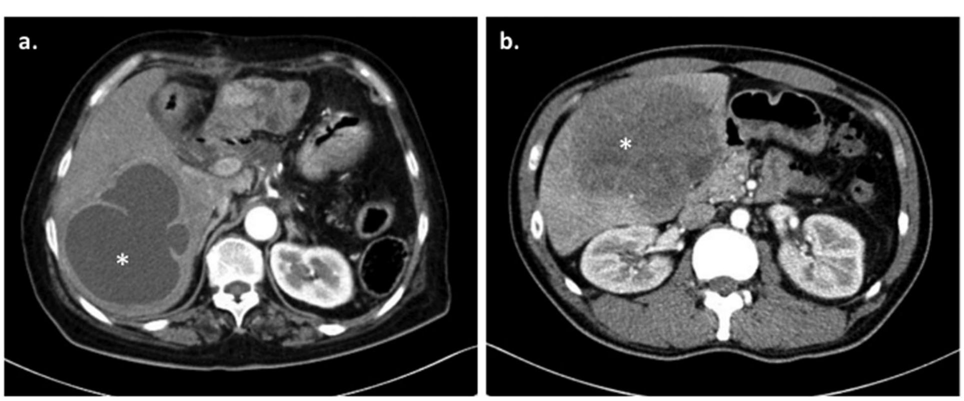

Figure 1. Contrast-enhanced CT images of pyogenic liver abscesses (asterisks): (a) liquified liver abscess; (b) liver abscess with non-liquified content.

liquefaction, but were not well liquified or amenable to optimal drainage. Size of abscess was measured by the widest diameter of the largest abscess identified, and multiloculated abscess was defined as an abscess with enhanced internal septations. For multiloculated or multiple abscesses, the degree of liquefaction was determined with the largest cavity. Time to defervescence, or time for temperature normalization, was defined as the number of days from fever onset to the time when the body temperature had declined to 37.3 °C or less for at least three consecutive days (≥ 72 h). Prolonged fever was defined if time to defervescence exceeded 15 days.

Percutaneous catheter draining

PCD was performed under CT guidance with standard sterile technique after local anaesthesia. Seldinger technique was used percutaneously to introduce drainage catheter into the abscess cavity. The size of catheter was determined based on the cavity size, pus viscosity and clinical experience of the attending radiologist. As abscess contents were aspirated, the pus was sent for bacterial culture, and immediate reimaging was performed to assure good positioning of the drainage catheter. Generally, broad-spectrum antibiotics were administered to patients before PCD; and specific antibiotics were prescribed once the bacterial culture results were available.

Statistical analysis

Statistical analyses were performed using Stata 14.0 SE or GraphPad Prism 6.0. Continuous variables with normal distributions were presented as mean ± SD while those with non-normal distributions were expressed as median with interquartile range (IQR). Continuous variables were analysed by Mann–Whitney *U* test. Categorical variables were analysed with Chi-square test or with Fisher's exact test, as appropriate. Univariate and multivariate logistic regression analysis was used to identify variables associated with prolonged fever by estimating the odds ratios (OR) with 95% confidence intervals (CI). A two-tailed $p < .05$ was considered statistically significant.

Ethical approval

This study conformed to the Declaration of Helsinki and was approved by the Medical Ethics Committee of Peking Union Medical College Hospital. Written informed consent for inclusion from each patient was waived by the Medical Ethics Committee of Peking Union Medical College Hospital because this was a retrospective study, and no study-related interventions were included.

Results

General characteristics

Overall, among 111 patients who had received PCD, 81 patients were enrolled after exclusion. The age of patients varied from 19 to 81 years old (mean 56.9 ± 13.9). The patients were predominately male (69.1%), and 48.1% were complicated with diabetes mellitus. Twelve patients (14.8%) had a previous history of cholelithiasis, while 11 (13.6%) had hepatopancreatobiliary malignancy. Abdominal pain and jaundice were present in 48.1% and 11.1% of patients, respectively (Table 1).

The median diameter of abscess was 7.6 (IQR, 6.1–9.3) centimetres. The majority of abscesses were located in the right lobe of liver (72.8%) whereas 19.8% were found in the left lobe. Five cases (6.2%) of abscesses were located in both lobes and 1 (1.2%) in the caudate lobe. Two thirds (54/81) of cases showed solitary abscess cavity. Sixty-seven of 81 patients (82.7%) had multiloculated lesions (Table 1).

Blood cultures were performed in 73 patients, showing positive results in 20 cases (27.4%). Pus aspirates from all patients were sent for cultures and 84.0% had positive findings (Table 2). Four patients (4.9%) had mixed infections with 2 or more microorganisms. The most common pathogen isolated from pus cultures was *Klebsiella pneumoniae* (60.5%), followed by *E. coli* (8.6%) in this study (Table 1). Only 2.0% (1/49) of *K. pneumoniae* strains exhibited extended-spectrum β-lactamase (ESBL) positivity, whereas 42.9% (3/7) of *E. coli* showed ESBL positivity.

All patients enrolled had received PCD treatments. The PCD procedures were performed within a median of 17 (IQR, 11–26) days after the onset of fever. Complications of PCD included pleural effusion (17.3%), pneumonia (9.9%), acute renal failure (2.5%), pneumothorax (1.2%) and intraperitoneal bleeding (1.2%) in the cohort. All patients suffering from PLA survived the disease, and the median period of hospital stay was 25 (IQR, 19–33) days (Table 1).

Early PCD versus delayed PCD treatment

To investigate the potential benefit of early PCD treatment, 24 patients with early PCD intervention were compared with 57 patients who received delayed PCD

Table 1. Characteristics of patients with pyogenic liver abscesses.

Variables	N = 81
Age (years)	56.9 ± 13.9
Sex (male)	56 (69.1%)
Diabetes mellitus	39 (48.1%)
History of benign hepatobiliary disease	25 (30.9%)
Previous history of PLA	2 (2.5%)
Hepatic cyst	3 (3.7%)
Fatty liver	6 (7.4%)
Cholelithiasis	12 (14.8%)
Cholecystitis	2 (2.5%)
Hepatopancreatobiliary malignancy	11 (13.6%)
Hepatocellular carcinoma	2 (2.5%)
Metastatic hepatic cancer	1 (1.2%)
Gallbladder cancer or cholangiocarcinoma	3 (3.7%)
Pancreatic or ampullary malignancy	5 (6.2%)
Abdominal surgery/intervention history	26 (32.1%)
Liver abscess drainage	1 (1.2%)
Liver cancer radiofrequency ablation	1 (1.2%)
Liver cancer interventional therapy	2 (2.5%)
Liver resection	3 (3.7%)
Pancreatobiliary surgery	7 (8.6%)
Other abdominal surgery	12 (14.8%)
Prodrome	
Enteric infection	10 (12.3%)
Respiratory tract infection	15 (18.5%)
Symptom	
Abdominal pain	39 (48.1%)
Jaundice	9 (11.1%)
Diameter of abscess (cm)	7.6 (6.1–9.3)
Site of abscess	
Right lobe	59 (72.8%)
Left lobe	16 (19.8%)
Bilobar	5 (6.2%)
Caudate lobe	1 (1.2%)
Number of abscesses	
Single	54 (66.7%)
Multiple	27 (33.3%)
Multiloculated abscesses	67 (82.7%)
Positive blood culture[a]	20/73 (27.4%)
Positive pus culture[b]	
Klebsiella pneumoniae	49 (60.5%)
Klebsiella oxytoca	2 (2.5%)
Escherichia coli	7 (8.6%)
Other *Enterobacteriaceae*	6 (7.4%)
Enterococcus spp	5 (6.2%)
Streptococcus spp	2 (2.5%)
Staphylococcus spp	1 (1.2%)
Fungus	1 (1.2%)
Period before PCD insertion after admission (days)	4 (2–7)
Period before PCD insertion after fever onset (days)	17 (11–26)
Complications with PCD treatment	
Pleural effusion	14 (17.3%)
Pneumonia	8 (9.9%)
Acute renal failure	2 (2.5%)
Pneumothorax	1 (1.2%)
Intraperitoneal bleeding	1 (1.2%)
Length of hospital stay (days)	25 (19–33)

Data were presented as number (percentage), mean ± standard deviation or median (IQR), as appropriate.
PCD: percutaneous catheter drainage.
[a]Blood cultures of eight cases were not performed.
[b]Four patients had mixed infections with two or more microbes.

treatment. Abdominal pain was significantly more prevalent in the early PCD group ($p = .002$). No significant differences were found between groups regarding catheter adjustment or PCD re-treatment. Time to defervescence was significantly shortened in the early PCD group as compared to the delayed PCD group ($p = .042$, Figure 2(a,b)). Similarly, time for temperature normalization differed significantly among groups stratified by timing of PCD treatment (every 7-day increase, Figure 2(c)). However, Bacteraemia, septic shock and ICU admission were not statistically different in the two groups (Table 3).

Table 2. Blood and pus culture positivity in patients with pyogenic liver abscesses.

		Blood culture			
		Positive	Negative	N/A	Total
Pus culture	Positive	18 (22.2%)	43 (53.1%)	7 (8.7%)	68 (84.0%)
	Negative	2 (2.5%)	10 (12.3%)	1 (1.2%)	13 (16.0%)
Total		20 (24.7%)	53 (65.4%)	8 (9.9%)	81 (100%)

Data were presented as number (percentage).
N/A: not available.

Factors associated with prolonged fever

As is shown in Table 4, patients with prolonged fever (time to defervescence exceeding 15 days) had increased length of hospital stay ($p = .005$). Thus, patients were further grouped by the duration of fever, and factors associated with prolonged fever were investigated. Diabetes was more frequent in patients with prolonged fever, although there showed no statistical difference in this cohort. The maximum body temperature was significantly higher in patients with prolonged fever ($p = .05$). There showed no differences in white blood cell count or in blood culture positivity. Diameter of abscess > 7.5 cm was related to prolonged fever ($p = .043$), and there was a lower percentage of early PCD treatment in patients with prolonged fever ($p = .009$). By multivariate analysis, early PCD treatment was identified as an independent protective factor of prolonged fever (OR, 0.305; 95% CI, 0.105–0.890; Table 5).

Discussion

Over the past decades, PCD, instead of surgery, has been viewed as the preferred treatment modality in the management of liver abscesses [17]. PCD, as a minimally invasive procedure, is both therapeutic and helps in finding microbiologic results. Recent studies have suggested PCD is safe and effective even in giant PLA, regardless of abscess complexity and/or multiplicity [16,18,20]. Therefore, PCD has been widely performed in the clinical treatment of PLA. Nevertheless, the practice of PCD lacks unified standards [10,13]. In this study, we investigated characteristics of PLA patients who had undergone PCD, with a particular

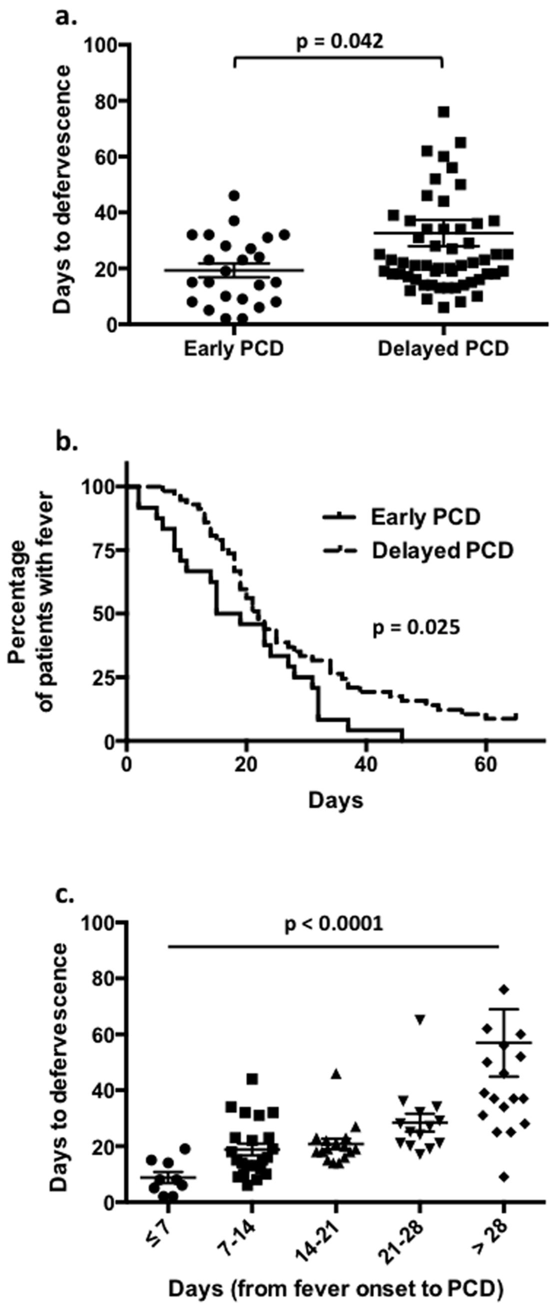

Figure 2. Time to defervescence was associated with timing of PCD treatment. (a) Days to defervescence were compared between early PCD and delayed PCD groups. Error bars, mean ± SEM. (b) Time for temperature normalization was significantly shortened with early PCD intervention. *p* Value, log-rank test. (c) Time to defervescence differed among groups stratified by timing of PCD treatment. Error bars, mean ± SEM.

focus on the relationship between timing of PCD and clinical improvement.

Diabetes mellitus, hepatopancreatobiliary diseases and underlying malignancy have been shown to be risk factors for PLA [21–23]. In our cohort, 48.1% of individuals were complicated with diabetes mellitus, 30.9% had a history of benign hepatobiliary diseases and 13.6% had hepatopancreatobiliary malignancies, which may be related to compromised immune function or changes in hepatobiliary structure and function. Consistent with previous research [2,24], most patients in our study had solitary abscesses, mainly located on the right lobes; however, neither number of abscesses nor abscess location was found associated with prolonged fever. Intriguingly, multiloculated abscesses were predominant in this cohort who had received PCD treatment. Traditionally, surgical drainage has been the approach in the management of multiloculated abscesses. Yet, recent years have seen a surge in the practice of PCD for PLA, and successful PCD with satisfactory efficacy has been reported in the treatment of multiloculated abscesses [16]. Nevertheless, surgical drainage is still warranted for patients who had inadequate responses to PCD.

In the present study, most pathogens of PLAs belonged to Enterobacteriaceae, among which *K. pneumoniae* was the predominant pathogenic cause and the majority of *K. pneumoniae* isolates were ESBL negative. Though *E. coli* was less common than *K. pneumoniae* in PLA, it showed higher rate of antibiotic resistance with 42.9% producing ESBL. These findings were similar to previous studies in Asian countries [25,26]. The bacterial spectrum may be useful in empiric antibiotic decision making.

Regarding PLA treatment, although PCD is generally preferred over surgical drainage, the best timing for PCD remains undetermined. In cases when abscesses are not fully liquified, a possible approach is to wait until the abscesses get mature and then to perform PCD (delayed PCD); the other potential option could be to insert drainage tubes immediately, as long as there's space for catheter placement, so that the abscesses can get drained once they become liquified (early PCD). In this study, patients were grouped by the timing of PCD treatment. The baseline characteristics were similar between the two groups, except that in patients receiving early PCD intervention, abdominal pain was more prevalent as compared to those with delayed PCD. It is reasonable that patients with obvious clinical symptoms may get intervention earlier. Furthermore, it might be a concern that with early PCD insertion, there's a bigger chance that catheter adjustment is needed. It is true that we may not be able to accurately predict the centre of liquefaction at early stage of PLA; but with delayed intervention, catheters could be placed at optimal sites when abscesses are already fully liquified. However, unexpectedly, with regard to catheter adjustment and the need for salvage drainage, we did not show statistical

Table 3. Comparison of patients with early and delayed PCD treatment.

Variables	Early PCD ($N=24$)	Delayed PCD ($N=57$)	p Value
Age (years)	57.5 ± 12.8	56.7 ± 14.4	.768
Sex (male)	14 (58.3%)	42 (73.7%)	.172
Diabetes mellitus	10 (41.7%)	29 (50.9%)	.449
Abdominal pain	18 (75%)	21 (36.8%)	.002
Jaundice	2 (8.3%)	7 (12.3%)	.718
Maximum body temperature (°C)	39.4 ± 1.2	39.6 ± 0.8	.490
$T > 37.3$ °C at admission	13 (54.2%)	23 (40.4%)	.253
MAP at admission (mmHg)	90.1 ± 14.9	91.1 ± 12.2	.721
WBC (10^9/L)	14.25 (9.15–18.05)	11.83 (8.62–15.98)	.280
Neutrophil (10^9/L)	11.91 (7.27–15.81)	9.59 (7.08–13.70)	.170
Lymphocyte (10^9/L)	0.89 (0.41–1.36)	1.06 (0.74–1.52)	.303
Hemoglobin (g/L)	112.6 ± 19.9	109.5 ± 17.1	.901
Platelet (10^9/L)	252.6 ± 172.8	259.4 ± 139.1	.779
Lactate dehydrogenase (U/L)	263.5 (222.5–388)	236 (202–269)	.293
PCT (ng/mL)	($n=18$)	($n=43$)	.837
<0.5	5 (27.8%)	14 (32.6%)	
0.5–2	3 (16.7%)	10 (23.3%)	
2–10	4 (22.2%)	9 (20.9%)	
≥10	6 (33.3%)	10 (23.3%)	
Alanine aminotransferase (U/L)	42 (20.5–90.5)	54 (32–85)	.444
Albumin (g/L)	32 (29–35)	30 (27–33)	.129
Total bilirubin (μmol/L)	13.25 (9.75–30.4)	13 (9.7–22)	.873
Direct bilirubin (μmol/L)	5.1 (3.6–19.05)	5.4 (4.3–12.7)	.664
Creatinine (μmol/L)	70 (56–89)	67 (59–83)	.873
Urea (mmol/L)	5.45 (4.03–8.87)	4.5 (3.63–5.82)	.094
PT (s)	14.05 (13.15–14.95)	14.2 (13.5–15.3)	.820
APTT (s)	31.75 (29.55–37.5)	32.8 (30–38)	.721
Diameter of abscess (cm)	7.3 (5.95–8.95)	7.84 (6.47–9.6)	.374
Catheter adjustment	3 (12.5%)	4 (7.0%)	.417
Secondary PCD required	5 (20.8%)	8 (14.0%)	.513
Bacteraemia	8/24 (33.3%)	12/49 (24.5%)	.577
Septic shock	7 (29.2%)	10 (17.5%)	.241
ICU admission	6 (25.0%)	8 (14.0%)	.334
Time to defervescence (days)	17 (8.5–29.5)	22 (17–36)	.042

Data were presented as number (percentage), mean ± standard deviation or median (IQR), as appropriate.
MAP: mean arterial pressure; WBC: white blood cell; PCT: procalcitonin; PT: prothrombin time; APTT: activated partial thromboplastin time; PCD: percutaneous catheter drainage; ICU: intensive care unit.

difference between early and delayed PCD groups in this cohort. Instead, we observed that with early PCD treatment, duration of fever was significantly shortened in comparison with delayed intervention. Defervescence is an important indicator for clinical improvement; in this perspective, our data suggests patients could benefit from early PCD intervention.

Finally, we tried to figure out factors associated with long-time fever, and whether the timing of PCD predicted prolonged fever. As is known, patients with diabetes are generally under an immunocompromised state. In previous studies, diabetes has been shown to be associated with unfavourable outcomes among patients with PLA [25,27]. However, in our study, although diabetes was more prevalent in patients with longer periods of fever, we have not shown a significant association between diabetes and prolonged fever. What we found was that the maximum body temperature was related to prolonged fever. The possible explanation could be that patients with higher temperature may experience more severe inflammation and systemic condition, and thus it takes longer time to defervesce and restore normal immune status. The size of liver abscess is the consequence of interactive effects of bacterial load, immune state and severity of inflammatory response. Several studies have suggested the size of abscess is positively correlated with the severity of disease and the length of hospital stay [18,20]. A recent study has gone further to show that maximum diameter of abscess independently predicts prolonged hospitalization and poor prognosis [25]. In our cohort, abscess diameter larger than 7.5 cm was found to be associated with prolonged fever, which was similar to those previous reports. The size of abscess reflects the interaction of bacterial load and immunocompetence, which determines clinical course and outcome of disease. In this study, our data also revealed that early PCD treatment was an independent protective factor of prolonged fever. Like other infectious diseases, appropriate antibiotic administration and effective drainage are considered as the standard of care for PLA. Our data suggested early PCD intervention for liver abscess patients, which was in line with the treatment principle and emphasized the importance of timely drainage to clinical improvement.

Table 4. Comparisons of clinical features, laboratory parameters and managements in patients grouped by duration of fever.

Variables	Febrile period ≤ 15 days (*N* = 24)	Febrile period > 15 days (*N* = 57)	*p* Value
Age (years)	56.7 ± 15.1	57.0 ± 13.5	.963
Sex (male)	19 (79.2%)	37 (64.9%)	.205
Diabetes mellitus	8 (33.3%)	31 (54.4%)	.083
Hepatopancreatobiliary malignancy	6 (25.0%)	5 (8.77%)	.075
Abdominal surgery history	9 (37.5%)	17 (29.8%)	.499
Maximum body temperature (°C)	39.2 ± 1.0	39.7 ± 0.8	.050
$T > 37.3$ °C at admission	11 (45.8%)	25 (43.9%)	.870
MAP at admission (mmHg)	93.0 ± 16.0	89.9 ± 11.5	.189
WBC (10^9/L)	16.61 (9.15–18.48)	11.83 (8.60–15.22)	.106
Neutrophil (10^9/L)	14.11 (7.41–16.91)	9.82 (6.70–12.56)	.076
Lymphocyte (10^9/L)	0.98 (0.41–1.36)	1.04 (0.72–1.52)	.816
Hemoglobin (g/L)	116.4 ± 20.5	107.9 ± 16.3	.089
Platelet (10^9/L)	281.1 ± 171.8	247.8 ± 138.5	.437
Lactate dehydrogenase (U/L)	230.5 (214–291)	243 (201–293)	.953
$PCT \geq 2$ (ng/mL)	9/18 (50.0%)	20/43 (46.5%)	.804
Alanine aminotransferase (U/L)	45 (20.5–81)	48 (31–85)	.344
Albumin (g/L)	31 (29–33)	31 (26–35)	.671
Total bilirubin (μmol/L)	18.2 (9.75–43.15)	12.2 (9.7–18.9)	.126
Direct bilirubin (μmol/L)	10.7 (4.05–29.45)	5.1 (4–11.3)	.161
Creatinine (μmol/L)	72 (57–102)	66 (57–81)	.187
Urea (mmol/L)	5.46 (3.95–8.38)	4.67 (3.77–5.82)	.192
Blood glucose at admission (mmol/L)	6.5 (5.7–8.6)	8.3 (6.0–10.6)	.069
PT (s)	14.2 (13.65–15.3)	14.1 (13.2–14.7)	.382
APTT (s)	32.45 (29.1–39.35)	32.1 (30–37.8)	.812
Positive blood culture	4/21 (19.0%)	16/52 (30.8%)	.309
KP isolated from pus	13 (54.2%)	36 (63.2%)	.450
Multiple abscess cavities	5 (20.8%)	22 (38.6%)	.121
Abscess location (right lobe only)	16 (66.7%)	43 (75.4%)	.418
Multiloculated abscess	18 (75.0%)	49 (86.0%)	.334
Diameter of abscess > 7.5 cm	8 (33.3%)	33 (57.9%)	.043
Early PCD treatment	12 (50.0%)	12 (21.1%)	.009
Catheter adjustment	2 (8.3%)	5 (8.8%)	1.000
Secondary procedure required	1 (4.2%)	12 (21.1%)	.095
PCD complications	7 (29.2%)	19 (33.3%)	.714
Outcomes			
Septic shock	6 (25.0%)	11 (19.3%)	.565
ICU admission	6 (25.0%)	8 (14.0%)	.334
Time for WBC normalization (days)	5.5 (2–10)	8.5 (3.5–12.5)	.142
Length of hospital stay (days)	20.5 (16.5–27)	28 (21–38)	.005

Data were presented as number (percentage), mean ± standard deviation or median (IQR), as appropriate.
MAP: mean arterial pressure; WBC: white blood cell; PCT: procalcitonin; PT: prothrombin time; APTT: activated partial thromboplastin time; KP: *Klebsiella pneumoniae*; PCD: percutaneous catheter drainage; ICU: intensive care unit.

Table 5. Factors associated with prolonged fever (>15 days) in patients with pyogenic liver abscesses.

	Univariate			Multivariate		
Variables	Odds ratio	95% CI	*p* Value	Odds ratio	95% CI	*p* Value
Maximum body temperature (°C)	1.728	1.001–2.983	.049	1.556	0.866–2.795	.139
Diameter of abscess > 7.5 cm	2.750	1.013–7.463	.047	2.269	0.789–6.522	.128
Early PCD treatment	0.267	0.096–0.741	.011	0.305	0.105–0.890	.030

PCD: percutaneous catheter drainage; CI: confidence interval.

The present study has several limitations. This is a retrospective study conducted in a single institution. As data were collected within one centre, it is unclear whether our findings can be generalized to other regions. Some incomplete medical records with missing data may also affect the results of the study. In addition, the susceptibility patterns of pathogens and types of antibiotics used have not been analysed in detail in this study. Lastly, as our work mainly focussed on the duration of fever, other aspects of clinical outcome were not fully evaluated. However, as we showed that the febrile period was related to the length of hospital stay, it was reasonable and straightforward to use fever duration as the outcome for analysis. Therefore, well-designed prospective studies avoiding selection bias are needed to validate the current findings.

Conclusions

In summary, PCD has become the treatment of choice in the management of PLA, and it has been utilized in treating large abscesses and multiloculated abscesses. Duration of fever was shortened with early PCD intervention. However, the rates of catheter adjustment and re-treatment were comparable regardless of the timing of PCD in the study cohort. Early PCD treatment was identified as a protective factor of prolonged fever. Our study proposes that early intervention should be provided if PCD is indicated for PLA. More robust evidence is required with future research.

Acknowledgments

The authors thank Department of Radiology for the cooperation and radiological analysis.

Ethical approval

The study was approved by the Medical Ethics Committee of Peking Union Medical College Hospital.

Consent form

Written informed consent was waived by the Medical Ethics Committee of Peking Union Medical College Hospital due to the anonymized retrospective nature of the analysis. All methods were performed in accordance with relevant guidelines and regulations.

Author contributions

Y.C. Liu, H. Zhu and J. Liu conceived the idea and designed this study. Z. Li collected the data. Y. Liu, A. Liu and J. Xu performed the analysis and interpreted the results. Y. Liu, Y.C. Liu and Y. Li drafted the manuscript. J. Liu and Y. Li made the revision. H. Zhu supervised the study and made the decision for submission. All the authors reviewed and approved the final manuscript.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This study was supported by Science Foundation of Peking Union Medical College Hospital for young scholars [Grant number: pumch201911884].

Data availability statement

The data sets generated and/or analysed during the current study are not publicly available due to data protection regulations of the institution, but are available from the corresponding authors on reasonable request permitted by Peking Union Medical College Hospital.

References

[1] Huang CJ, Pitt HA, Lipsett PA, et al. Pyogenic hepatic abscess. Changing trends over 42 years. Ann Surg. 1996;223(5):600–607.
[2] Singh S, Chaudhary P, Saxena N, et al. Treatment of liver abscess: prospective randomized comparison of catheter drainage and needle aspiration. Ann Gastroenterol. 2013;26(4):332–339.
[3] Mc FA, Chang KP, Wong CC. Solitary pyogenic abscess of the liver treated by closed aspiration and antibiotics; a report of 14 consecutive cases with recovery. Br J Surg. 1953;41(166):141–152.
[4] Tazawa J, Sakai Y, Maekawa S, et al. Solitary and multiple pyogenic liver abscesses: characteristics of the patients and efficacy of percutaneous drainage. Am J Gastroenterol. 1997;92(2):271–274.
[5] Harclerode TP, Gnugnoli DM. Percutaneous abscess drainage. Treasure Island (FL): StatPearls; 2021.
[6] Czerwonko ME, Huespe P, Bertone S, et al. Pyogenic liver abscess: current status and predictive factors for recurrence and mortality of first episodes. HPB (Oxford). 2016;18(12):1023–1030.
[7] Chen SC, Tsai SJ, Chen CH, et al. Predictors of mortality in patients with pyogenic liver abscess. Neth J Med. 2008;66(5):196–203.
[8] Chen CH, Wu SS, Chang HC, et al. Initial presentations and final outcomes of primary pyogenic liver abscess: a cross-sectional study. BMC Gastroenterol. 2014;14(1):133.
[9] Seeto RK, Rockey DC. Pyogenic liver abscess. Changes in etiology, management, and outcome. Medicine (Baltimore). 1996;75(2):99–113.
[10] Haider SJ, Tarulli M, McNulty NJ, et al. Liver abscesses: factors that influence outcome of percutaneous drainage. AJR Am J Roentgenol. 2017;209(1):205–213.
[11] Tan YM, Chung AY, Chow PK, et al. An appraisal of surgical and percutaneous drainage for pyogenic liver abscesses larger than 5 cm. Ann Surg. 2005;241(3):485–490.
[12] Cai YL, Xiong XZ, Lu J, et al. Percutaneous needle aspiration versus catheter drainage in the management of liver abscess: a systematic review and Meta-analysis. HPB (Oxford). 2015;17(3):195–201.
[13] Lo JZ, Leow JJ, Ng PL, et al. Predictors of therapy failure in a series of 741 adult pyogenic liver abscesses. J Hepatobiliary Pancreat Sci. 2015;22(2):156–165.
[14] Hope WW, Vrochides DV, Newcomb WL, et al. Optimal treatment of hepatic abscess. Am Surg. 2008;74(2):178–182.
[15] Singh O, Gupta S, Moses S, et al. Comparative study of catheter drainage and needle aspiration in management of large liver abscesses. Indian J Gastroenterol. 2009;28(3):88–92.
[16] Liu CH, Gervais DA, Hahn PF, et al. Percutaneous hepatic abscess drainage: do multiple abscesses or multiloculated abscesses preclude drainage or affect outcome? J Vasc Interv Radiol. 2009;20(8):1059–1065.

[17] Ferraioli G, Garlaschelli A, Zanaboni D, et al. Percutaneous and surgical treatment of pyogenic liver abscesses: observation over a 21-year period in 148 patients. Dig Liver Dis. 2008;40(8):690–696.

[18] Ahmed S, Chia CL, Junnarkar SP, et al. Percutaneous drainage for giant pyogenic liver abscess–is it safe and sufficient? Am J Surg. 2016; 211(1):95–101.

[19] Alvarez Perez JA, Gonzalez JJ, Baldonedo RF, et al. Clinical course, treatment, and multivariate analysis of risk factors for pyogenic liver abscess. Am J Surg. 2001;181(2):177–186.

[20] Du ZQ, Zhang LN, Lu Q, et al. Clinical characteristics and outcome of pyogenic liver abscess with different size: 15-year experience from a single center. Sci Rep. 2016;6:35890.

[21] Thomsen RW, Jepsen P, Sorensen HT. Diabetes mellitus and pyogenic liver abscess: risk and prognosis. Clin Infect Dis. 2007;44(9):1194–1201.

[22] Yeh TS, Jan YY, Jeng LB, et al. Pyogenic liver abscesses in patients with malignant disease: a report of 52 cases treated at a single institution. Arch Surg. 1998;133(3):242–245.

[23] Song H, Wang X, Lian Y, et al. Analysis of the clinical characteristics of 202 patients with liver abscess associated with diabetes mellitus and biliary tract disease. J Int Med Res. 2020;48(8):300060520949404.

[24] He S, Yu J, Wang H, et al. Percutaneous fine-needle aspiration for pyogenic liver abscess (3-6 cm): a two-center retrospective study. BMC Infect Dis. 2020;20(1): 516.

[25] Lee CH, Jo HG, Cho EY, et al. Maximal diameter of liver abscess independently predicts prolonged hospitalization and poor prognosis in patients with pyogenic liver abscess. BMC Infect Dis. 2021;21(1):171.

[26] Luo M, Yang XX, Tan B, et al. Distribution of common pathogens in patients with pyogenic liver abscess in China: a meta-analysis. Eur J Clin Microbiol Infect Dis. 2016;35(10):1557–1565.

[27] Du Z, Zhou X, Zhao J, et al. Effect of diabetes mellitus on short-term prognosis of 227 pyogenic liver abscess patients after hospitalization. BMC Infect Dis. 2020; 20(1):145.