JGH Open An open access journal of gastroenterology and hepatology Open Access
JGHF

doi:10.1002/jgh3.12913

ORIGINAL ARTICLE

# The influence of early adoption of nonenhanced computed tomography on management of patients with pyogenic liver abscess

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**Key words**
computed tomography, early diagnosis, hospital stay, pyogenic liver abscess.

Accepted for publication 3 May 2023.

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**Declaration of conflict of interest**: The authors declare that they have no competing interests.
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**Funding support:** Xiamen Chang Gung Hospital Science ProjectCMRPG1E0875, CMRPG1G0161

## Abstract

**Background and Aim:** A pyogenic liver abscess (PLA) is an infectious disease with high in-hospital mortality. It has no specific symptoms and is difficult to be diagnosed early in the emergency department. Ultrasound is commonly used to detect PLA lesions of PLA, but its sensitivity can be affected by lesion size, location, and clinician experience. Therefore, early diagnosis and prompt treatment (especially abscess drainage) are crucial for better patient outcomes and should be prioritized by clinical physicians.
**Methods:** We conducted a retrospective study to compare the effect of early and late (i.e., receiving CT scanning within 48 h and >48 h after admission) adoption of nonenhanced computed tomography (CT) scanning regarding the hospitalization days and interval between admission and drainage of patients with PLA.
**Results:** This study included 76 hospitalized patients with PLA in the Department of Digestive Disease of Xiamen Chang Gung Hospital in China who underwent CT examinations from 2014 to 2021. We conducted CT scans on 56 patients within 48 h of admission and on 20 patients more than 48 h after admission. The early CT group had a significantly shorter hospitalization length compared with the late CT group (15.0 days vs. 20.5 days; $P = 0.035$). Besides, the median time to initiate drainage after admission was also significantly shorter in the early CT group than in the late CT group (1.0 days vs. 4.5 days; $P < 0.001$).
**Conclusion:** Early CT scanning within 48 h of admission may aid in early PLA diagnosis and benefit disease recovery, as revealed by our findings.

## Introduction

A pyogenic liver abscess (PLA) is a life-threatening disease caused by bacterial invasion, resulting in the liver being filled with pus. It is associated with an in-hospital mortality rate of up to 2.2%–5.6%[1–3] and has diverse incidence rates ranging from 1.0 to 17.6 cases per 100 000 between countries.[3] Patients with PLA often exhibit nonspecific symptoms (abdominal pain, fever, nausea, vomiting, etc.), as well as laboratory findings (elevated white blood cells, C-reactive protein, hepatic enzymes, etc.). As a result, patients with suspected PLA are usually treated with empirical antibiotics initially. Drainages are mostly applied for the abscess ≥3 cm,[4] and percutaneous drainages are the preferred method due to their lower morbidity and mortality rates compared with surgical drainage.[5] Although adequate antibiotics combined with percutaneous drainages can effectively reduce mortality, delayed diagnosis can lead to poor outcomes, with rapid progression to sepsis.[6–8] Early diagnosis of patients with PLA remains a challenge for emergency clinicians.

Ultrasound and computed tomography (CT) imaging are traditional tools to identify hepatic lesions. Ultrasound is preferred for the initial detection of liver abscesses due to its convenience and availability in real-world settings, but some lesions may not be diagnosed via ultrasound due to their small size or location with poor visualization (e.g., segment 7/8 of the liver). The sensitivity of ultrasound (85%) has been reported to be lower than CT scan, which has a sensitivity of 97%.[9,10] CT scans are recommended for confirming PLA if ultrasound results are inconclusive but not commonly utilized in the initial examination.[11] A better tool used for early diagnosis with PLA is an unmet clinical need.

In China, CT imaging is considered the gold standard for assessing intra-abdominal infection.[12] We conducted a retrospective study to evaluate the feasibility of early CT imaging for examining patients with PLA and measuring its effects on disease status. This study retrospectively collected data from patients with PLA who received nonenhanced CT examinations, and compared disease characteristics, treatment strategy, and disease status between patients who received early CT scans (within 48 h after admission) and those who received late CT scans (>48 h after admission).

## Methods

***Study design.*** This was a retrospective study aimed at obtaining clinical data of 76 patients hospitalized at the Department of Digestive Disease of Xiamen Chang Gung Hospital in China, to analyze the disease status and management after early examination using nonenhanced CT to diagnose PLA. Patients with PLA who were hospitalized and received CT examination from January 2014 to June 2021 were included, while patients with amebic liver abscess, aged ≤14 years, or those who underwent surgery for PLA were excluded. Enrolled patients were divided into (1) the early CT group, comprising patients who received a CT scan within 48 h after admission; and (2) the late CT group, comprising patients who received a CT scan >48 h after admission. The primary endpoint was the difference in the length of hospitalization days between groups, while the secondary endpoint was to compare the interval between initiating percutaneous drainage and admission.

This study was approved by the institutional review board (IRB) of Xiamen Chang Gung Hospital (IRB number: XMCGIRB2021037) and waived the informed consent. The study was conducted in accordance with the applicable local regulations and the ethical principles outlined in the Declaration of Helsinki.

***Variables.*** Data collected from medical charts included demographics, disease characteristics, laboratory results, percutaneous drainage, hospitalization records, and body temperature during hospitalization. The severity of PLA was determined by using quick sequential organ failure assessment (qSOFA) and systemic inflammatory response syndrome (SIRS) at baseline. qSOFA is an assessment for identifying the severity of intra-abdominal infections; qSOFA ≥2 indicates patients with severe infection (score range: 0–3 points).[12,13] SIRS is used to determine the level of inflammatory status, with patients having severe inflammatory response if SIRS meets ≥2 criteria.

***Statistical methods.*** Continuous variables were compared using two sample *t*-tests or Wilcoxon rank-sum tests. Categorical variables were analyzed using Chi-square tests or Fisher's exact tests. A significant difference was defined as a *P* value <0.05. Data analyses were performed using Statistical Analysis Software (SAS®) version 9.4 (SAS Institute, Cary, NC, USA).

## Results

We analyzed data from 76 eligible patients diagnosed with PLA, with 56 patients receiving a CT scan within 48 h after admission (referred to as the early CT group) and 20 patients receiving a CT scan more than 48 h after admission (referred to as the late CT group) (Fig. 1). We compared demographic data,

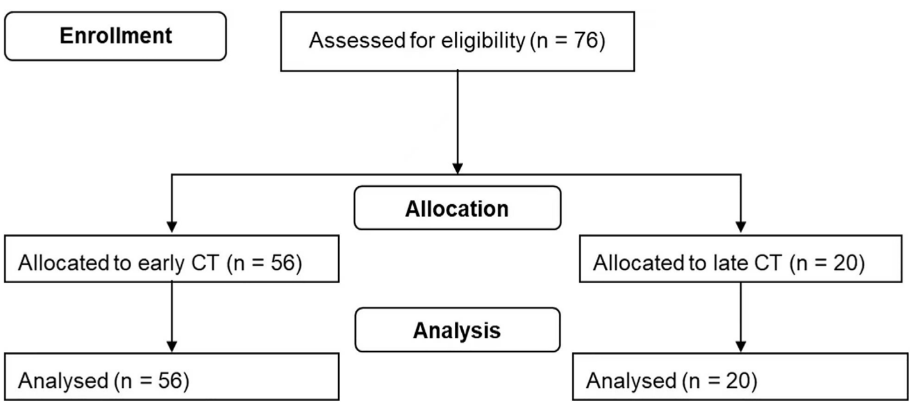


**Figure 1** Eligible patients who received a CT scan within 48 h after admission were referred to as the early CT group; those who received a CT scan over 48 h after admission were referred to as the late CT group.

comorbidities, disease characteristics, and severity of PLA between the two groups, and found no significant differences (Table 1). The median age was 55.6 years (range 24–78) in the early CT group and 51.8 years (range 15–93) in the late CT groups, with males accounting for a higher proportion in both groups (62.5% vs. 7 5.0%). For the early CT group, 42.9% of patients had diabetes mellitus, 17.9% had hypertension, and 10.7% had gallstones or bile duct stones; for the late CT group, 30.0% had hypertension, 25.0% had diabetes mellitus or gallstones, and 15.0% had cholangitis. Disease characteristics and severity of PLA were also comparable between groups. Biliary origin was the main cause of PLA in both groups (30.4% in early CT; 40.0% in late CT). The number of lesions and their diameter were similar in both groups, with lesions mostly located in the right lobe of the liver. Both groups had low risks of developing sepsis and low systemic inflammatory response (qSOFA ≤1 and SIRS <2).

Laboratory data are also summarized in Table 1. Generally, the laboratory results were comparable between the two groups, except for white blood cells (WBC), which were significantly lower in the early CT group than the late CT group ($11.4 \pm 5.52 \times 10^9$/L vs. $15.4 \pm 5.26 \times 10^9$/L; $P = 0.006$).

**Table 1** Comparison of clinical variables between early and late CT groups

| | Early CT, $n = 56$ | Late CT, $n = 20$ | $P$ value |
|---|---|---|---|
| Baseline demographics and comorbidities | | | |
| Age (years) | 55.6 (24.0–78.0)[a] | 51.8 (15.0–93.0)[a] | 0.322[b] |
| Sex, males | 35 (62.5)[a] | 15 (75.0)[a] | 0.312[b] |
| Comorbidity, *n* | | | |
| Diabetes mellitus | 24 (42.9)[a] | 5 (25.0)[a] | 0.158[b] |
| Hypertension | 10 (17.9)[a] | 6 (30.0)[a] | 0.253[b] |
| Biliary disease | | | 0.164[b] |
| Gallstones | 6 (10.7)[a] | 5 (25.0)[a] | |
| Bile duct stone | 6 (10.7)[a] | 0 (0.0)[a] | |
| Cholangitis | 3 (5.4)[a] | 3 (15.0)[a] | |
| Cholecystitis | 2 (3.6)[a] | 1 (5.0)[a] | |
| Baseline disease characteristics and severity | | | |
| Pathophysiology | | | 0.68[b] |
| Unknown | 36 (64.3)[a] | 12 (60.0)[a] | |
| Biliary origin | 17 (30.4)[a] | 8 (40.0)[a] | |
| Hematogenous spread | 2 (3.6)[a] | 0 (0.0)[a] | |
| Hepatocellular carcinoma | 1 (1.8)[a] | 0 (0.0)[a] | |
| Number of lesions | 1.6 ± 1.5[a] | 1.2 ± 0.5[a] | 0.40[b] |
| Location of lesions | | | |
| Right lobe | 42 (75.0)[a] | 14 (70.0)[a] | |
| Left lobe | 7 (12.5)[a] | 5 (25.0)[a] | |
| Bilateral | 7 (12.5)[a] | 1 (5.0)[a] | |
| Diameter of lesion (cm) | 5.9 ± 3.0[a] | 6.5 ± 2.7[a] | 0.42[b] |
| SIRS | 1.6 ± 1.2[a] | 1.9 ± 1.3[a] | 0.30[b] |
| qSOFA | 0.3 ± 0.6[a] | 0.2 ± 0.4[a] | 0.535[b] |
| Baseline laboratory data | | | |
| WBCs ($\times 10^9$/L) | 11.4 ± 5.5[a] | 15.4 ± 5.3[a] | **0.01**[b] |
| Hemoglobin (g/L) | 126.7 ± 18.6[a] | 122.5 ± 17.2[a] | 0.38[b] |
| Platelet ($\times 10^9$/L) | 232.5 ± 146.2[a] | 239.2 ± 94.6[a] | 0.30[b] |
| Hs-CRP (mg/L) | 187.6 ± 109.6[a] | 196.4 ± 128.4[a] | 0.88[b] |
| AST (U/L) | 100.3 ± 130.8[a] | 82.1 ± 68.5[a] | 0.71[b] |
| ALT (U/L) | 90.5 ± 103.5[a] | 94.2 ± 84.5[a] | 0.78[b] |
| Total bilirubin | 34.7 ± 52.7[a] | 28.1 ± 21.3[a] | 0.61[b] |
| Albumin (g/L) | 32.7 ± 7.1[a] | 32.6 ± 5.8[a] | 0.93[b] |
| Creatinine (μmol/L) | 87.2 ± 49.7[a] | 81.1 ± 16.8[a] | 0.62[b] |
| BUN (mmol/L) | 6.5 ± 7.1[a] | 5.4 ± 2.5[a] | 0.86[b] |
| ALK (U/L) | 184.8 ± 152.2[a] | 206.9 ± 167.9[a] | 0.26[b] |
| GGT (U/L) | 164.4 ± 155.3[a] | 170.5 ± 173.0[a] | 0.82[b] |

[a]Data are summarized as median (interquartile range), or *n* (%).

[b]To compare differences between groups, two sample *t*-tests or Wilcoxon rank-sum tests were used for continual variables; Chi-square tests or Fisher's exact tests were applied for categorical variables.

ALK, alkaline phosphatase; ALT, alanine aminotransferase; AST, aspartate aminotransferase; BUN, blood urea nitrogen; CT, computed tomography; GGT, gamma-glutamyl transferase; Hs-CRP, high-sensitivity C-reactive protein; PLA, pyogenic liver abscess; qSOFA, quick sequential organ failure assessment; SIRS, systemic inflammatory response syndrome; WBCs, White blood cells.

**Table 2** Comparison of clinical outcomes and treatments between early and late CT groups

| | Early CT, $n = 56$ | Late CT, $n = 20$ | $P$ value |
|---|---|---|---|
| Length of hospitalization (days) | 15.0 (3.0–68.0)[a] | 20.5 (6.0–37.0)[a] | **0.035**[b] |
| Interval between admission and initial drainage (days) | 1.0 (1.0–9.0)[a] | 4.5 (2.0–30.0)[a] | **<0.001**[b] |

[a]Data are summarized as median (interquartile range).
[b]To compare differences between groups, two sample *t*-tests or Wilcoxon rank-sum tests were used for continual variables; Chi-square tests or Fisher's exact tests were applied for categorical variables.
Significant *P* values are marked in bold.
CT, computed tomography.

The early CT group had significantly shorter hospital stays (early CT vs. late CT = 15.0 days vs. 20.5 days; $P = 0.035$) and a significantly shorter interval to initiate drainages than the late CT group (1.0 day vs. 4.5 days; $P < 0.001$) (Table 2). However, the duration of fever and body temperature during hospitalization were not significantly different between the groups (data not shown).

## Discussion

An intra-abdominal infection such as PLA can lead to a high mortality rate caused by sepsis if not recognized early and managed promptly. Prompt and accurate diagnosis and treatment are crucial. With the routine clinical practice of using CT imaging for identifying intra-abdominal infection in China, this two-arm, retrospective study collected clinical data to evaluate the effects of early adoption of nonenhanced CT imaging (i.e., within 48 h after admission) on the disease status and recovery in patients with PLA. Patients receiving early or late CT scans had comparable disease severity, except for a lower WBC level in the early CT group. The study found that patients receiving an early CT scan had a shorter hospital stay and received drainages earlier.

Compared with other Western studies, outcomes of patients receiving CT scan within 48 h after admission in the current study were also more favorable, with a shorter length of stay (15.0 days) than other Western real-world studies (Italy: 24 days; United Kingdom: 22 days)[6,14] and a lower mortality rate of 0% *versus* other studies (Italy: 11 patients [10.1%]; United Kingdom: 8 patients [12.3%]).[6,14] In the comparison with Asian studies, the length of hospital stay and in-hospital mortality in our study were also better than a Taiwanese study (19.6 days; 6.3%),[15] and similar to another Chinese study (14.5 days; 1.5%).[8] Differences in patient and disease characteristics (lesion size, pathogenesis, and comorbidity) between studies and races are inevitable; CT scanning conducted in the early 48 h may be a potential first-line diagnostic tool for identifying liver abscess. Early diagnosis allows physicians to plan treatment strategies, which may contribute to improving disease status and faster recovery. These suggest that an early CT scan within 48 h after admission may enable early diagnosis of PLA for effective and prompt treatment.

Furthermore, 51.7% of eligible patients ($n = 29$; data not shown) in the current study had the lesion located in segment 7/8 of the liver. This study also presented that first-line CT scanning in the emergency department enabled detection of the lesion in the liver segment earlier where ultrasound examination may fail to detect the lesion thoroughly.

However, there are some limitations in this study. First, our findings may not be generalizable as it was a single-center study conducted in China. Second, there was a selection bias in the patients. The enrolled individuals were from different departments, including gastroenterology and nongastroenterology of emergency, chest, and endocrinology. Those nongastroenterological physicians preferred to choose abdominal echo as the initial screening tool, considering the cost and radiation exposure and CT as the later method. Thus, we hope the findings in the result may raise the alertness of PLA, especially for physicians other than gastroenterologists. Third, the number of enrolled patients per group was imbalanced, despite their baseline data being generally homogeneous. Forth, we observed that the WBC level was significantly lower in the early CT group than the late CT group, and such difference may bias the comparison of disease status and management between groups. Results should be interpreted with caution due to the imbalance in the patient pool, and a randomized-controlled study is required to validate our findings. Fifth, 56.5% of patients ($n = 43$) were infected by *Klebsiella pneumoniae* (data not shown), and diverse pathogens causing PLA may influence the therapeutic decision and strategy; therefore, results need to be interpreted with care.[2,16] To our best knowledge, this study is the first research to evaluate the impact of adopting early CT imaging on PLA patients in comparison with late CT imaging. And the result suggests that early adoption of nonenhanced CT imaging within 48 h after admission may enable earlier definite diagnosis of liver abscess for effective and prompt treatment, leading to a shorter hospital stay. However, further studies on large scale are needed to validate these findings.

## Conclusion

The retrospective study showed that early adoption of nonenhanced CT scanning for patients with suspected pyogenic liver abscesses led to a decrease in the length of hospital stay and earlier drainages for patients after admission. Moreover, we hope the findings in this study might remind clinicians, especially those other than gastroenterologists, remain vigilant for liver abscesses and arrange earlier CT examinations to achieve a definite diagnosis.

## Acknowledgments

The authors acknowledge the assistance from Formosa Biomedical Technology Corp. CRO Division in the statistical analysis and editorial support.

## Ethics statement

The study protocol was reviewed and approved by the Institutional Review Board of Xiamen Chang Gung Hospital (approval number: XMCGIRB2021037). Because of the retrospective nature of the study, written patient consent was waived by the Institutional Review Board of Xiamen Chang Gung Hospital. All methods were conducted in accordance with the guidelines of the Declaration of Helsinki.

***Data availability statement.*** The data of this study are available from the corresponding author, upon reasonable request. Tung-Ying Chiang and Yang-Bor Lu have full access to all the data in the study and take responsibility for the integrity of the data, the accuracy of the data analysis, and the conduct of the research.

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