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Early predictors for the diagnosis of liver abscess in the emergency department

Dennis Wen Jie Chia[1] · Win Sen Kuan[2,3] · Weng Hoe Ho[2,3] · Tiong Beng Sim[2,3] · Mui Teng Chua[2,3]

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Abstract

Diagnosing pyogenic liver abscess (PLA) in the emergency department (ED) is challenging due to its non-specific clinical presentation. We aim to identify predictors that aid in diagnosis of PLA in ED patients. This retrospective chart review included patients diagnosed with PLA in a tertiary hospital between January 2008 and December 2012. We compared the demographics, clinical characteristics, investigations and outcomes between patients with PLA diagnosed and missed in the ED. During the study period, 155 patients were admitted via the ED with a cause of death or discharge diagnosis of PLA. Mean age was 58.1 (standard deviation [SD] 15.8) years, with male predominance of 69.7%. There were 79.4% of patients with diagnosis of PLA missed in the ED. Fulfillment of SIRS criteria was associated with increased odds of diagnosing PLA in the ED (adjusted OR 3.20, 95% CI 1.03–9.92), while a higher SpO_2/FiO_2 ratio was associated with decreased odds of a timely ED diagnosis (adjusted OR 0.993, 95% CI 0.988–0.998). Missed ED diagnosis of PLA did not result in significant differences in mortality or treatment failure ($p=0.939$), and median length of stay (11 days [IQR 8–16] vs. 11 days [IQR 7–17], $p=0.48$). Non-fulfillment of the SIRS criteria and a higher SpO_2/FiO_2 ratio at ED presentation were associated with higher likelihood of missed diagnosis. Despite that, a missed diagnosis of PLA in the ED did not appear to affect outcomes.

Keywords Liver abscess · Point-of-care ultrasonography · Systemic inflammatory response syndrome · Emergency services

Introduction

Pyogenic liver abscess (PLA) is a potentially life-threatening condition associated with high morbidity and mortality. Its reported incidence ranges from 8 to 22 cases per 100,000 hospital admissions, with a fatality rate ranging from 6 to 28.6% [1, 2]. The presentation is often varied and atypical, frequently mimicking other diseases, rendering its diagnosis challenging to the unsuspecting emergency physician. An early clinical diagnosis requires a high index of suspicion and is often based on a constellation of non-specific clinical findings.

Although the diagnosis of PLA has improved in the last decade through development and availability of more sensitive and specific imaging modalities in the emergency department (ED) such as ultrasonography (US) and computed tomography (CT), there is often delay in obtaining such definitive imaging as a diagnostic adjunct if PLA was not regarded as a differential diagnosis in the first place. This is often due to a paucity of presenting signs, symptoms as well as lack of diagnostic laboratory findings during the initial stages of presentation. Prompt diagnosis and adequate treatment with antibiotics and/or drainage are required to reduce mortality and morbidity in these patients.

Our study aims to identify predictors for diagnosis of PLA in patients presenting to the ED. Patients with timely diagnosis of PLA in the ED are compared with patients who had missed or delayed diagnosis of PLA to evaluate for predictors and risk factors.

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✉ Mui Teng Chua
mui_teng_chua@nuhs.edu.sg

[1] Emergency Department, Sengkang General Hospital, 110 Sengkang East Way, Singapore 544886, Singapore

[2] Emergency Medicine Department, National University Hospital, National University Health System, 9 Lower Kent Ridge Road, Level 4, Singapore 119085, Singapore

[3] Department of Surgery, Yong Loo Lin School of Medicine, National University of Singapore, Singapore, Singapore

Methodology

Study design

This study was a retrospective chart review conducted in the National University Hospital, a tertiary medical center in Singapore. Ethics approval for waiver of consent was obtained from the Domain Specific Review Board, National Healthcare Group, Singapore (2013/00876).

Study setting and population

The National University Hospital (NUH) is an academic tertiary care hospital with more than 1200 inpatient beds and over 120,000 ED attendances annually. Records of patients aged 18 years and older with a diagnosis of PLA (International Classification of Diseases, Ninth Revision, code 572.0) between January 2008 and December 2012 were selected from the hospital discharge database and hospital death register. The inclusion criteria were patients diagnosed with PLA or had a diagnosis of PLA as cause of death, and were admitted from the ED. We excluded patients who were admitted from outpatient clinics, transferred from another hospital, had known history of liver abscess or missing ED records.

The diagnosis of PLA was based on the evidence of one or more fluid collections in the liver without radiological characteristics of malignancy on US or CT studies with either one of the two following conditions: (1) identification of pus or bacteria either microscopically or by culture, or (2) a reduction in size of collection and clinical improvement in response to the antibiotics administered. Locally in our ED, diagnostic abdominal imaging is ordered based on emergency priority and whether immediate surgical intervention is needed. In patients without signs of acute abdomen, formal abdominal imaging may be done electively in the inpatient setting or in the ED based on clinicians' discretion.

All patients ultimately received either US or CT in the ward or ED to confirm the diagnosis of liver abscess. Treatment for PLA was in the form of: (1) antibiotics, (2) percutaneous catheter drainage under US or CT guidance, or (3) open drainage. Initial empirical treatment usually included administration of broad-spectrum antibiotics, with subsequent targeted therapy based on microbiological results.

Data collection

Chart reviews were conducted using the hospital's computerized patients' records system: ED Web and CPSS-2 (Computerized Patient Support System-2). Data collected from the chart reviews included patients' demographics, past medical history, clinical presentation, physical examination findings, laboratory and microbiological results, imaging studies such as US and CT scans, ED diagnosis and disposition, and in-hospital outcomes.

Outcome measures

Classification of missed or timely diagnosis was defined based on the location where the diagnosis was made. A diagnosis of PLA was considered not missed if it was made in the ED whether at index or repeat ED attendance. Patients with diagnosis made in ED were defined as those with an ED diagnosis of PLA that corresponds with the discharge or death diagnosis. Patients with diagnosis missed were those with PLA as a discharge or death diagnosis for which review of initial ED chart did not show PLA as a differential diagnosis. Additionally, patients who had previously presented to the ED or outpatient services for the same complaints but were not diagnosed with PLA, were defined as re-attendances if they have a diagnosis of PLA either from the repeat ED visit (not missed in ED) or in the inpatient wards (missed in ED).

Statistical analyses

Results were analyzed using Stata 14 (StataCorp LP, College Station, TX). Parametric and non-parametric variables were analyzed by Student's *t* test or Mann–Whitney *U* test as appropriate, and categorical variables were analyzed using χ^2 test or Fisher's exact test, as indicated. Predictors for diagnosis of PLA in ED are reported in odds ratios (ORs) with their 95% confidence intervals (CIs). A value of $p < 0.05$ was considered statistically significant. Clinically relevant variables and variables with $p < 0.10$ during univariate analyses were included for multivariate regression analyses.

Results

A total of 155 patients were diagnosed with PLA over a 5-year period between 1 January, 2008 and 31 December, 2012. Among these patients, 79.4% (124/155) had diagnosis missed in the ED and 44.5% (69/155) were re-attendances within 1 week. For the re-attendances ($n = 69$), 65.2% (45/69) had first attended the ED, while the rest had initially consulted general practitioners in outpatient services. The mean age of the entire study population was 58.1 years (SD 15.8) with Chinese ethnicity ($n = 116$, 74.8%) and male predominance ($n = 108$, 69.7%). Patients who had misdiagnosis did not differ significantly from those who were diagnosed in ED in terms of baseline comorbidities and mortality risk (Table 1 and Supplementary Table 1). A larger proportion of patients who were diagnosed were of immediate consult

Table 1 Baseline demographics and comorbidities

Variables	Missed in ED ($N=123$)	Diagnosed in ED ($N=32$)	P value
Male	83 (67.48)	25 (78.13)	0.243
Race			0.631
Chinese	91 (73.98)	25 (78.13)	
Non-Chinese	32 (26.02)	7 (21.88)	
Age, mean (SD)	58.3 (15.2)	57.7 (18.1)	0.842
Reattendance within 1 week	58 (47.15)	11 (34.38)	0.195
Triage PAC			0.107
P1	6 (4.88)	5 (15.63)	
P2	94 (76.42)	22 (68.75)	
P3	23 (18.70)	5 (15.63)	
Consult PAC			0.049[a]
P1	11 (8.94)	8 (25.00)	
P2	101 (82.11)	23 (71.88)	
P3	11 (8.94)	1 (3.13)	
Comorbidities			
Hypertension	63 (51.22)	18 (56.25)	0.612
Ischemic heart disease	13 (10.57)	6 (18.75)	0.209
Diabetes mellitus	47 (38.21)	14 (43.75)	0.568
Stroke	11 (8.94)	2 (6.25)	1.000*
Dyslipidemia	39 (31.71)	10 (31.25)	0.960
Chronic renal failure	8 (6.50)	5 (15.63)	0.097
Previous liver abscess	2 (1.63)	0 (0.00)	
Chronic liver disease	6 (4.88)	0 (0.00)	
Organ transplant recipient	3 (2.44)	0 (0.00)	
Autoimmune diseases	4 (3.25)	0 (0.00)	
History of gallstones	3 (2.44)	2 (6.25)	0.275*
Recent hepatobiliary surgery or procedures	7 (5.69)	1 (3.13)	1.000*
Malignancy	11 (8.94)	0 (0.00)	
On immunosuppressants	11 (8.94)	3 (9.38)	1.000*
Recent HBS sepsis	9 (7.32)	0 (0.00)	
Recent concurrent treatment for infection	5 (4.07)	1 (3.13)	1.000*

All values expressed as *n* (%) unless otherwise stated

PAC Patient acuity category, *PAC 1* critically ill and requires immediate attention, *PAC 2* major emergency requiring urgent care, *PAC 3* minor emergency, seen after PAC 2 patients, *HBS* hepatobiliary system, *IQR* interquartile range, *SD* standard deviation

*Fisher's exact test

[a]Bonferroni-adjusted P value for significance = 0.016. P value for $P1$ vs $P2 = 0.033$; $P1$ vs $P3 = 0.101$ [non-significant (NS)]; $P2$ vs $P3 = 0.692$ (NS)

acuity of patient acuity category (PAC) 1 (8/32, 25%) (Table 1).

The presence of myalgia, higher SpO_2/FiO_2 ratio, absence of liver function tests and POCUS done in ED, a quick sequential organ failure assessment (qSOFA) score of 0 or 1, and not fulfilling systemic inflammatory response syndrome (SIRS) criteria predicted a missed diagnosis of liver abscess (Tables 2, 3, 4 and Supplementary Table 1). In total, 9.68% of patients ($n=15$) received point-of-care ultrasonography (POCUS) in the ED but only 40% (6/15) of these were correlated with formal ultrasound findings (Table 4). After multivariate analysis, the fulfillment of SIRS criteria was associated with increased odds of diagnosing PLA in the ED (adjusted OR 3.20, 95% CI 1.03–9.92, $p=0.044$), while a higher SpO_2/FiO_2 ratio was associated with decreased odds of a timely ED diagnosis (adjusted OR 0.993, 95% CI 0.988–0.998, $p=0.010$). The variable, "location where CT was performed", was not included in the multivariate analysis due to non-convergence of the multivariate model as a result of data exhibiting complete separation. The location where CT liver was performed almost perfectly predicted whether

Table 2 History and physical findings

Variables	Missed in ED ($N=123$)	Diagnosed in ED ($N=32$)	P value
History			
Presence of fever	106 (86.18)	28 (87.50)	1.000*
Days of fever, median (IQR)	5 (2–7)	4.5 (2–7)	0.706
Chills	68 (55.28)	15 (46.88)	0.395
Rigor	50 (40.7)	12 (37.50)	0.695
Abdominal pain	53 (43.09)	19 (59.38)	0.100
Location of abdominal pain ($n=72$)	$N=53$	$N=19$	0.856*
RUQ	44 (83.02)	15 (78.95)	
Right loin to groin	1 (1.89)	1 (5.26)	
Generalized	6 (11.32)	2 (10.53)	
Non-RHC	2 (3.77)	1 (5.26)	
Jaundice	7 (5.69)	2 (6.25)	1.000*
Vomiting	35 (28.7)	13 (40.6)	0.194
Diarrhea	16 (13.2)	5 (15.6)	0.725
Constipation	8 (6.67)	3 (9.38)	0.700*
Myalgia	24 (19.51)	1 (3.13)	0.029*
Anorexia	45 (36.59)	13 (40.63)	0.674
Vital signs, median (IQR)			
Heart rate (per min)	104 (90–114)	106 (93.5–121)	0.380
SBP (in mmHg)	120 (106–137)	124 (102–137)	0.844
DBP (in mmHg)	70 (64–80)	69 (58.5–83.5)	0.503
MAP (in mmHg)	88 (77–97)	88 (74–100)	0.830
Respiratory rate (per min)	18 (18–20)	18 (18–23)	0.193
Temperature (°C)	37.8 (36.8–38.6)	38.1 (36.8–38.8)	0.520
SpO_2/FiO_2	466.7 (457.1–471.4)	461.9 (442.9–466.7)	0.003
Pain score	0 (0–0)	0 (0–2)	0.487
GCS	15 (15–15)	15 (15–15)	0.270
Physical examination			
Jaundiced	16 (13.01)	3 (9.38)	0.766*
Hepatomegaly	15 (12.20)	5 (15.63)	0.606
Splenomegaly	1 (0.81)	0 (0.00)	1.000*
Distension	2 (1.63)	0 (0.00)	1.000*
Tenderness	53 (43.09)	17 (53.13)	0.310
Site of abdominal tenderness ($n=70$)	$N=53$	$N=17$	0.292*
RUQ	36 (67.92)	15 (88.24)	
Non-right sided	15 (28.30)	2 (11.76)	
Generalized	2 (3.77)	0 (0.00)	

All values expressed as n (%) unless otherwise stated

DBP Diastolic blood pressure, *GCS* Glasgow Coma Scale, *IQR* interquartile range, *MAP* mean arterial pressure, *RHC* right hypochondrium, *RUQ* right upper quadrant, *SBP* systolic blood pressure

*Fisher's exact test

a diagnosis of PLA would be missed or diagnosed in ED as presented in Table 4.

Majority of patients with positive blood culture results (72.3%, 112/155) had infection due to *Klebsiella pneumoniae,* which constitutes 84.8% (95/112) of all positive blood cultures and 88.8% (95/107) of all Gram-negative and mixed (Gram-negative and Gram-positive) bacteremia. A larger proportion of patients who were diagnosed with PLA in the ED required admission to high dependency or intensive care unit (OR 4.96, 95% CI 1.78–13.84). A missed diagnosis did not result in differences in outcomes in terms of management, treatment failure and length of stay (Table 5). Among patients who were admitted to the general ward, a misdiagnosis did not result in increased odds of transfer to the HD/ICU during inpatient stay (OR 1.85, 95% CI 0.47–6.25, $p=0.329$). The overall mortality rate was 4.55% (7/155).

Table 3 Laboratory investigations

Variables	Missed in ED ($N=123$)	Diagnosed in ED ($N=32$)	P value
FBC done in ED, median (IQR)[a]			
Total white cell count ($\times 10^9$/L)	13.71 (10.19–18)	14.09 (11.75–18.35)	0.387
Neutrophil ($\times 10^9$/L)	11.94 (8.51–15.96)	12.69 (10.69–15.81)	0.460
Hemoglobin (g/dL)	12.7 (10.9–13.9)	13.0 (11.0–14.4)	0.551
Platelets ($\times 10^9$/L)	227 (160–342)	234.5 (183–308)	0.912
Total white cell count			0.653*
Low	4 (3.25)	1 (3.13)	
Elevated	94 (76.42)	27 (84.38)	
Normal	25 (20.33)	4 (12.50)	
RP done in ED, median (IQR)[b]			
Sodium (mmol/L)	134 (131–137)	135 (134–137)	0.373
Potassium (mmol/L)	3.7 (3.3–4.1)	3.85 (3.35–4.1)	0.456
Urea (mmol/L)	5.6 (3.8–7.9)	5.5 (3.9–9.5)	0.995
Creatinine (μmol/L)	79 (63–114)	90.5 (66.5–133.5)	0.193
Liver function tests[c]			0.014*
Done in ED	104 (84.55)	32 (100)	
Done in ward	19 (15.45)	0	
Total bilirubin (μmol/L), median (IQR)	16 (9–31)	17.5 (9–28)	0.742
Total bilirubin			0.446
Low or normal	92 (74.80)	26 (81.25)	
Elevated	31 (25.20)	6 (18.75)	
AST (U/L), median (IQR)	64 (36–109)	62 (49–161.5)	0.132
AST			0.418
Low or normal	48 (39.02)	10 (31.25)	
Elevated	75 (60.98)	22 (68.75)	
ALT (U/L), median (IQR)	58 (33–105)	75 (39–185.5)	0.157
ALT			0.433
Low or normal	71 (57.72)	16 (50.00)	
Elevated	52 (42.28)	16 (50.00)	
AST: ALT ratio			0.772*
< 1.0	49 (39.84)	15 (46.88)	
1.0–2.0	62 (50.41)	14 (43.75)	
> 2.0	12 (9.76)	3 (9.38)	
ABG			0.536*
Done in ward	41 (33.33)	12 (37.50)	
Done in ED	7 (5.69)	0	
Not done	75 (60.98)	20 (62.50)	
ABG results, median (IQR)	$N=48$	$N=12$	
pH	7.44 (7.41–7.49)	7.42 (7.32–7.46)	0.157
$PaCO_2$ (mmHg)	29.55 (24.8–32)	28.45 (23.3–32.9)	0.725
HCO_3 (mmol/L)	19.4 (17.3–22)	18.1 (15–23.9)	0.624
BE	−4 (−6.7 to −1.4)	−6 (−9.6 to −1.8)	0.252
P/*F* ratio	339.3 (283.3–387.1)	386.0 (294.6–450.4)	0.155

All values expressed as *n* (%) unless otherwise stated

ABG Arterial blood gas, *ALT* alanine transaminase, *AST* aspartate transaminase, *ED* emergency department, *FBC* full blood count, *IQR* interquartile range, *RP* renal panel

*Fisher's exact test

[a]Total white cell count: 3.84–10.01 × 10^9/L, neutrophil count: 1.56–6.27 × 10^9/L, hemoglobin: 11.4–14.7 g/dL, platelet count: 164–387 × 10^9/L

[b]Sodium: 135–145 mmol/L, potassium: 3.5–5.0 mmol/L, urea: 2.0–6.5 mmol/L, creatinine: 50–90 μmol/L

[c]Total bilirubin: 5–30 μmol/L, AST: 10–50 U/L, ALT: 10–70 U/L

Table 4 Radiological findings

Variables	Missed in ED ($N=123$)	Diagnosed in ED ($N=32$)	P value
Point-of-care ultrasound			
POCUS liver done in ED	4 (3.25)	11 (34.38)	0.0001*
POCUS liver findings ($n=15$)	$N=4$	$N=11$	0.297*
None seen	4 (100)	5 (45.45)	
Single	0	5 (45.45)	
Multiple	0	1 (9.09)	
Formal ultrasonography			
US done in ward	57 (46.34)	9 (28.13)	0.063
US findings in ward ($n=66$)	$N=57$	$N=9$	0.713*
None	1 (1.75)	0	
Single	46 (80.70)	7 (77.78)	
Multiple	10 (17.54)	2 (22.22)	
US location (ward)	$N=57$	$N=9$	0.207*
Left	15 (26.32)	2 (22.22)	
Right	36 (63.16)	4 (44.44)	
Both	6 (10.53)	3 (33.33)	
Correlation (POCUS)	$N=4$	$N=11$	0.067*
No	4 (100.00)	5 (45.45)	
Yes	0	6 (54.55)	
CT liver			
Location of performing CT			0.0001*
Done in ED	1 (0.81)	31 (96.88)	
Done in ward	114 (92.68)	1 (3.13)	
Not done	8 (6.50)	0	
CT findings ($n=147$)	$N=115$	$N=32$	0.448
Single	90 (78.26)	27 (84.38)	
Multiple	25 (21.74)	5 (15.63)	
Liver lobe involved ($n=146$)	$N=114$	$N=32$	0.800*
Left	29 (25.44)	7 (21.88)	
Right	70 (61.40)	22 (68.75)	
Both	15 (13.16)	3 (9.38)	
CT size ($n=144$)	$N=113$	$N=31$	0.303*
< 5 cm	42 (37.17)	7 (22.58)	
5–10 cm	63 (55.75)	22 (70.97)	
> 10 cm	8 (7.08)	2 (6.45)	
CT loculated ($n=140$)	$N=111$	$N=30$	0.873
No	22 (20.0)	6 (20.0)	
Yes	88 (80.0)	24 (80.0)	

All values expressed as n (%) unless otherwise stated

CT Computed tomography, *ED* emergency department, *POCUS* point-of-care ultrasonography, *US* ultrasonography

*Fisher's exact test

Discussion

Due to the lack of specific clinical signs and symptoms, as well as diagnostic laboratory tests, diagnosing PLA remains a difficult task for emergency physicians, especially when the time available for evaluation of each patient is usually limited in the acute setting. Our study has further reiterated that classical features in history and physical examination could not be reliably used to diagnose PLA in the ED. On the other hand, non-fulfillment of the SIRS criteria and higher SpO_2/FiO_2 were associated with higher odds of missed diagnosis.

Table 5 Outcomes table

	Missed in ED ($N=123$)	Diagnosed in ED ($N=32$)	P value
Type of organism			*0.318
Anaerobic	1 (0.81)	0	
Gram-negative	79 (64.23)	25 (78.13)	
Gram-positive	2 (1.63)	1 (3.13)	
Fungal	1 (0.81)	0	
Negative	38 (30.89)	5 (15.63)	
Both Gram-positive and Gram-negative	2 (1.63)	1 (3.13)	
Disposition from ED			0.001
General ward	114 (92.68)	23 (71.88)	
HD/ICU	9 (7.32)	9 (28.13)	
Management			0.457
Conservative management	49 (39.84)	10 (31.25)	
Percutaneous drainage	60 (48.78)	16 (50.00)	
Operative drainage	14 (11.38)	6 (18.75)	
Treatment failure			*0.939
Failure of conservative management requiring percutaneous drainage	7 (5.74)	1 (3.13)	
Failure of percutaneous drainage requiring surgery	11 (9.02)	4 (12.50)	
No treatment failure	98 (80.33)	26 (81.25)	
Death	6 (4.92)	1 (3.13)	
Length of stay (in days)	11 (8–16)	11 (7–17)	0.477

ED Emergency department, *HD* high dependency, *ICU* intensive care unit

The classical triad of fever, chills and right upper quadrant pain in PLA [3] was not always present. Although a majority of patients presented with fever (86.5%, 134/155), only 38.1% (59/155) of patients had complaints of right upper quadrant abdominal pain and a smaller proportion (32.9%, 51/155) had definite tenderness on examination. Abdominal pain has been described as a symptom [4] that increases the likelihood of PLA being diagnosed in the ED, prompting attending physicians to consider intraabdominal or hepatobiliary sepsis as a possible differential. Though patients in our study cohort who had PLA diagnosed in ED had a higher proportion of abdominal pain (59.4% vs. 43.1%), statistical significance was not achieved ($p=0.100$). This reflects the non-specific nature of clinical presentation in many cases, and the difficulty to achieve early and timely diagnosis.

In our study cohort, 72.3% (112/155) of patients had positive blood cultures, of which 84.8% (95/112) were *Klebsiella pneumoniae*, similar to findings in other Asian countries such as Taiwan [5], South Korea [6] and Hong Kong [7]. The high prevalence of positive cultures in our cohort is likely due to the high incidence of fever (close to 90% of the study cohort, Table 2) and routine practice of drawing blood cultures before initiation of parenteral antibiotics [8]. Interestingly, there is also an increase in number of *Klebsiella*-associated PLA in Western countries such as the United States, where *Escherichia coli* has long been the predominant pathogen [9]. The clinical significance in *Klebsiella pneumoniae*-associated PLA lies in its high rate of metastatic complications including bacteremia, necrotizing fasciitis, endophthalmitis and meningitis [10, 11], with diabetic patients being at increased risk for such sequelae [12]. For patients with this invasive syndrome, appropriate antimicrobial treatment combined with percutaneous drainage of liver abscesses increases their chances of survival [10]. Given the increasing prevalence of diabetes mellitus in Singapore with an estimated number of 1 million residents being affected by 2050 [13] and the high complication rates of PLA in diabetic patients [12], there is a need for ED physicians to be more vigilant to recognize this clinical syndrome and initiate appropriate management timely.

We found that patients who fulfilled the systemic inflammatory response syndrome (SIRS) criteria were more likely to be associated with a correct diagnosis made in the ED. During the period included for this study, sepsis-2 definitions [14] were in place and physicians were diagnosing sepsis based on patients fulfilling the SIRS criteria combined with suspected infection. We postulate that patients fulfilling SIRS criteria were more likely to have prompted attending physicians to adopt early source identification and control, hence the association with a correct diagnosis as compared to patient who did not fulfill the SIRS criteria.

The overall mortality rate for our study group was 4.55% (7/155), lower than the reported mortality rate of 6 [1]–28.6% [2] internationally. Despite evidence suggesting that a delayed diagnosis [15] and drainage [16] of PLA would lead to a poorer prognosis, our results did not show that a delayed diagnosis of PLA in the ED led to a poorer outcome, which is congruent with the results from a study in Taiwan [4]. This lower mortality rate could be a reflection of reduced disease severity among patients in our study cohort, as demonstrated by the proportion of patients with low prognostic scores. Another possible reason could be the implementation of guidelines in managing sepsis in our ED since 2008 [17–19] with an emphasis on early broad-spectrum antibiotics and aggressive fluid resuscitation, which would be equally important in keeping the mortality rate low.

Although there was a higher proportion of POCUS performed in patients who were diagnosed in the ED (34.38% vs 3.25%), 45.45% (6/11) of these patients had negative POCUS findings. This higher proportion could possibly be due to other suspicious clinical findings that resulted in attending physicians having a higher index of suspicion, contributing to a higher proportion of POCUS being done. Given the nature of our study, reverse causation could not be excluded. While there are no studies commenting on the accuracy of ED physicians on POCUS of the liver for PLA, POCUS when performed by on-call gastroenterologists in the ED was shown to have a sensitivity of 85.8% [20]. In our study, formal ultrasonography of the liver, if done, was able to detect close to 100% of liver abscesses. Given ultrasonography is readily available in most modern EDs, more studies should be undertaken to evaluate if formal ultrasonography training could equip emergency physicians with the appropriate skills in detecting liver abscesses with bedside point-of-care imaging. Before that, formal ultrasonography of the liver should be considered in patients with no specific source of infection to evaluate for PLA, which may not have localizing signs and symptoms. Though the performance of CT had a highly accurate diagnostic performance in our study cohort with ultrasound being inferior in comparison, ultrasound has its advantages as being non-invasive, less costly, easily accessible, and most importantly negates risks of radiation and contrast allergy, thus meriting it as a bedside point-of-care test, possibly expediting care and timely intervention in patients with positive findings.

The strength of our study lies in the availability of a large number of variables including clinical features, laboratory and microbiological findings, radiological characteristics, disease severity and treatment outcomes for a complete evaluation to identify predictors for missed diagnosis. Furthermore, this study is an important reminder to clinicians to consider PLA in patients with an unclear source of infection.

Limitations

Our study has its limitations. First, the retrospective design harbors inherent weaknesses with information bias. However, given a low prevalence of liver abscess, a prospective study would not have been pragmatic and resource efficient. Second, the low prevalence also limited the overall sample size despite a study period of 5 years. In spite of this, our study has a larger sample size within such a short period compared to most previous studies in the current literature [1, 3, 7, 21, 22]. The overall small sample size also resulted in relatively low events in various variables which limited the ability for conclusive associations. However, these results are hypothesis generating and serves to remind clinicians of an infrequently seen but important condition.

Third, the retrospective nature of this study did not allow us to review and validate the ultrasonographic findings performed by the attending physicians. Fourth, the study cohort was identified based on databases and diagnosis codes, and hence may introduce a degree of selection bias. Lastly, the classification of whether a diagnosis of PLA was missed or not was based on the location where the diagnosis was made rather than at the index ED visit. The outcome measured was defined as such, because it is routine practice in our ED to provide appropriate discharge advice for patients to return to the ED (i.e., scheduled reattendance) for non-resolving symptoms. This enables ED physicians to follow through on the initial decisions made, which could signify evolution of the disease process with unclear symptoms and signs at the index presentation.

Conclusion

A missed diagnosis of PLA in the ED did not appear to affect outcomes. Further studies should be conducted to evaluate the utility of POCUS in ED for diagnosis of liver abscess in patients with suspected infection with no clear source.

Compliance with ethical standards

Conflict of interests On behalf of all authors, the corresponding author states that there is no conflict of interest.

Statement of human and animal rights All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Our study is a retrospective study. For this type of study, formal consent is not required.

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