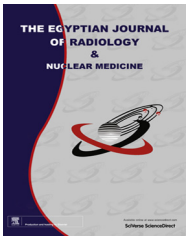
The Egyptian Journal of Radiology and Nuclear Medicine (2014) **45**, 109–115

Egyptian Society of Radiology and Nuclear Medicine

The Egyptian Journal of Radiology and Nuclear Medicine

www.elsevier.com/locate/ejrnm
www.sciencedirect.com



ORIGINAL ARTICLE

Percutaneous treatment of large pyogenic liver abscess

Mohammad Alaa Abusedera [a,*], **Ashraf Mohammad El-Badry** [b]

[a] *Sohag University, Nasser City, Sohag 82524, Egypt*
[b] *Sohag University, Sohag University Street, Nasser City, Sohag 82524, Egypt*

Received 6 June 2013; accepted 10 November 2013
Available online 15 December 2013

KEYWORDS

Liver;
Abscess;
Drainage;
Aspiration

Abstract Surgical drainage has been the traditional mode of treatment of pyogenic liver abscess but this was replaced by IV broad-spectrum antibiotics and imaging-guided percutaneous drainage either via needle aspiration or percutaneous catheter drainage (CD). There is a debate about which is better intermittent needle aspiration or CD.

Our objective is to compare the outcome of CD versus intermittent needle aspiration of pyogenic liver abscess and to compare the single step Trocar technique versus the modified Seldinger technique.

Patients and methods: 88 patients, 65 men and 23 women, mean age 44.6 (18–73) years had pyogenic liver abscess. Patients were divided in two groups randomly; aspiration group with maximum of three attempts and the CD group. Ultrasound or CT was used.

Results: Aspiration was successful in 60% of cases (26/43). CD was successful in 98% (44/45). Three patients were treated by surgical drainage (two patients of the aspiration group and one of the CD group) with favorable outcome. Both Seldinger and single step Trocar techniques were comparable as regards outcome and procedure-related pain but the procedure time of Trocar was significantly shorter. No major complications were encountered.

Conclusion: CD is more efficient than needle aspiration. Aspiration can be used for simple small abscesses. Trocar technique is less time-consuming than the Seldinger technique.

1. Introduction

Pyogenic liver abscess is a rare, life-threatening disease that has an increasing incidence rate in the United States and Europe. The high morbidity and mortality rates associated with the treatment of pyogenic liver abscess were improved significantly with the introduction of ultrasound (US) and computed tomography (CT) guided percutaneous drainage (1–6).

* Corresponding author. Tel.: +20 1094274500; fax: +20 934602963.
E-mail addresses: malaa2@yahoo.com (M.A. Abusedera), elbadryam@yahoo.com (A.M. El-Badry).

Peer review under responsibility of Egyptian Society of Radiology and Nuclear Medicine.

ELSEVIER Production and hosting by Elsevier

0378-603X © 2014 Production and hosting by Elsevier B.V. on behalf of Egyptian Society of Radiology and Nuclear Medicine.
Open access under CC BY-NC-ND license. http://dx.doi.org/10.1016/j.ejrnm.2013.11.005

Surgical drainage of pyogenic liver abscess was the traditional mode of treatment (7); however, it was associated with remarkably high (10–47%) morbidity and mortality rates (8,9). Modern treatment has shifted toward IV broad-spectrum antibiotics and image-guided percutaneous needle aspiration or percutaneous catheter drainage (CD). Currently, indications for surgical drainage include inaccessibility or multiplicity of abscesses that cannot be drained percutaneously (10,2,11) or failed percutaneous drainage. There is debate about the first line of management of large pyogenic liver abscesses.

Percutaneous needle aspiration is considered as effective as catheter drainage especially for simple abscesses that are 50 mm or less in diameter (12). Many authors believe that CD is more effective than percutaneous needle aspiration in the management of liver abscess (13–15). Some studies have shown therapeutic needle aspiration to be a simpler, less costly, and equally effective mode of treatment (16,17).

Our study aimed to compare the clinical outcome of percutaneous image-guided catheter drainage with intermittent needle aspiration of pyogenic liver abscesses and to compare safety and clinical outcome of the single step Trocar technique versus the modified Seldinger technique.

2. Patients and methods

All patients with pyogenic liver abscesses who were admitted to our hospital between July 2003 and June 20013 were considered candidates for the study. Eligibility criteria were the presence of >2 cm symptomatic pyogenic liver abscess(s) which was confirmed at ultrasound or CT examination in adult patients or cooperative young patients who could tolerated the procedure with local anesthesia. Young children were excluded because children were not cooperative enough and required general anesthesia. Patients with coexisting coagulopathy, liver neoplasm or amoebic abscess or perforated abscess complicated by peritonitis were excluded too.

Pre-procedure written informed consent was obtained from all patients. Patient consent for the study was waived as this is a retrospective study. The institutional ethics committee approved the study.

Coagulation profile was evaluated before the scheduled procedure and promptly corrected. Local infiltration anesthesia was provided by 6–8 ml of Lidocaine hydrochloride 2%. Access of the liver abscess was obtained guided by ultrasound whenever feasible using free hand technique. Ultrasound exam was carried out by convex 3–5 MHz transducer of either Logic C5 premium (General Electric Medical Systems, Milwaukee, WI) or Sonoline 51–450 (Siemens Medical Systems, Issaquah, WA). CT was performed using light speed General Electric Medical Systems. The choice of aspiration or continuous catheter drainage was random. In patients assigned to the needle aspiration, an 18-gauge Trocar needle was advanced into the abscess cavity and the contents were aspirated in an attempt to completely evacuate the cavity followed by irrigation of the abscess cavity with normal saline; the volume of infused saline was less than 1/2 of the drained pus. In the catheter drainage group, ultrasound guided single step Trocar technique or modified Seldinger technique was applied (Fig. 1a). The details of both techniques were explained elsewhere. Plastic-based

Fig. 1a 65 year old male patient presented with right upper abdominal pain and fever of 38.7 °C. Leukocytic count was 18,000, with absolute neutrophilia, ultrasound examination has shown a single large cystic lesion about $8 \times 7 \times 6$ cm at the right lobe of the liver, diagnostic aspiration revealed frank pus, that was sent for gram stain and culture and sensitivity, ultrasound-guided catheter drainage was achieved using 10 Fr and pig tail catheter was inserted by single step Trocar technique within the abscess cavity.

catheter Multipurpose Flexiema catheter (Boston scientific USA) or polyurethane-based catheter Genoflex (Genesis Medical England) was used. Complete evacuation of the abscess cavity was attempted followed by irrigation with normal saline. The volume of infused saline was less than 1/2 the drained pus. Lavage and aspiration were repeated till the contents came back clear. The catheters were connected to a completely closed collecting system and routine catheter care was instituted. A daily estimate of the amount, color, and consistency of the drainage fluid was recorded. Irrigation of the catheter with about 5–10 ml of normal saline was done once daily to avoid catheter blockage. Aspirated pus was examined and microbiologic tests were performed to determine the causative organism. Blood culture before antibiotic administration was performed. Broad spectrum antibiotics, including Cefazoline 1 g/12 h and Augmentin 1.2 g/8 h IV and with Metronidazole (500 mg IV or 500 mg orally three times a day) were initiated. Once the laboratory results were available, antibiotics were changed on the basis of sensitivity tests. Broad-spectrum antibiotics were continued in patients in whom pus culture had returned negative. The antibiotics were continued for 10 days (14 days for

Metronidazole) after defervescence. All patients were followed up to assess the time needed for clinical improvement, length of hospital stay, and development of complications. Periodic US examination was carried out every third day to assess the cavity size until the patients were discharged. Catheters were removed when the patients showed clinical improvement (defervescence and relief from local symptoms and normalization of elevated leukocyte counts), the catheter output dropped to less than 10 ml/24 h for 2 consecutive days, and follow-up US examination showed negligible residual cavity less than 2 cm.

Patients in the percutaneous needle aspiration group who did not improve clinically after the first aspiration and continued to have leukocytosis or showed refilling of the abscess cavity on follow-up US, were subjected to a second and third aspiration. Failure to improve after third aspiration was considered as failure of aspiration therapy and catheter for continuous drainage was inserted. Those patients were not included in the CD group. After discharge, all patients were followed up with periodic clinical and US examinations to assess any recurrence of the disease and to monitor the size of the abscess cavity. The patients were examined weekly during the first month, monthly for the next 3 months and at two monthly intervals thereafter until complete resolution of the abscess was achieved (Figs. 1b–1d). Treatment was considered successful if all of the following criteria were met: clinical subsidence of infection (subsidence of fever and local signs and symptoms, and normalization of elevated leukocyte counts), US evidence of abscess resolution (disappearance or marked decrease in the abscess cavity (more than 50% reduction of longest diameter before treatment)) and follow-up imaging showed resolution of the abscess Fig. 1d (total resolution or reduction in size to <2 cm) with no evidence of relapse or recurrence during follow-up.

Periods of hospitalization and the time needed for clinical improvement, 50% reduction in size of abscess cavity, and total or near-total resolution of the abscess after percutaneous treatment were recorded.

Patients in whom catheter drainage failed, were subjected to open surgery with 28 French soft plastic external drainage tube left in-place.

All operative procedures were carried out under general anesthesia with epidural analgesia. The area extending from the nipples to the upper thighs was disinfected by the application of povidone–iodine. Prophylactic antibiotic (Cefazolin) was administered intravenously just before the incision. The peritoneal cavity was accessed via the right subcostal incision, the falciform ligament is divided and a self-retaining retractor was installed. For lesions located in segments VII and/or VIII, maximum exposure was obtained by division of the right triangular and a portion of the right coronary ligaments followed by rotation of the right liver lobe and placement of sterile towels behind. Superficial abscesses were initially aspirated by a sterile syringe to take samples for cytologic and bacteriologic examination and to render the abscess wall flaccid and easy to handle. Unroofing was performed by incision of the abscess wall, drainage of contents and finally excision of the abscess wall. The resected specimen was sent for histopathological assessment. A 28 French soft plastic drain was placed in the unroofed abscess cavity for external drainage. The wound was closed in layers. For lesions in the left lateral section (segments II and III), left subcostal extension of the original incision was performed by division of the left coronary and triangular ligaments. Lesions located in segments IV, V and VII were unroofed as described above without liver mobilization.

Statistical analysis was done with statistical software (SPSS 10.0, SPSS). Descriptive and analytic statistics were used.

Fig. 1b Ultrasound examination of same patient 6 days after catheter insertion with defervescence and size reduction and cavity collapsed over the catheter arrow.

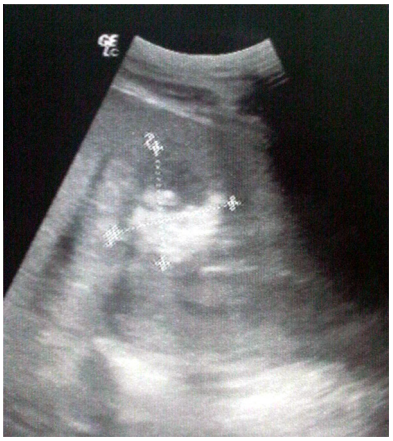


Fig. 1c US exam of the same patient 6 weeks after discharge showing heterogenous echogenic focal lesion.

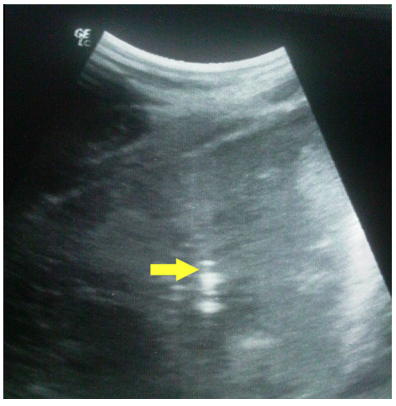


Fig. 1d US 6 months later showed minute echogenic spot at the site of treated liver abscess.

Quantitative variables were compared by the two-sample Student's t test for independent samples with adjustment for unequal variances when needed or by the Mann–Whitney U test for variables not normally distributed. Categoric variables were analyzed by the chi-square test. All statistical tests were performed with a 95% level of statistical significance.

3. Results

Ninety-two patients were initially enrolled in the study. Four were excluded because of associated hepatic malignant disease (2 patients) and ruptured liver abscess and acute peritonitis that required immediate laparotomy and surgical management (2 patients). Of the remaining 88 patients, 65 were men and 23 were women. The mean age was 44.6 (range, 18–73) years. Before admission, patients had symptoms for 5.9 days at average (range, 2–14 days). Aspiration and catheter drainage (CD) groups did not differ significantly with respect to demographic data, clinical features, or biochemical values (Table 1). There were no statistically significant differences between the two groups with regard to underlying pathologic condition and abscess characteristics (Table 1). The etiology of the liver abscess was not found in 48 (55%) of the 88 patients, however biliary origin was identified in 33 patients (26%) and of portal origin in 17 patients (19%) (Table 1). The most common coexisting disease was diabetes in 49 (56%) of the patients. A microbial pathogen was isolated in 20 (44%) of the patients in the CD group and 17 (40%) of the patients in the percutaneous needle aspiration group. All patients who had positive results of both blood and abscess cultures had identical pathogens. Bacteria in the positive cultures were predominantly gram negative, *Klebsiella pneumoniae* was the leading species (Table 2).

Details on the outcome of the procedure are shown in Table 2. Aspiration was successful in 60% of cases (26/43). Single aspiration was successful in 9% of cases (4/43). Repeated aspiration was attempted in 22 patients of 43 patients who have not responded to the first aspiration. Only 4 patients out of 22 improved with second aspiration and only a single patient out of 18 responded after the third attempt. Three aspiration attempts failed to treat the abscess in 40% of cases (17/43), 15 of them were treated successfully with CD and only two required surgical drainage after failure of CD. Those patients were not included in the catheter drainage group.

In the percutaneous needle aspiration group, the average longest diameter of the abscess was significantly greater in patients with unsuccessful (10.5 ± 3.2 cm) than in patients with successful (5.5 ± 3.5 mm) needle aspiration ($p = 0.02$). The average volume of abscesses (360 ml) in the 17 patients in whom needle aspiration was unsuccessful was significantly ($p = 0.03$) larger than the average volume (140 ml) of the abscesses in the 26 patients who responded to 1 or 2 or 3 aspirations. However, other characteristics were similar in aspiration-successful and aspiration-failure groups.

Intermittent needle aspiration was successful for all patients with abscesses 5 cm in longest diameter or smaller. However, this treatment was unsuccessful for all 7 patients with complex multi septated abscesses regardless of the diameter. CD was successful in 98% of cases (44/45). In 4 out of 6 patients with multi septated abscesses, CD was performed twice because

Table 1 Liver abscess characteristics of aspiration and catheter drainage groups.

Parameter	Aspiration	Drainage	p Value
	Total 43	45	
Age	18–73	20–71	0.81
Sex			
M	32	33	
F	11	12	
Pain	43	45	0.54
Fever	42 (98)	42 (93)	
Leucocytosis > 10×10^3	40 (93)	41 (91)	
Co-morbidity			
DM	24 (56)	25 (55)	0.77
IHD	12 (28)	13 (29)	
HTNS	19 (44)	18 (42)	
Solitary	33 (77)	37 (82)	0.67
Multiple	10 (23)	8 (18)	
Right lobe	26 (61)	27 (60)	
Left lobe	13 (30)	13 (29)	
Both lobes	4 (9)	5 (11)	
Volume			
Range	15–355	17–360	0.08
Mean	131 [91.2]	169 [106.2]	
Size			
Range	3–12	4–13	0.32
Mean	6.6 [2.1]	7.2 [3]	
Biliary cause	11 (26)	12 (27)	0.59
Portal cause	9 (21)	8 (18)	
Cryptogenic	23 (53)	25 (56)	

Number between () are percentage and number between [] are standard deviation.

Table 2 Outcome of aspiration and catheter drainage.

	Catheter drainage $n = 43$	Aspiration $n = 45$	p Value
Improvement	26 (60)	44 (98)	0.03
Single procedure	21 (49)	40 (89)	
Two procedures	4 (9)	4 (9)	
Three procedures	1 (2)	0 (0)	
Duration fever subsidence	1–8 [5.6]	2–9 [4.4]	0.76
WBC < 11	4–16 [7.8]	3–15 [8.5]	0.81
> 50% Size reduction	5–17 [10.4]	6–22 [11.5]	0.77
Organisms			
Klebsiella pneumoniae	10 (23)	12 (27)	0.42
E. coli	8 (19)	7 (16)	
Pseudomonas	4 (9)	5 (11)	
Staph	7 (16)	7 (16)	
Poly	4 (9)	4 (9)	
Negative	10 (23)	10 (22)	
Hospital stay (days)	3–22 [6.6]	7–33 [8.3]	0.88

Numbers between () are percentage and numbers between [] are standard deviation.
N: number.
© Mann–Whitney *U* test; $Z = -0.02$; $p = 0.88$.

drainage was inadequate with the first attempt and the catheter was upgraded from 8 to 12 French.

Either modified Seldinger or Trocar techniques were carried out (Table 3). Abscess characteristics were not statistically different in subgroups treated with either technique.

US was the main image guiding modality, used in 71% of the CD group (32/45) but CT was used in 29% (13/45). Seldinger technique was technically successful 100% after the first attempt but the Trocar technique failed once using polyethylene-based 10 French catheter in a single patient but it was successful in the second attempt using a plastic-based catheter. This patient had liver cirrhosis and a tough capsule. Clinical outcome was not different in both techniques. Procedure time for the Trocar technique was significantly shorter than that of Seldinger; mean of 14 min versus 20 min ($p = 0.001$).

CD was unsuccessful in 2% of cases (1/45) to drain multi septated abscess with thick pus and debris even with upgraded catheter from 8 to 12 French catheter. This patient had undergone surgical drainage with favorable outcome. Total duration of catheter drainage for each patient in the drainage group ranged from 7 to 33 days with a mean of 8.3 ± 6.4 days. At the end of treatment, the abscess cavity had disappeared completely in 35 of 85 successfully treated patients and had decreased more than 50% in the other 40 patients. On final examination 6 months after the beginning of treatment, abscesses were absent in all successfully treated patients.

No recurrence of abscess in any treated groups in the follow up was recorded. Hospital stay was not significantly different between the aspiration and CD groups (*Mann–Whitney U test*; $Z = -0.02$; $p = 0.98$) (Table 2). Neither group of patients had procedure-related major complications such as bleeding of any degree of septicemia. Three patients in the CD group and none in the aspiration group had minor complications.

Patient tolerated both Trocar and modified Seldinger technique without a significant difference in analog pain scores. One patient of the Seldinger technique group complained of severe pain at the catheter entry site that was relieved with oral analgesic. A pericatheter leak developed in two patients, one of the Trocar group and other the Seldinger technique group. In one patient, the catheter was blocked with debris; the leak discontinued after flushing of the catheter with normal saline. The other reason was the catheter kink that was exchanged, the leak stopped after the catheter exchange.

4. Discussion

Pyogenic liver abscesses are uncommon, although associated mortality is rare, morbidity and prolonged hospitalization are common. Image guided intervention and anti-microbial therapy are the mainstay of treatment and open surgical intervention is rarely required (18,19). Several studies (2,10,11,17,20) have shown that a large proportion of patients can be treated with excellent results with a combination of parenteral antibiotics and image-guided percutaneous drainage.

Three randomized studies (12,20,21) in which, use of continuous catheter drainage (CD) was compared with repeated needle aspiration in the management of liver abscess. The recommendations for first-line percutaneous treatment differed. Yu et al. (20) performed a randomized trial involving 64 patients with pyogenic liver abscess. Those investigators concluded that percutaneous needle aspiration was probably as effective as continuous CD. They recommended percutaneous needle aspiration as a first-line approach because of procedure simplicity, patient comfort, and reduced price and shorter hospital stay. Rajak et al. (21) compared percutaneous needle aspiration and CD in a randomized study involving 50 patients with liver abscess. Those investigators concluded that CD was more effective than percutaneous needle aspiration. In that study, lack of response to a second attempt at percutaneous needle aspiration was considered failure of treatment. In the study of Zerem and Hadzic (12) percutaneous needle aspiration was successful in 20 (67%) of the 30 patients after one ($n = 12$), two ($n = 7$), or three ($n = 1$) aspirations. Our results were comparable to those reported by Zerem and Hadzic in 2007, we considered 3 attempts of aspirations as the maximum number of trials as the

Table 3 Comparison between Seldinger and single step Trocar techniques.

	Seldinger 23	Trocar 22	*p* Value
Us 32	12	20	
CT 13	2	11	
Lesion size	9–11	8–12	0.77
Volume	250	230	0.64
Success first	20	20	1.0
Success second	2	2	
Procedure time			
Range	15–35	10–18	**0.001**
Mean	25	11	
Procedure apin score	3–6	4–5	0.66

Seldinger versus Trocar technique for catheter drainage.
Us: ultrasound.
CT: computed tomography.

majority of successful drainage by aspiration occurred after the first attempt (49%) and only (9%) in the second attempts. The third attempt was successful in a single patient out of 18. This confirms that further needle aspiration is rarely successful. Percutaneous needle aspiration of all multiloculated abscesses failed and CD was necessary. Other authors prefered continuous catheter drainage as a reliable and effective approach to the management of liver abscess (22–24).

In our study CD was successful in 98% of cases and only a single patient of the CD group required surgical drainage and 2 patients of the aspiration group who failed catheter drainage although catheter upgrading was attempted. Failure was seen probably because debris was too big to be drained through a catheter. In the study of Liao et al. in 2012 who had 18% failure rate that required surgical drainage and they found a wide range of attenuation values within the abscess that are predictors of percutaneous drainage failure which is consistent with the presence of Debris (25). In their study gas within the abscess was another predictor of CD failure. In ours a single case had gas within the abscess that probably is iatrogenic rather than gas forming organisms in other series impressive of virulent organism and debilitated patient.

We excluded patients with coexisting hepatic malignant disease which is a poor prognostic factor and the leading cause of death among patients with pyogenic liver abscess. In a study of Lai et al. in 2013, they had a 34% failure rate of CD for patients with pyogenic liver abscess who had pancreatic biliary malignancy. Abscess resolution was achieved in 67% and 32% died during hospitalization (26).

Our results are comparable to those of Zerem and Hadzic 2007 (12), who had 100% success rate with CD and 0% mortality. Patients with coexisting malignancy of biliary origin were excluded from their study too. In our study we used US and CT to guide catheter placement without difference in success rate or complication but these results were different from results of Bergert et al. in 2004 who found that US-guided drainage of pyogenic liver abscess had better outcome and less failure and complication rates compared to the CT guided drainage (22).

In our study iatrogenic air bubbles that were seen within liver abscess preclude safe US guided insertion of a pig tail catheter so CT scan was used. Other indications for CT were that multiple abscesses required multiple catheters. There were no significant differences between US versus CT groups.

Trocar and modified Seldinger techniques could be used for pyogenic liver abscess drainage but the procedure time of the Trocar technique was shorter. Both techniques were well tolerated. Technical success was achieved after a single puncture in 31 out 32 and single cases required two punctures this is comparable to the study of Fan et al. in 2008 who were successful in 91 out of 93 in CD procedures to drain a variety of abdominal and pelvic collections (27). They used 7–8.3 French catheter but we used 8–12 French catheter. In our study, both Trocar and the modified Seldinger techniques were successful to access abscesses except in a single case with the Trocar technique using 10 French polyurethane-based catheter that was difficult to pass through a tough liver capsule but the procedure was successful with 10 French plastic-based catheter.

Because our institution is a referral hospital, many of these patients had been partially treated with antibiotics before being referred to us; this probably accounts for the high percentage of abscesses with negative results of pus cultures in our study. These results were similar to those of other investigators (15–17). Similar to the results of other studies (10–12) *K. pneumoniae* was the most commonly isolated microorganism in our series. *K. pneumoniae* can be a source of gas in liver abscess (28).

DM was the most common associated co morbidity and this is similar to other investigators findings (18). DM is risk factor for pyogenic liver abscess. Thomsen et al. found that diabetic persons had 3.6-fold increased risk of experiencing pyogenic liver abscess, compared with population control subjects (adjusted relative risk, 3.6; 95% confidence interval, 2.9–4.5 (29).

Hospital stay and duration to clinical improvement and time needed for the resolution of abscesses in successfully treated patients did not significantly differ in both aspiration and CD groups and it is similar to the findings of other investigators (20).

Although the treatment of liver abscess has been mainly percutaneous drainage, operative intervention is still indicated and surgery remains necessary after failure of the initial treatment but should also be considered as an early intervention for cases presenting with gas-forming abscesses and septic shock and when treatment of the underlying cause is immediately required (30). In our series 3 patients failed CD because of thick debris that required surgical exploration and open drainage. Surgical drainage was successful without recurrence or complication.

In conclusion, CD is more efficient than intermittent percutaneous needle aspiration. Intermittent percutaneous needle aspiration is an acceptable alternative in abscesses that are 50 mm or less in longest diameter. Aspiration is not efficient for multi septated liver abscesses. These cases should be reserved for CD. Trocar or Seldinger technique can be used for catheter placement, however Trocar is simpler and less time-consuming than the modified Seldinger technique. Detailed controlled randomized study is needed to explore the utility of different catheters for the Trocar technique.

Conflict of interest

The authors have no conflict of interest to disclose.

References

(1) Branum GD, Tyson GS, Branum MA, Meyers WC. Hepatic abscess: changes in etiology, diagnosis, and management. Ann Surg 1990;212:655–62.
(2) Huang CJ, Pitt HA, Lipsett PA, Osterman FA Jr, Lillemoe KD, Cameron JL, et al. Pyogenic hepatic abscess: changing trends over 42 years. Ann Surg 1996;223:600–7.
(3) Neoptolemos JP, Macpherson DS, Holm J, Fossard DP. Pyogenic liver abscess: a study of forty-four cases in two centres. Acta Chir Scand 1982;148:415–21.
(4) Northover JM, Jones BJ, Dawson JL, Williams R. Difficulties in the diagnosis and management of pyogenic liver abscess. Br J Surg 1982;69:48–51.
(5) Miedema BW, Dineen P. The diagnosis and treatment of pyogenic liver abscesses. Ann Surg 1984;200:328–35.
(6) Silver S, Weinstein AJ, Cooperman A. Changes in the pathogenesis and detection of intrahepatic abscess. Am J Surg 1979;137:608–10.
(7) Satani B, Davidson ED. Hepatic abscesses: improvement in mortality with early diagnosis and treatment. Am J Surg 1978;135:647–50.
(8) Gerzof SG, Johnson WC, Robbins AH, Nabseth DC. Intrahepatic pyogenic abscesses: treatment by percutaneous drainage. Am J Surg 1985;149:487–94.
(9) Lee JF, Block GE. The changing clinical pattern of hepatic abscesses. Arch Surg 1972;104:465–70.
(10) Barakate MS, Stephen MS, Waugh RC, Gallagher PJ, Solomon MJ, Storey DW, et al. Pyogenic liver abscess: a review of 10 years experience in management. Aust NZ J Surg 1999;69:205–9.
(11) Mohan S, Talwar N, Chaudhary A, Andley M, Ravi B, Kumar A. Liver abscess: a clinicopathological analysis of 82 cases. Int Surg 2006;91:228–33.
(12) Zerem Enver, Hadzic Amir. Sonographically guided percutaneous catheter drainage versus needle aspiration in the management of pyogenic liver abscess. AJR 2007;189:W138–42.
(13) Seeto RK, Rockey DC. Pyogenic liver abscess: change in etiology, management and outcome. Medicine 1996;75:I 99–I 128.
(14) Robert JH, Miresew D, Ambroseui P, Khoury G, Greenstein Al, Rohner A. Critical review of the treatment of pyogenic liver abscess. Surg Gynecol Obstet 1992;l74:97–102.
(15) Hashimoto L, Hermann R, Broniatowski 5G. Pyogenic hepatic abscess: results of current management. Am Surg 1995;61:407–11.
(16) Back SY, Lee MG, Cho KS, Lee SC, Sung KB, Auh YH. Therapeutic percutaneous aspiration of hepatic abscesses: effectiveness in 25 patients. AJR 1993;160:799–802.
(17) Giorgio A, Tarantino L, Mariniello N, Francica G, Scala E, Amoroso P, et al. Pyogenic liver abscesses: 13 years of experience in percutaneous needle aspiration with US guidance. Radiology 1995;l95:122–4.
(18) O'Farrell N, Collins CG, McEntee GP. Pyogenic liver abscesses: diminished role for operative treatment. Surgeon 2010;8(4):192–6.
(19) Mezhir JJ, Fong Y, Jacks LM, Getrajdman GI, Brody LA, Covey AM, et al. Current management of pyogenic liver abscess: surgery is now second-line treatment. J Am Coll Surg 2010;210(6):975–83.
(20) Yu SC, Ho SS, Lau WY, Yeung DT, Yuen EH, Lee PS, et al. Treatment of pyogenic liver abscess: prospective randomized comparison of catheter drainage and needle aspiration. Hepatology 2004;39:932–8.
(21) Rajak CL, Gupta S, Jain S, Chawla Y, Gulati M, Suri S. Percutaneous treatment of liver abscesses: needle aspiration versus catheter drainage. AJR 1998;170:1035–9.
(22) Bergert H, Kersting S, Pyrc J, Saeger HD, Bunk A. Therapeutic options in the treatment of pyogenic liver abscess. Ultraschall Med 2004;25:356–62.
(23) Lee KT, Wong SR, Sheen PC. Pyogenic liver abscess: an audit of 10 years' experience and analysis of risk factors. Dig Surg 2001;18:459–66.
(24) Alvarez Pérez JA, González JJ, Baldonedo RF, Sanz L, Carreño G, Junco A, et al. Clinical course, treatment, and multivariate analysis of risk factors for pyogenic liver abscess. Am J Surg 2001;181:177–86.
(25) Liao W-I, Tsai S-H, Yu C-Y, Huang G-S, Lin Y-Y, Hsu C-W, et al. Pyogenic liver abscess treated by percutaneous catheter drainage: MDCT measurement for treatment outcome. Eur J Radiol 2012;81(4):609–15.
(26) Lai KC, Cheng KS, Jeng LB, Huang CC, Lee YT, Chang HR, et al. Factors associated with treatment failure of percutaneous catheter drainage for pyogenic liver abscess in patients with hepatobiliary–pancreatic cancer. Am J Surg 2013;205(1):52–7.
(27) Fan WC, Chan CC, Chan JCS. Image-guided drainage using the Trocar technique. J HK Coll Radiol 2008;11:69–71.
(28) Yu C, Lee C. Pyogenic liver abscess. N Engl J Med 2011;364:1154.
(29) Thomsen Reimar W, Jepsen Peter, Sørensen Henrik T. Diabetes mellitus and pyogenic liver abscess: risk and prognosis. Clin Infect Dis 2007;44(9):1194–201.
(30) Alkofer B, Dufay C, Parienti JJ, Lepennec V, Dargere S, Chiche L. Are pyogenic liver abscesses still a surgical concern? A western experience. HPB Surg 2012;316013(10):19.