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Diaphragmatic Disruption Ahead of Herniation Following Hepatic Radiofrequency Ablation

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1. Abstract

A 48-year-old man with HBV-related cirrhosis was found to have three small hepatocellular carcinomas (HCC) in segment 5, 6 and 8 with a clinical stage of T2N0M0/BCLC stage A. He was treated with percutaneous radiofrequency ablation (RFA) with the aid of artificial pleural effusion to prevent thermal lung injury. However, a delayed diaphragmatic hernia with colon incarceration occurred 11 months later. Diaphragmatic disruption was noted retrospectively 4 months ahead of herniation at the previous image study. It is recommended to handle carefully HCC with RFA at the unfavorable location. Early detection of diaphragmatic injury could be repaired by minimally invasive surgery.

2. Introduction

Hepatocellular carcinoma (HCC) is one of the leading causes of cancer death in the world [1]. In Taiwan, HCC ranks the top 2 cancer related mortality. According to HCC treatment guideline, radiofrequency ablation (RFA) is one of treatment modalities for very early stage (BCLC stage 0) or unresectable early stage (BCLC stage A) [2-4]. Compared to other local ablative techniques, RFA is widely accepted for its effectiveness, more controllable ablation extent, and less invasiveness. In small HCCs, RFA even provides equivalent survival rates to surgical resection [5, 6].

The major complication rate of RFA is low [7]. However, some serious complications, such as hollow viscera perforation, pleural effusion, liver abscess, biliary stenosis, intraperitoneal hemorrhage, and tumor seeding were still reported sporadically [8, 9]. Here, we report a case of diaphragmatic hernia with the incarcerated bowel into the thoracic cavity 11 months after RFA. Diaphragmatic disruption could be identified 4 months ahead of the herniation.

3. Case Presentation

A 48-year-old man, with HBV-related liver cirrhosis, type 2 diabetes mellitus (DM), and end-stage renal disease (ESRD) under regular hemodialysis, was found to have an elevated AFP (667.2 ng/ml). Computed tomography (CT) scan and magnetic resonance imaging (MRI) showed 3 hepatic nodules, measuring 2.35 cm in segment (S) 7 (Figure 1), 0.77 cm in S6 and 0.92 cm in S8. The Barcelona-Clinic Liver Cancer (BCLC) stage was A with Child-Pugh score 6. Liver transplantation was first recommended due to the poor liver function. However, the patient finally decided to receive RFA.

Prior to RFA, artificial pleural effusion (APE) was created by infusion of 300 ml water containing 5% dextrose for the high-risk located S7 HCC (<1 cm from the liver capsule). After sedation and local anesthesia, percutaneous RFA was done by the assistance of real-time virtual sonography for inconspicuous nodules in S6 and S8. An internally cooled straight electrode with an adjustable 2-3 cm active tip was used. Three punctures and overlapping ablations were done for

S7 tumor to achieve a 0.5-1.0 cm ablative safety margin. The power used was 40 (S 6 and S8) to 70 (S7) watts for 4'10" (S6), 4'30" (S8) to 10 (S7) minutes. Impedances (baseline/maximal) were 50/82 (S7), 80/120 (S8) and 60/80 (S6) ohms. Total energy ranged 7171 (S8), 8666 (S6) to 86473 (S7) joules. After RFA, there were no immediate complications such as bowel perforation and bleeding. Abdominal sonography on the next day showed complete ablation on the three tumors. The patient was discharged 4 days after RFA. AFP decreased to 6.6 ng/ml 3 months after RFA. Dynamic CT showed no tumor recurrence 8 months after RFA.

Eleven months later, the patient was admitted to the Emergency Department with chief complaint of fever for 2 days, accompanied with progressive abdominal pain and vomiting. Chest radiography showed right pleural effusion and dilation of bowel loops in the chest cavity (Figure 2). Abdominal CT revealed a right hemidiaphragm defect with colon herniation into the pleural cavity. On the third day, the patient underwent open surgery to close the hole in the diaphragm. Reviewing previous images, diaphragm remained intact until 4 months after RFA. Diaphragm discontinuity was noted by Abdominal CT (Figure 3). After the reduction surgery, the patient became stable without complications.

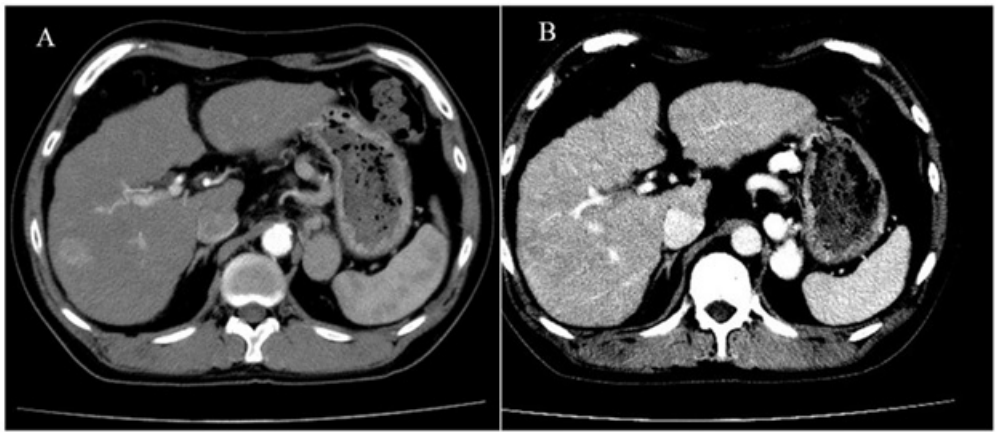

Figure 1: Abdominal computed tomography (CT) showed a hepatic nodule in segment 7 with hyperintensity in the arterial phase (A) and washout in the portal venous phase (B).

Figure 2: Chest radiography of P-A view (standing) revealed dilated bowel loops in the thoracic cavity.

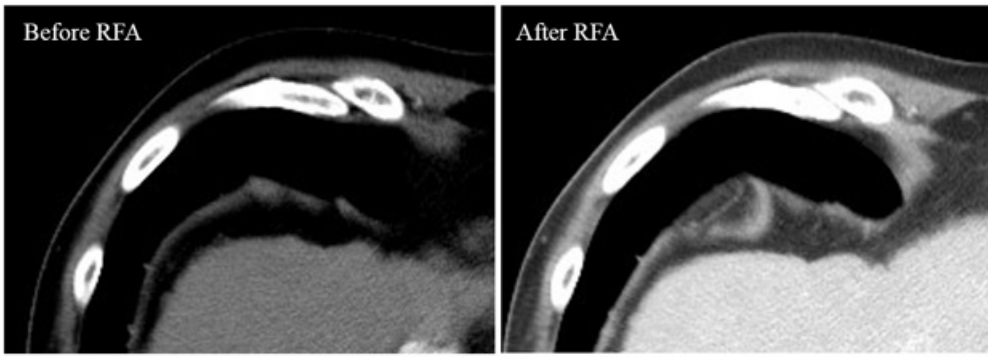

Figure 3: Abdominal CT before radiofrequency ablation (RFA) showed intact diaphragm and the diaphragm was disrupted at 7 months after RFA.

4. Discussion

DH following RFA was extremely rare. The incidence was less than 0.1% without the application of artificial effusion [10]. Only 13 cases of RFA related DH were reported in English literature (Table 1) [11-15]. All 13 DHs were late-onset, ranging from 7 to 96 months after RFA. RFAs were usually done for S5-8 lesions (12/13) in these cases, especially lesions in S8. In our case, RFA for the S7 nodule could lead to the diaphragmatic injury. APE was done for preventing thermal injury on the right lung. However, DH occurred 11 months after the RFA therapy. The timeline of diaphragmatic disruption and herniation was not studied in the previously reported 13 cases. We were the first to review all the images done after RFA. Diaphragm disruption could be found in abdominal CT at 7 months after RFA. Early detection of diaphragm disruption might be possible and thus prevent DH by minimally invasive measures, such as laparoscopic repair. The prognosis of RFA-related DH was relatively good. But two patients died of HCC rupture or hepatic failure.

Unfavorable tumor location and poor conspicuity were two major relative contraindications of ultrasound-guided percutaneous RFA in early-stage HCC [16]. The subcapsular location, poor liver function and liver cirrhosis were also considered to increase the risk of DH [13]. In addition, our patient also had DM and ESRD. All these factors added the risk of diaphragmatic injury following RFA. Therefore, a good guidance method was necessary for unfavorable sites to reduce complications. Fusion imaging of CT/MRI, and ultrasound with contrast were reported to be helpful techniques to increase tumor conspicuity and then to reduce thermal injury to surrounding organs or structures. It was also reported that after conventional transarterial chemoembolization, the retentional intra-tumoral iodized oil could serve as the contrast to index lesion, and then making the fluoroscopic- or CT-guided RFA achievable for the HCCs of BCLC stage 0 or A [17].

Table 1: 13 cases of diaphragmatic hernia occurring after radiofrequency ablation for HCC

No	Author	Year	Age/ Sex	Site	Guidance method	Artificial liquid	Onset of defect (month)	Treatment for DH	Outcomes
1	Koda et al. [12]	2002	61/F	S6 and S8	Sonography	n.a.	13	OS	Died 1 month postop (HCC rupture)
2	Shibuya et al. [12]	2006	72/M	S4/S8	Sonography	n.a.	18	OS	Alive
3	di Francesco et al. [12]	2008	49/M	Dome of the right lobe	Sonography	X	15	OS	Alive
4	Yamagami et al. [12]	2011	71/F	S7	CT fluoroscopy	n.a.	9	Conservative treatment for PE	Alive
5	Boissier et al. [12]	2011	65/F	S5 and S8	Sonography	n.a.	7	OS with bowel resection	Alive
6	Singh et al. [12]	2011	46/F	S5/S8	Sonography	n.a.	11	LS	Alive
7	Meiqi et al. [13]	2011	61/F	S8	Sonography	n.a.	12	OS with bowel resection	Alive
8	Jong Sun et al. [12]	2012	61/M	S5 and S8	Sonography	X	9	Conservative treatment for PE	Alive
9	Nakamura et al. [12]	2014	81/M	S4 and S8	Sonography	X	18	OS with bowel resection	Alive
10	Nomura et al. [12]	2014	62/M	S8	Sonography	X	96	LS	Alive
11	Saito et al. [12]	2015	80/M	S5 and S8	Sonography		33	OS	Died 23 days postop (liver failure)
12	Abe et al. [14]	2016	72/F	S5 and S8	Sonography	n.a.	15	OS	Alive
13	Ushijima et al. [15]	2021	82/M	S8	n.a.	n.a.	16	LS	Alive
14	Our case	2021	48/M	S7, S6 and S8	Sonography	✓	11	OS	Alive

Artificial liquid: artificial ascites or pleural effusion, DH: diaphragmatic hernia
F: female, M: male, S: segment, LS : laparoscopic surgery, OS : open surgery
RVS: real-time virtual sonography, PE: pleural effusion, n.a.: not available

For protective measures, subphrenic artificial infusion could significantly reduce diaphragmatic injury [18], and APE was recommended for dorsal tumors to prevent lung injury, while artificial ascites was for lesions on the ventral side or attached to surrounding organs [19]. In this case, APE was not enough to prevent diaphragmatic injury. Subphrenic artificial infusion was, therefore, recommended to reduce the risk of diaphragmatic injury, not just APE.

In summary, we should be careful handling HCCs with RFA at the unfavorable locations with adequate protective measures. Early detection of diaphragmatic injury could prevent potential major complications and repaired by minimally invasive surgery, such as endoscopic repair.

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