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Contents

Thrice Monthly Volume 10 Number 20 July 16, 2022

OPINION REVIEW

- 6759 Semaglutide might be a key for breaking the vicious cycle of metabolically associated fatty liver disease spectrum?

Cigrovski Berkovic M, Rezig T, Bilic-Curcic I, Mrzljak A

MINIREVIEWS

- 6769 Drainage of pancreatic fluid collections in acute pancreatitis: A comprehensive overview
Bansal A, Gupta P, Singh AK, Shah J, Samanta J, Mandavdhare HS, Sharma V, Sinha SK, Dutta U, Sandhu MS, Kochhar R

- 6784 Frontiers of COVID-19-related myocarditis as assessed by cardiovascular magnetic resonance

Luo Y, Liu BT, Yuan WF, Zhao CX

ORIGINAL ARTICLE

Case Control Study

- 6794 Urinary and sexual function changes in benign prostatic hyperplasia patients before and after transurethral columnar balloon dilatation of the prostate

Zhang DP, Pan ZB, Zhang HT

- 6803 Effects of the information-knowledge-attitude-practice nursing model combined with predictability intervention on patients with cerebrovascular disease

Huo HL, Gui YY, Xu CM, Zhang Y, Li Q

Retrospective Cohort Study

- 6811 Effects of Kampo medicine hangebyakujutsutemmato on persistent postural-perceptual dizziness: A retrospective pilot study

Miwa T, Kanemaru SI

Retrospective Study

- 6825 Longitudinal changes in personalized platelet count metrics are good indicators of initial 3-year outcome in colorectal cancer

Herold Z, Herold M, Lohinszky J, Szasz AM, Dank M, Somogyi A

- 6845 Efficacy of Kegel exercises in preventing incontinence after partial division of internal anal sphincter during anal fistula surgery

Garg P, Yagnik VD, Kaur B, Menon GR, Dawka S

Observational Study

- 6855 Influence of the water jet system vs cavitron ultrasonic surgical aspirator for liver resection on the remnant liver

Hanaki T, Tsuda A, Sunaguchi T, Goto K, Morimoto M, Murakami Y, Kihara K, Matsunaga T, Yamamoto M, Tokuyasu N, Sakamoto T, Hasegawa T, Fujiwara Y

- 6865** Critical values of monitoring indexes for perioperative major adverse cardiac events in elderly patients with biliary diseases

Zhang ZM, Xie XY, Zhao Y, Zhang C, Liu Z, Liu LM, Zhu MW, Wan BJ, Deng H, Tian K, Guo ZT, Zhao XZ

- 6876** Comparative study of surface electromyography of masticatory muscles in patients with different types of bruxism

Lan KW, Jiang LL, Yan Y

Randomized Controlled Trial

- 6890** Dural puncture epidural technique provides better anesthesia quality in repeat cesarean delivery than epidural technique: Randomized controlled study

Wang SY, He Y, Zhu HJ, Han B

SYSTEMATIC REVIEWS

- 6900** Network pharmacology-based strategy for predicting therapy targets of Sanqi and Huangjing in diabetes mellitus

Cui XY, Wu X, Lu D, Wang D

META-ANALYSIS

- 6915** Endoscopic submucosal dissection for early signet ring cell gastric cancer: A systematic review and meta-analysis

Weng CY, Sun SP, Cai C, Xu JL, Lv B

- 6927** Prognostic value of computed tomography derived skeletal muscle mass index in lung cancer: A meta-analysis

Pan XL, Li HJ, Li Z, Li ZL

CASE REPORT

- 6936** Autosomal dominant osteopetrosis type II resulting from a *de novo* mutation in the *CLCN7* gene: A case report

Song XL, Peng LY, Wang DW, Wang H

- 6944** Clinical expression and mitochondrial deoxyribonucleic acid study in twins with 14484 Leber's hereditary optic neuropathy: A case report

Chuenkongkaew WL, Chinkulkitnivat B, Lertrit P, Chirapapaisan N, Kaewsutthi S, Suktitipat B, Mitrpant C

- 6954** Management of the enteroatmospheric fistula: A case report

Cho J, Sung K, Lee D

- 6960** Lower lip recurrent keratoacanthoma: A case report

Liu XG, Liu XG, Wang CJ, Wang HX, Wang XX

- 6966** Optic disc coloboma associated with macular retinoschisis: A case report

Zhang W, Peng XY

- 6974** A 7-year-old boy with recurrent cyanosis and tachypnea: A case report
Li S, Chen LN, Zhong L
- 6981** Schwannomatosis patient who was followed up for fifteen years: A case report
Li K, Liu SJ, Wang HB, Yin CY, Huang YS, Guo WT
- 6991** Intentional replantation combined root resection therapy for the treatment of type III radicular groove with two roots: A case report
Tan D, Li ST, Feng H, Wang ZC, Wen C, Nie MH
- 6999** Clinical features and genetic variations of severe neonatal hyperbilirubinemia: Five case reports
Lin F, Xu JX, Wu YH, Ma YB, Yang LY
- 7006** Percutaneous transhepatic access for catheter ablation of a patient with heterotaxy syndrome complicated with atrial fibrillation: A case report
Wang HX, Li N, An J, Han XB
- 7013** Secondary positioning of rotationally asymmetric refractive multifocal intraocular lens in a patient with glaucoma: A case report
Fan C, Zhou Y, Jiang J
- 7020** Laparoscopic repair of diaphragmatic hernia associating with radiofrequency ablation for hepatocellular carcinoma: A case report
Tsunoda J, Nishi T, Ito T, Inaguma G, Matsuzaki T, Seki H, Yasui N, Sakata M, Shimada A, Matsumoto H
- 7029** Hypopituitary syndrome with pituitary crisis in a patient with traumatic shock: A case report
Zhang XC, Sun Y
- 7037** Solitary plasmacytoma of the left rib misdiagnosed as angina pectoris: A case report
Yao J, He X, Wang CY, Hao L, Tan LL, Shen CJ, Hou MX
- 7045** Secondary coronary artery ostial lesions: Three case reports
Liu XP, Wang HJ, Gao JL, Ma GL, Xu XY, Ji LN, He RX, Qi BYE, Wang LC, Li CQ, Zhang YJ, Feng YB
- 7054** Bladder perforation injury after percutaneous peritoneal dialysis catheterization: A case report
Shi CX, Li ZX, Sun HT, Sun WQ, Ji Y, Jia SJ
- 7060** Myotonic dystrophy type 1 presenting with dyspnea: A case report
Jia YX, Dong CL, Xue JW, Duan XQ, Xu MY, Su XM, Li P
- 7068** Novel mutation in the *SALL1* gene in a four-generation Chinese family with uraemia: A case report
Fang JX, Zhang JS, Wang MM, Liu L
- 7076** Malignant transformation of primary mature teratoma of colon: A case report
Liu J

- 7082** Treatment of pyogenic liver abscess by surgical incision and drainage combined with platelet-rich plasma: A case report
Wang JH, Gao ZH, Qian HL, Li JS, Ji HM, Da MX
- 7090** Left bundle branch pacing in a ventricular pacing dependent patient with heart failure: A case report
Song BX, Wang XX, An Y, Zhang YY
- 7097** Solitary fibrous tumor of the liver: A case report and review of the literature
Xie GY, Zhu HB, Jin Y, Li BZ, Yu YQ, Li JT
- 7105** MutL homolog 1 germline mutation c.(453+1_454-1)_(545+1_546-1)del identified in lynch syndrome: A case report and review of literature
Zhang XW, Jia ZH, Zhao LP, Wu YS, Cui MH, Jia Y, Xu TM
- 7116** Malignant histiocytosis associated with mediastinal germ cell tumor: A case report
Yang PY, Ma XL, Zhao W, Fu LB, Zhang R, Zeng Q, Qin H, Yu T, Su Y
- 7124** Immunoglobulin G4 associated autoimmune cholangitis and pancreatitis following the administration of nivolumab: A case report
Agrawal R, Guzman G, Karimi S, Giulianotti PC, Lora AJM, Jain S, Khan M, Boulay BR, Chen Y
- 7130** Portal vein thrombosis in a noncirrhotic patient after hemihepatectomy: A case report and review of literature
Zhang SB, Hu ZX, Xing ZQ, Li A, Zhou XB, Liu JH
- 7138** Microvascular decompression for a patient with oculomotor palsy caused by posterior cerebral artery compression: A case report and literature review
Zhang J, Wei ZJ, Wang H, Yu YB, Sun HT
- 7147** Topical halometasone cream combined with fire needle pre-treatment for treatment of primary cutaneous amyloidosis: Two case reports
Su YQ, Liu ZY, Wei G, Zhang CM
- 7153** Simultaneous robot-assisted approach in a super-elderly patient with urothelial carcinoma and synchronous contralateral renal cell carcinoma: A case report
Yun JK, Kim SH, Kim WB, Kim HK, Lee SW
- 7163** Nursing a patient with latent autoimmune diabetes in adults with insulin-related lipodystrophy, allergy, and exogenous insulin autoimmune syndrome: A case report
He F, Xu LL, Li YX, Dong YX
- 7171** Incidental diagnosis of medullary thyroid carcinoma due to persistently elevated procalcitonin in a patient with COVID-19 pneumonia: A case report
Saha A, Mukhopadhyay M, Paul S, Bera A, Bandyopadhyay T
- 7178** Macular hole following phakic intraocular lens implantation: A case report
Li XJ, Duan JL, Ma JX, Shang QL

LETTER TO THE EDITOR

- 7184** Is every microorganism detected in the intensive care unit a nosocomial infection? Isn't prevention more important than detection?

Yildirim F, Karaman I, Yildirim M

ABOUT COVER

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Laparoscopic repair of diaphragmatic hernia associating with radiofrequency ablation for hepatocellular carcinoma: A case report

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Abstract

BACKGROUND

Radiofrequency ablation (RFA) is an effective treatment for early-stage hepatocellular carcinoma (HCC). Although RFA is a relatively safe technique compared with surgery, several complications have been reported to be following/accompanying this treatment. Delayed diaphragmatic hernia caused by RFA is rare; however, the best surgical approach for its treatment is uncertain. We present a case of laparoscopic repair of diaphragmatic hernia due to RFA.

CASE SUMMARY

An 80-year-old woman with segment VIII HCC was treated twice in 5 years with RFA; 28 mo after the second RFA, the patient complained of right hypochondriac pain. Computed tomography revealed that the small intestine was incarcerated in the right thorax. The patient was diagnosed with diaphragmatic hernia and underwent laparoscopic repair by non-absorbable running sutures. The patient's postoperative course was favorable, and the patient was discharged on postoperative day 12. The diaphragmatic hernia has not recurred 24 mo after surgery.

CONCLUSION

Laparoscopic treatment of iatrogenic diaphragmatic hernia is effective and minimally invasive.

Key Words: Diaphragmatic hernia; Radiofrequency ablation; Hepatocellular carcinoma; Complication; Laparoscopic surgery; Case report

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Core Tip: Radiofrequency ablation (RFA) is an effective treatment for hepatocellular carcinoma (HCC). Delayed diaphragmatic hernia caused by RFA is uncommon; however, the best surgical approach to its treatment has not been determined. Herein, we present a rare case of delayed-onset diaphragmatic hernia due to RFA and its treatment with laparoscopic repair. This case highlights the ultimate importance of that RFA for HCC located close to the diaphragm should be performed using artificial ascites under computed tomography guidance to prevent an injury to the diaphragm. Laparoscopic treatment of iatrogenic diaphragmatic hernia is effective and minimally invasive.

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INTRODUCTION

Hepatocellular Carcinoma (HCC) is ranked as the sixth most common neoplasm and the third leading cause of death to cancer[1]. Surgical resection, transplantation, ablation, transarterial chemoembolization and the use of tyrosine-kinase inhibitors are treatments with proven survival benefit. Radiofrequency ablation (RFA) is an effective treatment for early-stage HCC. Although RFA is a relatively safe technique compared with surgery, several complications have been identified[2-7]. In an analysis of 3670 patients who underwent RFA for HCC, Mulier *et al*[3] reported an overall complication rate of 8.9%. The major complications following RFA were abdominal bleeding, abdominal infection, and biliary tract damage; 5 cases (0.1%) of injury to the diaphragm were also reported. Delayed diaphragmatic hernia caused by RFA is uncommon; however, the best surgical approach to its treatment has not been determined. Here, we present a case of delayed-onset diaphragmatic hernia resulting from RFA and its treatment with laparoscopic repair, along with the review of the relevant literature.

CASE PRESENTATION

Chief complaints

An 80-year-old woman had been followed up for autoimmune hepatitis-related liver cirrhosis and recurrent HCC. Colonoscopy for chronic diarrhea revealed rectal cancer, and the patient was accordingly admitted to our hospital for resection of the tumor. High anterior resection was performed. On postoperative day 10, the patient complained of right hypochondriac pain.

History of present illness

The patient had been followed up for autoimmune hepatitis-related liver cirrhosis and recurrent HCC. The patient's condition was classified as Child-Pugh Class B (7 points) with hypoalbuminemia (2.1 g/dL) without encephalopathy or ascites. Gadoxetate sodium enhanced magnetic resonance imaging revealed masses that were highly suspicious for HCC located in the Segment VIII (S8) near the liver surface (Figure 1A). RFA was performed under ultra-sonographic guidance using an expandable needle (LeVeon™ Needle Electrode; Boston Scientific, Inc., Natick, MA, United States) 55 mo before hernia repair, with no early complications. No artificial pleural effusion or artificial ascites was used. Twenty-eight months before the hernia repair, the patient underwent repeat RFA for recurrent HCC located in S8 near the inferior vena cava (Figure 1B). Artificial pleural effusion was used during the second RFA.

History of past illness

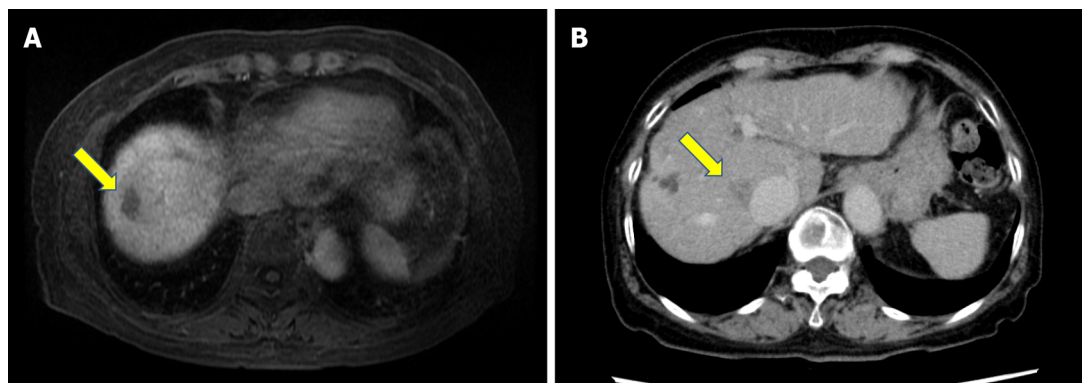
The patient had medical histories of hypertension, hyperuricemia, heart failure, pneumonia, and laparoscopic cholecystectomy.

Personal and family history

There was no family history of malignant tumors.

Physical examination

On her physical examination, the patient showed tenderness of the right hypochondrium without rebound tenderness, although the vital signs were normal.



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Figure 1 Location of tumors. A: Gadolinium ethoxybenzyl diethylenetriamine pentaacetic acid-enhanced magnetic resonance imaging revealed a low-intensity area in segment VIII (S8) near the surface of the liver in the hepatobiliary phase (arrow); B: Abdominal contrast-enhanced computed tomography revealed a nodular lesion (20 mm) in S8 of the liver near the inferior vena cava, indicating washout in the delayed phase (arrow).

Laboratory examinations

A blood test revealed normal white cell count (4800/ μ L; normal range, 3500-8000/ μ L) and C-reactive protein level (0.22 mg/dL; normal < 0.30 mg/dL). It also revealed low albumin level (2.1 g/dL) and coagulopathy, including low platelet count (8.7×10^4 / μ L; normal range, $15-35 \times 10^4$ / μ L) and high international normalized ratio of prothrombin time (1.29; normal range, 0.80-1.20) due to liver cirrhosis.

Imaging examinations

A contrast-enhanced computed tomography (CT) scan revealed small intestine incarcerated in the right thorax (Figure 2). No findings suggested intestinal ischemia.

FINAL DIAGNOSIS

The final diagnosis of the presented case is diaphragmatic hernia due to RFA for HCC.

TREATMENT

The patient immediately underwent emergency surgery. The patient underwent laparoscopic hernia repair in the dorsosacral position under general anesthesia. Four trocars were inserted into the abdomen (Figure 3). The first 12-mm trocar was introduced in the left-upper abdomen using the open-entry technique so as to avoid adhesions between the abdominal wall and visceral organs due to the previous surgery. After pneumoperitoneum by carbon dioxide insufflation, three more trocars were inserted at the right lateral abdomen, the mid-upper abdomen (12-mm trocars for operator) and near the umbilicus (a 5-mm trocar for scopist). Small intestine had slipped through the diaphragmatic defect and was observed to be incarcerated in the right thorax (Figure 4A). The small intestine was gently pulled back into the abdominal cavity using laparoscopic bowel-grasping forceps (Figure 4B). Bowel resection was not required. The hernia defect was estimated to be approximately 5 cm in diameter (Figure 4C). Intra-abdominal air pressure was reduced from 8 mmHg to 6 mmHg because the intrathoracic air pressure was increased through the defect and the pulmonary ventilation volume was decreased.

The defect was repaired using synthetic non-absorbable monofilament polypropylene sutures (3-0 PROLENE; Ethicon Inc., Somerville, NJ, United States) in the running fashion (Figure 4D). No drainage tube was placed. The operative duration was 76 min, and the estimated blood loss was < 5 mL.

OUTCOME AND FOLLOW-UP

The patient's postoperative course was favorable, and the patient was discharged on postoperative day 12. The diaphragmatic hernia has not recurred 24 mo after the surgery.

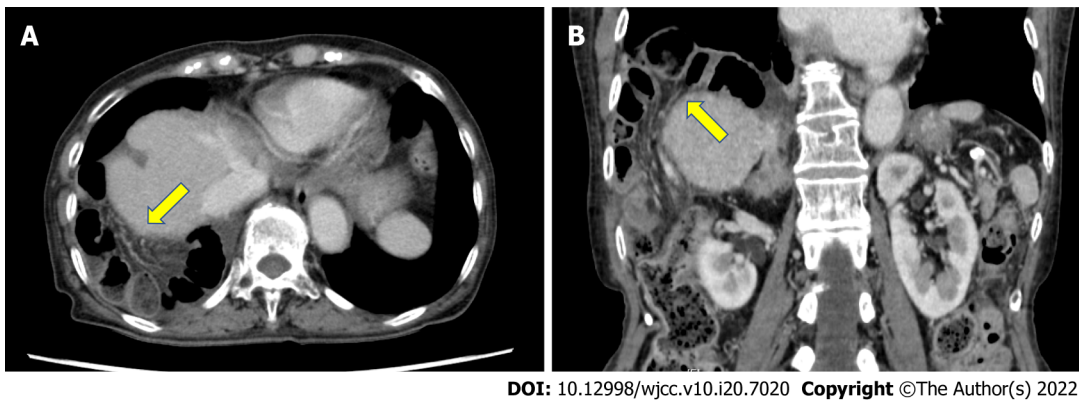


Figure 2 Contrast-enhanced computed tomography image at the onset of diaphragmatic hernia. Contrast-enhanced CT revealed small intestine incarcerated in the right thorax (arrow). A: Horizontal plane; B: Coronal plane.

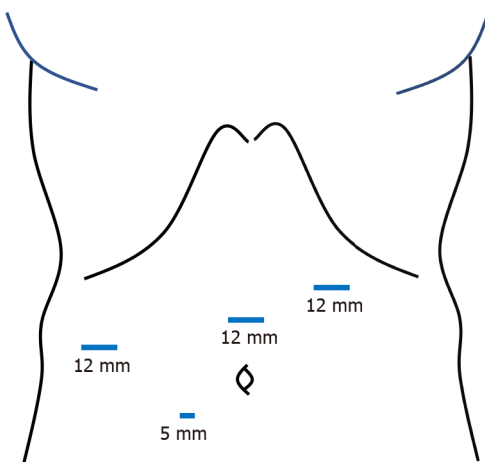


Figure 3 Scheme of trocars placement. Four trocars were inserted into the abdomen. The first 12-mm trocar was introduced in the left-upper abdomen using the open-entry technique, while avoiding adhesions between the abdominal wall and visceral organs due to the previous surgery. After pneumoperitoneum by carbon dioxide insufflation, three more trocars were inserted at the right lateral abdomen, the mid-upper abdomen (12-mm trocars for operator) and near the umbilicus (a 5-mm trocar for scopist).

DISCUSSION

Diaphragmatic hernia associated with RFA is an uncommon complication. However, diaphragmatic hernia is fatal for patients of liver cirrhosis. Therefore, it is important to recognize the risks of diaphragmatic hernia and provide prompt treatment. Twenty cases of diaphragmatic hernia due to RFA have been reported in English including our case. The background of the patients and the details of RFA are given in Table 1[8-21]. The details of diaphragmatic hernia and the treatment are presented in Table 2. The median age of the cases under study was 71 years [Interquartile range (IQR) 61-79]. There were 11 (55%) males and 9 females (45%) in the current study. The most common (13 patients, 65%) cause underlying liver diseases in patients was Hepatitis C. In the present study, 16 patients (80%) had the tumor located in S8. Diaphragmatic hernia tends to occur frequently after RFA for S8 HCC, as the location of the tumor is adjacent to the diaphragm. Physical and thermal damage to the diaphragm can result in a defect in diaphragm because of poor wound healing in patients with liver cirrhosis[22].

In most cases including ours, RFA was performed under sonographic guidance. Yamagami *et al*[12] reported that the tip of the RFA electrode is relatively difficult to detect by sonography as compared to CT while performing RFA for HCC located close to the diaphragm. According to the surgical findings, the scar on the liver caused by the first RFA was close to the hernia orifice (Figure 4D), suggesting that the first RFA had caused the diaphragmatic hernia. In only 2 out of 20 cases, RFA was performed using artificial pleural effusion, while in 18 cases (90%) RFA was performed without using artificial pleural effusion or ascites. Wang and Kao[23] have reported that the use of artificial ascites protected the abdominal wall and adjacent organs from burn injuries during RFA for HCC. Clinicians and radiologists should therefore consider the use of artificial ascites during RFA to prevent diaphragmatic heat injury. Furthermore, some studies have reported that laparoscopic RFA is also useful for

Table 1 The background and the details of radiofrequency ablation in the reported cases

Case	Ref.	Age	Sex	Underlying liver disease	Child-Pugh classification	Tumor location (size)	Guiding modality	Artificial ascites/pleural effusion	Type of needle	The number of RFA
1	Koda <i>et al</i> [8], 2003	61	F	HB	B	S6, S8 (15 mm, 10 mm, 25 mm)	Sonography	None	Expandable	2
2	Shibuya <i>et al</i> [9], 2006	72	M	AH	NA	S4/S8 (28 mm)	Sonography	None	Expandable	2
3	di Francesco <i>et al</i> [10], 2008	49	M	AH and HC	NA	S8 (54 mm)	NA	None	Cool-tip	1
4	Yamagami <i>et al</i> [12], 2011	71	F	HC	B	S7 (24 mm)	CT	None	Cool-tip	1
5	Singh <i>et al</i> [11], 2011	46	F	AH and HB	A	S2/S3, S5/S8 (17 mm, 18 mm)	Sonography	None	Cool-tip	1
6	Kim <i>et al</i> [13], 2013	61	M	AH	A	S5, S8 (13 mm, 11 mm)	Sonography	None	Cool-tip	2
7	Zhou <i>et al</i> [14], 2013	61	F	HB	NA	S8 (15 mm)	NA	NA	NA	1
8	Nakamura <i>et al</i> [15], 2014	81	M	HC	NA	S4, S8 (19 mm, 24 mm)	Sonography	None	Cool-tip	1
9	Nomura <i>et al</i> [16], 2014	62	M	HC	C	S8 (21 mm)	Sonography	None	Cool-tip	1
10	Saito <i>et al</i> [17], 2015	81	M	HC	C	S3, S5, S5/S8, S8 (NA)	NA	NA	NA	3
11	Abe <i>et al</i> [18], 2016	72	F	HC	B	S5 (NA)	NA	NA	NA	Several times
12	Nagasu <i>et al</i> [19], 2017	49	M	AH	A	S4 (17 mm)	Sonography	None	Cool-tip	Several times
13	Nagasu <i>et al</i> [19], 2017	79	F	HC	B	S8 (19 mm)	Sonography	None	Cool-tip	Several times
14	Nagasu <i>et al</i> [19], 2017	68	M	HC	C	S8 (26 mm)	CT	None	Expandable	1
15	Nagasu <i>et al</i> [19], 2017	70	F	HC	C	S6 (23 mm)	Sonography	None	Cool-tip	1
16	Nagasu <i>et al</i> [19], 2017	65	M	HC	B	S8 (21 mm)	Sonography	None	Cool-tip	1
17	Nagasu <i>et al</i> [19], 2017	76	F	HC	A	S8 (20 mm)	Sonography	None	Cool-tip	Several times
18	Morito <i>et al</i> [20], 2021	78	M	HC	NA	S6/S7, S8 (NA)	Thoracoscopic	Artificial pleural effusion	NA	2
19	Ushijima <i>et al</i> [21], 2021	82	M	HC	B	S6, S4/S5, S8 (NA)	NA	NA	NA	3
20	Current case	83	F	AIH	B	S8 (20 mm)	Sonography	Artificial pleural effusion	Expandable	2

F: Female; M: Male; RFA: Radiofrequency ablation; HB: Hepatitis B; AH: Alcoholic hepatitis; HC: Hepatitis C; AIH: Autoimmune hepatitis; HCC: Hepatocellular carcinoma; CM: Conservative management; CT: Computed tomography; OS: Open surgery; LS: Laparoscopic surgery; NA: Not available.

preventing physical injury to the diaphragm[24-26].

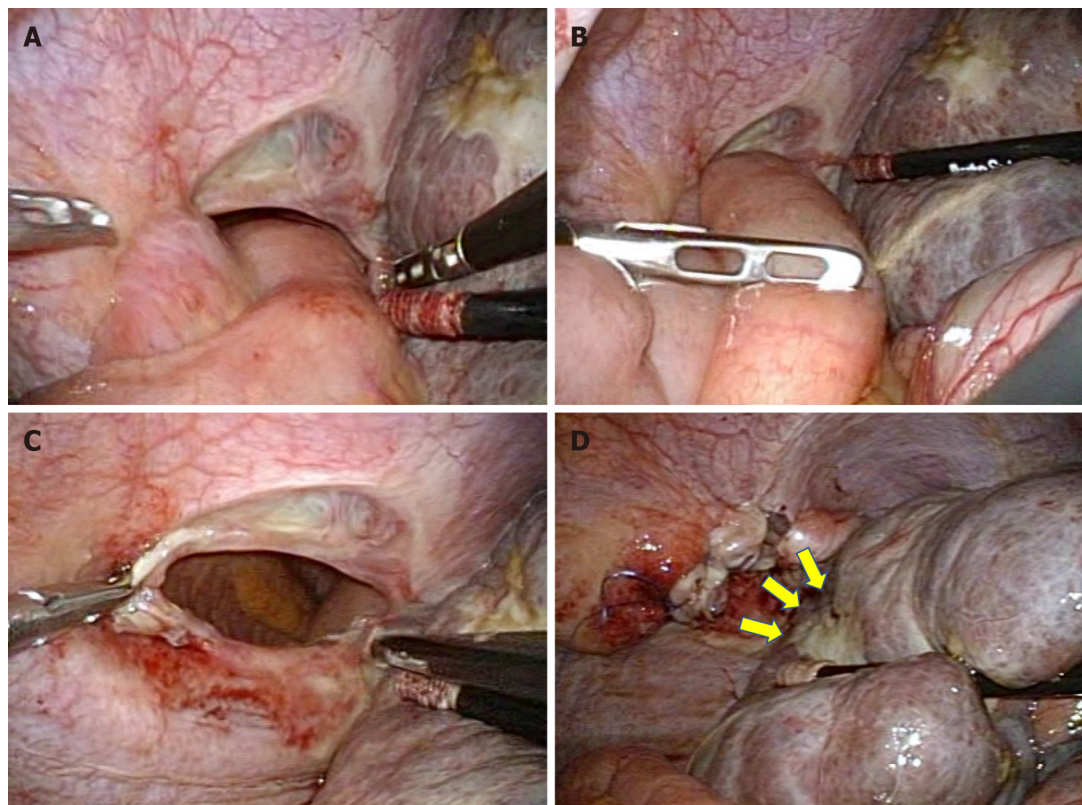
The median duration of time between occurrence of hernia and the previous RFA was 17 mo (IQR 12-25) in the current study. Diaphragmatic hernia is a late-onset complication of RFA. In the present case, diaphragmatic hernia occurred 28 mo after the final RFA. With the progression of liver atrophy, the space between the diaphragm and the liver enlarges, and intestines can move onto the liver, a

Table 2 The details of diaphragmatic hernia and the corresponding treatments in the reported cases

Case	Ref.	Times from last RFA (mo)	Symptoms	Herniated viscera	Size of hernia orifice (cm)	Necrosis of intestines	Surgical approach	Suture/mesh	Postoperative complication	Prognosis
1	Koda <i>et al</i> [8], 2003	32	Dyspnea	Colon	5	No	OS	Suture	Hemorrhage from rupture of the HCC	Died of HCC rupture
2	Shibuya <i>et al</i> [9], 2006	18	Right upper abdominal pain and dyspnea	Small intestine	NA	NA	Surgery	Suture	None	Alive
3	di Francesco <i>et al</i> [10], 2008	15	Nausea and vomiting	Small intestine	3	No	OS	Suture	None	Alive
4	Yamagami <i>et al</i> [12], 2011	36	Dyspnea	Colon	NA	No	CM	-	-	Alive
5	Singh <i>et al</i> [11], 2011	19	Right upper abdominal pain and dyspnea	Colon	5	No	LS	Non-absorbable interrupted suture	None	Alive
6	Kim <i>et al</i> [13], 2013	9	None	Mesenteric fat	2	No	CM	-	-	Alive
7	Zhou <i>et al</i> [14], 2013	12	Lower abdominal pain, nausea and vomiting	Transverse colon	4	Yes	OS	Suture	None	Alive
8	Nakamura <i>et al</i> [15], 2014	18	Right upper abdominal pain and dyspnea	Small intestine	5	Yes	OS	Non-absorbable interrupted suture	None	Alive
9	Nomura <i>et al</i> [16], 2014	96	Nausea	Right colon	4	No	LS	Non-absorbable interrupted suture	Recurrence of diaphragmatic hernia	Alive
10	Saito <i>et al</i> [17], 2015	28	Right upper abdominal pain	Small intestine	4	No	OS	Suture	Liver failure	Died of liver failure
11	Abe <i>et al</i> [18], 2016	15	Right upper abdominal pain and dyspnea	Transverse colon	10	No	OS	Non-absorbable suture	None	Alive
12	Nagasu <i>et al</i> [19], 2017	17	None	None	NA	No	OS	Interrupted suture	None	Alive
13	Nagasu <i>et al</i> [19], 2017	9	Abdominal pain	Small intestine	NA	No	OS	Interrupted suture	None	Alive
14	Nagasu <i>et al</i> [19], 2017	21	Abdominal pain	Mesenteric fat	NA	No	OS	Interrupted suture	None	Died of liver failure
15	Nagasu <i>et al</i> [19], 2017	8	Dyspnea	Colon	NA	Yes	OS	Interrupted suture	None	Died of liver failure
16	Nagasu <i>et al</i> [19], 2017	16	Abdominal pain	Colon	NA	No	OS	Interrupted suture	None	Died of liver failure
17	Nagasu <i>et al</i> [19], 2017	6	None	None	NA	No	OS	Interrupted suture	None	Alive
18	Morito <i>et al</i> [20], 2021	12	Nausea and abdominal pain	Small intestine	8	Yes	OS	Non-absorbable interrupted suture	None	Alive
19	Ushijima <i>et al</i> [21], 2021	16	Dyspnea	Transverse colon	2	No	LS	Non-absorbable suture and mesh	None	Alive

20	Current case	28	Right upper abdominal pain	Small intestine	5	No	LS	Non-absorbable running suture	None	Alive
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RFA: Radiofrequency ablation; HB: Hepatitis B; AH: Alcoholic hepatitis; HC: Hepatitis C; AIH: Autoimmune hepatitis; HCC: Hepatocellular carcinoma; CM: Conservative management; OS: Open surgery; LS: Laparoscopic surgery; NA: Not available.



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Figure 4 Surgical findings. A: The small intestine had migrated through the diaphragmatic defect and was incarcerated in the right thorax; B: The small intestine was pulled back gently into the abdominal cavity by using laparoscopic bowel-grasping forceps; C: The size of the hernia orifice was estimated to be approximately 5 cm in diameter; D: The scar on the liver resulting from the first RFA was found to be close to the hernia opening (arrowheads). The defect was repaired using synthetic non-absorbable monofilament polypropylene sutures in the running fashion.

phenomenon called Chilaiditi syndrome[27]. Clinicians should be aware of the possibility of the occurrence of delayed-onset diaphragmatic hernia after RFA.

Diaphragmatic hernia is a fatal disease that generally requires emergency surgery. However, 2 cases took conservative management because there were no symptoms of a strangulated hernia and they considered the risks of surgery[12,13]. The best surgical approach to treat diaphragmatic hernia has not been established. Liver cirrhosis is an important risk factor in surgery due to the factors, such as coagulopathy, poor nutritional status, adaptive immune dysfunction, cirrhotic cardiomyopathy, and renal and pulmonary dysfunction[28]. In 4 cases out of 20 cases, the laparoscopic approach was adopted. The laparoscopic approach is safer and more feasible than open surgery, considering the possibility of postoperative complications followed by reduced collateral circulation in the abdominal wall[16,29]. Furthermore, the laparoscopic approach is useful for securing a field of view over the surgical site, as the location of the hernia defect is deep. However, insufficient respiratory function may preclude the laparoscopic approach because of the risks of pneumoperitoneum and pneumothorax. In our case, we reduced abdominal air pressure from 8 mmHg to 6 mmHg because thoracic air pressure increased through the hernia orifice and pulmonary ventilation volume decreased.

We repaired the diaphragmatic hernia by non-absorbable running sutures. In most cases, the hernia repair was performed by non-absorbable interrupted sutures. Regardless of the suture techniques, absorbable sutures should not be used to prevent the recurrence of hernia[30]. On the other hand, we did not use a mesh owing to the possibility of HCC recurrence, as the use of a mesh patch could preclude another RFA. However, if the diaphragmatic hernia recurs without the need for bowel resection, the use of mesh should be considered.

CONCLUSION

RFA for HCC located close to the diaphragm should be performed using artificial ascites under CT guidance to prevent an injury to the diaphragm. Clinicians should also monitor patients who have undergone RFA, staying alert to the possibility of delayed-onset diaphragmatic hernia. Laparoscopic treatment of iatrogenic diaphragmatic hernia is effective and minimally invasive.

FOOTNOTES

Author contributions: Tsunoda J interpreted the patient data based on the case notes and drafted the manuscript; Nishi T performed the surgery and supervised the manuscript; all other members equally contributed to the medical treatment.

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