Artificial ascites assisted microwave ablation for liver cancer adjacent to the diaphragm and perioperative nursing care

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Abstract

Background

To investigate the feasibility and effectiveness of artificial ascites assisted microwave ablation (MWA) in the treatment of liver cancer near the deep diaphragm and the importance of perioperative nursing.

Methods

A retrospective analysis was performed on patients who received MWA assisted by artificial ascites for liver cancer adjacent to the deep diaphragm from January 2016 to December 2022. Normal saline was used as artificial ascites to protect the deep diaphragm during MWA. The success rate of the procedure, the incidence of major complications, the technical efficacy of ablation, and the local tumor progression were recorded.

Results

A total of 62 lesions in 54 patients were enrolled, including 44 males and 10 females, with an average age of 55.64 ± 10.33 years. The ultrasound image quality scores of liver cancer before and after ascites were 3.57 ± 0.79 and 4.89 ± 0.33, respectively. The difference between the two groups was statistically significant ($t = 16.324$, $P < 0.05$). There was no injury to the diaphragm, no burn to the skin at the puncture site, and no abdominal hemorrhage. 1 patient developed a right pleural effusion, which was not drained. The complete ablation rate was 94.4% (51/54) at 1 month after ablation. Three patients had recurrence and were treated with MWA again. The patients in this study were followed up for 12 to 45 months, with a median follow-up time of 21 months. The local tumor progression rate was 5.6% (3/54).

Conclusion

MWA assisted by artificial ascites is a safe and effective treatment for liver cancer near the deep diaphragm. Systematic nursing measures are of great significance for the rapid recovery of patients and the success rate of surgery.

Induction

Liver cancer is the fourth leading cause of death worldwide, with approximately half of the cases occurring in China[1, 2]. Abdominal surgery, liver transplantation, and local thermal ablation are commonly used methods for treating liver cancer[3, 4]. Thermal ablation utilizes energy such as radio frequency, microwave, or laser to generate high temperatures and destroy tumor tissue for therapeutic purposes[5]. Compared to radio frequency and laser ablation, microwave ablation (MWA) can heat tissue more rapidly, reaching higher temperatures, and thus more quickly destroying tumor cells. MWA has a smaller thermal deposition effect on blood vessels and bile ducts, which means it is safer when treating tumors close to these structures, reducing damage to surrounding tissues. Additionally, microwaves can penetrate tissues more effectively and deliver energy to greater depths, making it more effective in treating deeper-seated tumors[6, 7].

However, for lesions adjacent to the deep diaphragm muscle, some lesions may be difficult to visualize due to the influence of gas in the lungs, posing challenges for ablation[8]. Furthermore, the heat generated during ablation can affect the diaphragm muscle and potentially cause damage[9]. Therefore, when performing MWA for liver cancer adjacent to the deep diaphragm muscle under ultrasound guidance, issues such as the quality of the ultrasound images and diaphragm muscle protection need to be addressed.

To protect the diaphragm muscle from thermal injury, an artificial ascites injected into the perihepatic peritoneal space can be used as a heat barrier to separate the ablation zone from the diaphragm[10, 11]. This study aims to retrospectively analyze the safety and effectiveness of artificial ascites-assisted MWA for liver cancer adjacent to the deep diaphragm muscle, as well as perioperative nursing measures to ensure the safety of the procedure and reduce the occurrence of complications.

Materials and methods

Trial design

The study has been approved by the Ethics Committee of our institution and strictly adheres to the ethical guidelines of the Helsinki Declaration. We selected liver cancer patients who received artificial ascites-assisted MWA treatment near the diaphragm at Hangzhou Xixi Hospital from January 2016 to December 2022 as the study subjects. All patients or their guardians have signed informed consent forms.

Inclusion criteria: Clinical diagnosis of liver cancer that meets the Milan criteria or histopathological confirmation through preoperative puncture biopsy; tumor located within 1cm of the diaphragm, with a single lesion diameter not exceeding 5cm or multiple lesions (≤ 3) with each individual lesion diameter not exceeding 3cm; Child-Pugh class A or B.

Exclusion criteria: Presence of major vascular invasion and/or distant metastasis; Patients who were not regularly followed up after surgery or lost to follow-up will be excluded from the study.

Artificial ascites technique

The location of the tumor is first assessed and the tumor is shown with clarity by ultrasound. Then, using a single cavity central venous catheter set, 5ml of 0.9% sodium chloride solution was drawn and the guide wire was pre-placed into the empty needle tube. Under the guidance of ultrasound, the needle tip was slowly inserted parallel to the liver surface, and the puncture point was located near the gall bladder at the lower margin of the right anterior lobe of the liver. When the resistance suddenly decreases, 0.9% sodium chloride solution is injected, and if there is no resistance, the wire is quickly deduced into the abdominal cavity, and then the needle is withdrawn and the drainage tube is placed along the guide wire. During the operation, the patient kept his head low and his feet high, and continued to instillate 0.9% sodium chloride solution at 40℃ into the abdominal cavity until the separation distance between the liver and the diaphragm was ≥ 0.5cm.

Ablation procedure

Esaote MyLab 90 (Paraxen, Italy) color doppler ultrasound was used, equipped with contrast-enhanced ultrasound function, abdominal convex array probes CA431 and CA541, frequency range from 1 to 8MHz. MWA was performed using KY-2000 MWA instrument (Kangyou, Nanjing, China). After the establishment of artificial ascites, ultrasound guided MWA was performed. All patients underwent general anesthesia and the procedure was performed according to the ablation plan determined preoperatively: the ablation power was set at 60W, the size of the ablation area was approximately 3.5 cm ×2.5 cm, and the ablation time at each point was 6 minutes. Tumors with a diameter of less than 2 cm were ablated with a single needle and a single point, while tumors with a diameter of 2 to 5 cm were ablated with a single needle and multiple points or double needles and multiple points overlapping. Ablation was required to extend 0.5 cm beyond the tumor margin to ensure a safe margin. Immediately after ablation, contrast-enhanced ultrasound assessment was performed to determine whether the ablation zone reached the safe boundary. If the safe boundary was reached, the ablation was terminated; otherwise, additional ablation was performed immediately until the safe boundary was reached.

Tumor image quality score

The clarity of liver cancer was assessed by scoring the ultrasound images obtained before and after artificial ascites. The scores were independently assessed by three radiologists with more than 10 years of experience. Each ultrasound image was scored, and the average value was used as the final score. The scoring criteria were as follows: 1 point: The lesion was affected by gas in the lung and could not be visualized. Score 2: the displayed portion was less than 1/3 of the lesion. Score 3: The displayed portion was between 1/3 and 2/3 of the lesion. Score 4: the displayed portion was larger than 2/3 of the lesion. Score 5: complete and clear visualization of the lesion. This scoring system can help physicians evaluate the quality and clarity of ultrasound images of liver cancer to guide subsequent treatment and decision making.

Perioperative nursing

Preoperative nursing means that nurses explain the purpose, methods, advantages, surgical process, precautions and possible complications of MWA to patients and their families in detail, so as to eliminate the anxiety and tension of patients. Routine preoperative care.

During the operation, firstly, the venous access was established to assist the patient to choose the supine or lateral position according to the location of the lesion. Test equipment operation, check whether the connecting instrument pipeline is smooth. Assist the doctor to operate the MWA instrument, closely observe the ECG monitoring, bleeding, heart rate increase, slow down, dyspnea and other reactions.

Postoperative care included the patient's vital signs and clinical symptoms were monitored for the first 72 hours after ablation to detect any early complications such as fever, swelling, pain, bleeding, etc. In particular, severe complications, which may result in significant morbidity and disability, require an increased level of care, hospitalization, or a significantly prolonged hospital stay.

The above nursing measures for MWA before, during and after operation are designed to ensure the smooth operation and promote the recovery of patients. Nurses should closely observe the changes of patients' condition during the whole process and communicate with doctors in time to ensure the safety and comfort of patients.

Complications

Pain and fever are common mild complications after ablation, and even pleural effusion may occur. Burns and even perforations of the diaphragm, gastrointestinal injuries, severe bleeding, and stress ulcers require further treatment. In particular, severe complications that may lead to significant morbidity and disability require increased levels of care, hospitalization, or significantly prolonged hospital stays.

Follow-up

Patients with complications will be managed accordingly, while those without serious complications will be discharged 3–7 days after surgery. Contrast-enhanced MRI or contrast-enhanced CT was performed at 1 month after ablation to evaluate the short-term efficacy of MWA. Complete ablation was defined if the ablation completely covered the lesion without abnormal enhancement. The ablation was defined as incomplete ablation if it did not completely cover the lesion and there was neoplastic enhancement. If residual lesions are present, repeat thermal ablation or surgical resection may be required. Subsequently, contrast-enhanced MRI or contrast-enhanced CT was performed every 3–6 months to assess local tumor progression, and technical efficacy and local tumor progression (LTP) were recorded.

Statistical analysis

Data analysis and mapping were performed using the R software (Version 3.5.3). Patient age, tumor size and sonographic quality score were used as measurement data, expressed as mean ± SD, and t test was used for comparison between groups. The number of cases of adverse reactions and complications, the number of cases of tumor complete ablation and the number of cases of local tumor progression were counted as the count data, expressed as cases (%). The chi-square test or Fisher test was used for comparison between groups. $P < 0.05$ was considered statistically significant.

Results

Baseline characteristics

A total of 62 lesions in 54 patients were included in this study, and all patients underwent percutaneous MWA. There were 44 males and 10 females, aged from 35 to 82 years, with an average age of 55.64 ± 10.33 years. 46 of these patients had only one lesion, whereas 8 patients had two lesions. Of these patients, 39 were treated for the first time, whereas 15 were recurrent (7 had prior surgical resection and 8 had prior thermal ablation). The size of the tumors ranged from 14 to 49 mm, with a mean size of 29.43 ± 7.47 mm, Table 1.

Table 1
Clinical information of patients and characteristics of Liver cancer [n, %]

Characteristic	Liver cancer (n = 54)	*P* value
Age (year)	55.64 ± 10.33	
Sex		
Male	44(81.5)	
Female	10(18.5)	
Number of lesions		
Single	46(85.2)	
Multiple	8(14.8)	
Treatment mode		
First	39(72.2)	
Once more	13(17.8)	
Tumor size (mm)	31.64 ± 8.37	
Image score		
Before	3.57 ± 0.79	<0.05
After	4.89 ± 0.33	
Artificial ascites dosage (ml)		
Max	500	
Minimum	2000	
Average	1021 ± 544	
Ablation completion rate	51(94.4)	
Complication		
Diaphragmatic injury	0	
Hematoma	0	
Pleural effusion	1(2.0)	
Fever	11(20.4)	
Pain	12(22.2)	

Ultrasonic image evaluation

The score of ultrasonographic image quality before artificial ascites was 3.57 ± 0.79, while the score of ultrasonographic image quality after artificial ascites was 4.89 ± 0.33. The difference between the two groups was statistically significant (t = 16.324, $P < 0.05$). It means that the quality of lesion image was significantly improved after artificial ascites treatment, Fig. 1.

The amount of artificial ascites

Artificial ascites successfully separated the diaphragm from the liver at a distance of ≥ 0.5 cm in all 54 patients. The average dosage of 0.9% sodium chloride solution was (1021 ± 544)ml (range, 500–2000 ml).

Microwave ablation

Among the 62 lesions, 45 cases were ablated with single needle and single point, and 17 cases were ablated with single needle and multiple points or double needle and multiple points overlapping. In 13 cases, the ablation range was insufficient, and additional ablation was performed immediately until the safe boundary was reached.

Complications

There were no treatment-related deaths or cardiopulmonary complications due to fluid overload. No diuretics or punctures were required to manage any of the patients infused with artificial ascites. The ascites was completely absorbed before the patient was discharged.

There was no injury to the diaphragm, no burn to the skin at the puncture site, and no abdominal hemorrhage. One patient developed a right pleural effusion, which was not drained.

The most common minor complications after ablation were pain and fever. 11 patients developed fever after treatment and were treated with antipyretics. 12 patients required analgesics after treatment.

Efficacy

Enhanced MRI or enhanced CT examination was performed within 1 month after ablation, and the complete ablation rate was 94.4% (51/54). Three patients had a recurrence and were subsequently treated with ultrasound-guided MWA. The patients in this study were followed up for 12 to 48 months after surgery, with a median follow-up of 20 months. According to the results of enhanced MRI or enhanced CT examination, the local tumor progression rate was 5.6% (3/54).

Discussion

MWA can effectively control and eliminate liver cancer lesions[12]. The patient's normal liver tissue was preserved to the greatest extent and the impact on liver function was reduced[13]. Artificial ascites technique can separate the diaphragm from the liver, which can not only improve the image quality of liver cancer ablation near the diaphragm, but also reduce the thermal damage of the diaphragm caused by microwave energy. Perioperative high quality nursing can improve the safety and therapeutic effect of MWA. Therefore, safe and effective treatment methods and systematic nursing measures are of great significance for the rapid recovery of patients and the success rate of surgery.

Artificial ascites can improve the visualization of the adjacent deep diaphragmatic muscle lesions. Artificial ascites increases the distance between the lesion and the lung by separating the liver from the diaphragm and reduces the interference of gas in the lung, thereby improving the quality of the sonographic image of the lesion[14, 15]. In this study, the quality scores of tumor ultrasonographic images before and after artificial ascites were established. It showed that the quality of ultrasonographic images could be significantly improved after artificial ascites, which improved the clarity and integrity of the tumor adjacent to the top of the diaphragm, thus improving the accuracy of puncture and ablation, and increasing the confidence of the operator.

The thermal barrier formed by artificial ascites can reduce the thermal damage of the diaphragm during ablation[16]. None of the patients in this study had diaphragmatic injury after ablation. Huang[14] et al. evaluated the feasibility and effectiveness of thermal ablation of liver cancer adjacent to the gastrointestinal tract in patients with previous abdominal surgery assisted by artificial ascites. Artificial ascites was successfully used in 38 out of 40 operations (95% success rate), and the surrounding organs were effectively protected. However, the use of artificial ascites may be limited by abdominal adhesions, which prevent the separation of fluid from the patient's gastrointestinal tissue, especially in patients with a history of previous abdominal surgery. None of the cases in this study showed any radiographic evidence of diaphragmatic injury on postoperative review, and no abnormalities such as perforation were found during follow-up, suggesting that the artificial ascites played a protective isolating role.

In the present study, only one patient developed a small pleural effusion that was not treated with drainage. In this patient, the lesion was large and tightly connected to the diaphragm, along with a history of surgery and the presence of visceral adhesions. Injecting too much ascites may lead to the occurrence of pleural effusion, and may also be related to indirect stimulation of the diaphragm and lung after the heat of ascites heats up[17].

Mild adverse effects such as low fever and epigastric pain are common after ablation of liver cancer, and generally do not require special treatment, and these symptoms will disappear on their own[18]. Artificial ascites infusion can even reduce the pain during subcapsular radiofrequency ablation of hepatocellular carcinoma[19].

Studies have shown that failure to reach the safe boundary of liver cancer ablation is an important factor for postoperative local tumor progression [20]. In all cases in our study, contrast-enhanced ultrasonography was used during ablation to assess immediate efficacy, and in patients with inadequate ablation, additional ablation was performed immediately during the procedure until a safe margin was reached. One month after operation, the complete ablation rate was 94.4% (51/54), which was similar to the previous reports on thermal ablation for liver cancer adjacent to the diaphragm[21].

Perioperative nursing mainly includes comprehensive nursing of patients' psychological, physiological and social background, and nursing throughout the whole operation process to ensure that patients receive comprehensive nursing and satisfactory treatment effect[22]. Strengthening preoperative education can relieve patients' anxiety and improve their surgical compliance. Nursing staff should be proficient in the knowledge and treatment procedures related to ablation technology, and formulate relevant nursing process plans. The patient's condition should be closely observed after operation, and relevant treatment measures should be taken in cooperation with the doctor to ensure the smooth progress of all aspects of the operation[23]. Safe and effective treatment methods and systematic nursing measures are of great significance for the rapid recovery of patients and the success rate of surgery[24].

This study has the following limitations: First, this study is a retrospective study with a small sample of included cases; therefore, prospective, large-sample studies are needed to prove the safety and efficacy of artificial ascites in liver cancer ablation. Second, the tumor sonographic quality score in this study was subjective and related to the experience of the operator.

Conclusion

In conclusion, artificial ascites can not only improve the clarity of the lesion sonography, but also try to avoid the heat burn of the diaphragm by thermal ablation, so as to reduce the occurrence of complications. Perioperative high quality nursing can improve the accuracy and safety of MWA treatment, so as to improve the therapeutic effect.

Abbreviations

Microwave ablation = MWA

Local tumor progression = LTP

Declarations

Availability of data and materials

All data generated or analysed during this study are included in this published article.

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Contributions

QQ.A., YH.P. and DL.L. contributed to the data curation, analysis, investigation and writing of the manuscript. F.L., ZX.K. and DL.L. performed and analysed the ultrasonography examinations and operation of the patients. QQ.A. and X.Z. also reviewed, edited the writing and validated the whole analysis process. All authors read and approved the final manuscript.

Ethics declarations

Ethics approval and consent to participate

This study was conducted according to the “Declaration of Helsinki”. Ethics approval is obtained from the medical ethics committee of Hangzhou Xixi Hospital and written informed consent was obtained from all patients.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no conflict of interest.

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Figures

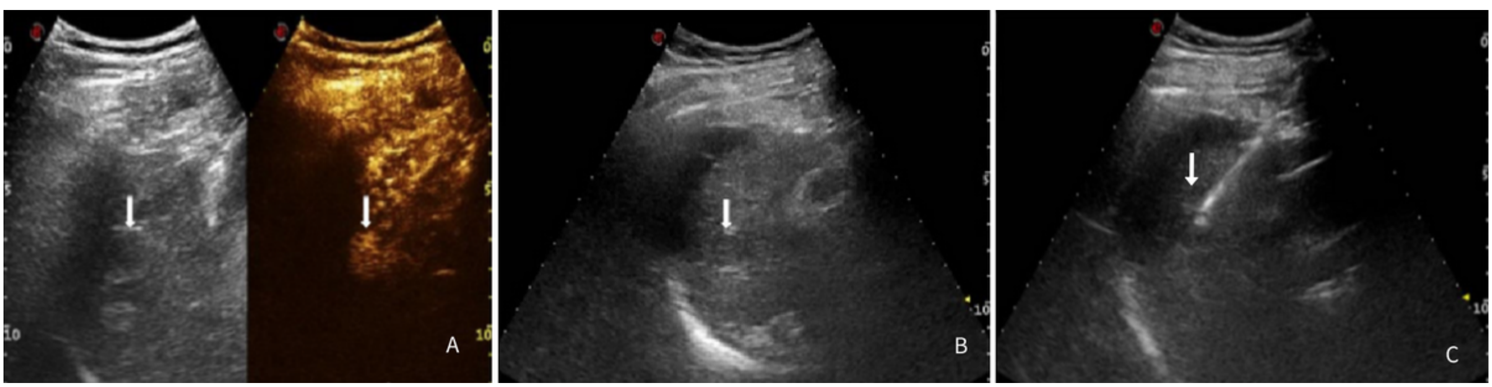

Figure 1

Microwave ablation of liver cancer was performed after artificial ascites

A 67-year-old man presented with an ultrasound image of a liver cancer in the right liver adjacent to the dome of the diaphragm. A shows that the liver cancer could not be clearly displayed by conventional ultrasound, and the lesion could not be completely visualized by CEUS (the arrow indicates the location of the tumor). B, artificial ascites was established during microwave ablation, and the outline of the lesion was clearly visible (hypoechoic nodules indicated by arrows). C shows ultrasound-guided microwave ablation, with precise needle placement during the operation to complete the microwave ablation treatment (hypoechoic nodules indicated by arrows).