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RESEARCH

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A novel and effective strategy for the treatment of large hepatic hemangioma: combining preoperative embolization with laparoscopic-assisted and ultrasound-guided ablation

Xin Jin[1†], Ziman Zhu[1†], Wei Zhao[1], Liyuan Sun[1], Bin Hu[1], Hongbo Huan[1], Yuliang Tu[1], Dadong Wang[1] and Kai Jiang[1*]

Abstract

Background Hepatic hemangioma is the most common benign liver tumor. This study aims to evaluate the feasibility, safety and efficacy of Trans-arterial embolization (TAE) combined with thermal ablation in the treatment of large hepatic hemangioma (> 5 cm).

Methods From January 2018 to December 2021, 82 patients and 112 large HH with a maximum mean diameter of 8.24 ± 0.26 cm (range: 4.3–16.0 cm) and a cumulative diameter of 9.45 ± 0.45 cm (range:5.0–29.6 cm) were treated with laparoscopic-assisted and ultrasound (US)-guided percutaneous radiofrequency ablation (RFA) or microwave ablation (MWA) during a single general anesthesia episode following TAE. After surgery, therapeutic efficacy was assessed by contrast-enhanced imagings during follow-up. Median follow-up time was 14 months (range: 2–48 months).

Results All patients have a mean operating time of 79.10 ± 2.59 min. The plain CT revealed that 112 treated lesions were totally covered (100%). Hemoglobinuria was detected in 28 patients (34.1%), and there were no cases of acute renal failure. Abdominal pain occurred in 40 patients (48.8%), while peritoneal effusion in six (7.3%). Acute cholecystitis developed in 11 patients (13.4%), constipation in five (6.1%), and nausea and vomiting in 14 (17.1%). According to the Clavien–Dindo classification, 54 patients (65.9%) had minor complications, while none had severe complications. The follow-up, no Hepatic hemangioma growth was observed.

Conclusion Preoperative TAE combined with thermal ablation is a novel therapeutic strategy for large HH. This strategy is simple, less risky, and feasible.

Keywords Hepatic hemangioma, Trans-arterial embolization, Radiofrequency ablation, Microwave ablation, Ultrasound-guided, Laparoscope, Safety

†Xin Jin and Ziman Zhu contributed equally to this article.

*Correspondence:
Kai Jiang
jiangk301@126.com

Introduction

Hepatic hemangiomas (HH) are mesodermal tumors composed of blood-filled spaces, supplied by the hepatic artery, and lined by a single layer of flat endothelial cells [1, 2]. In their early stages, the vast majority of HH are asymptomatic, do not interfere with patients' normal lives, and can be followed without surgical resection. As the tumor continues to grow and further compresses the gastrointestinal tract, diaphragm, and heart, certain patients may experience symptoms like abdominal pain, maldigestion, jaundice, thrombocytopenia, and even spontaneous rupture [3–5].

Surgical resection, trans-arterial embolization, radiation therapy, and thermal ablation are the most common treatments for HH [6]. Surgical resection is regarded as a classical and effective treatment for HH, and it can be classified based on the surgical approach into three types: open resection, laparoscopic resection, and robotic resection. According to the literature, minimally invasive resection is more effective than open resection, although both procedures are associated with a high risk of surgical bleeding and postoperative complications. Unfortunately, surgical resection complications have an incidence rate of up to 27% and a mortality rate of 9% [6–14].

Thermal ablation for HH is classified into two types: radiofrequency ablation (RFA) and microwave ablation (MWA). The ablation can be performed via a percutaneous, laparoscopic, or laparotomy approach and guided by ultrasonography or computed tomography (CT). As the diameter and number of HH increase, patients may require a longer ablation time, more electrode punctures, higher energy, and more power, increasing the risks of severe intraoperative and postoperative hemoglobinuria, hemolytic jaundice, acute liver failure, renal failure, and organ injury. The significance and impact of thermal ablation in the treatment of HH are still controversial, particularly in patients with giant HH (> 10 cm) [6, 15–17]. Giant HH contains a large volume of blood and requires a relatively longer ablation time, resulting in sudden and massive fatal hemolysis [18, 19]. Therefore, it is feasible to safely and effectively reduce the blood flow to HH prior to thermal ablation.

Trans-arterial embolization (TAE) achieves ischemic necrosis of HH, further reduces tumor volume, and relieves clinical symptoms by embolizing HH blood vessels and injecting pingyangmycin and bleomycin into the tumor. However, extensive collateral circulation usually develops around the tumor and, hence, the tumor continues to grow several years after treatment. Therefore, TAE is regarded as a means of relieving HH symptoms rather than a cure [20–25].

Regardless of the treatment method, the most challenging aspect in treating symptomatic giant HH is limiting its blood supply. Therefore, we believe that the main treatment principle is to safely and feasibly control the volume of blood flowing into the tumor. CT-guided RFA of large HH following TAE has been reported to have good therapeutic effects [20, 24]. Therefore, we developed a new combined treatment strategy in which patients underwent super-selective embolization of the feeding artery by TAE first, followed shortly by thermal ablation of the HH guided by ultrasonography and laparoscopy for localization under general anesthesia.

Patients and methods

The study included 82 patients (65 females and 17 males) who underwent laparoscopic-assisted and ultrasound (US)-guided percutaneous thermal ablation (RFA + MWA) following TAE from January 2018 to December 2021. All procedures, including both percutaneous and laparoscopic-assisted thermal ablation components, were performed during a single general anesthesia episode. As shown in Table 1, the patients had a median age of 47.5 years (range: 28–65 years) and 112 large HH with a maximum mean diameter of 8.24 ± 0.26 cm (range: 4.3–16.0

Table 1 Preoperative baseline characteristics of patients and hepatic hemangiomas

Variables	No./%
Patients (No.)	82
Mediate age (years, Range)	47.5 (28,65)
Male/Female (No.)	65 (79.3%)
Male	17 (20.7%)
Clinical presentation	
Rapid enlargement	73 (89.0%)
Abdominal pain or discomfort	9 (11.0%)
Maximum diameter of tumor (cm)	8.24 ± 0.26
Cumulative maximum diameter (cm)	9.45 ± 0.45
Range (cm)	3.0, 29.6
Number (1/2/3)	59 (72.0%)/16(19.5%)/7(8.5%)
Tumor size	
≧ 5 cm and < 10 cm (%)	56 (62.9%)
≧ 10 cm and < 15 cm (%)	18 (20.2%)
≧ 15 cm (%)	8 (9.0%)
Single	59 (72.0%)
Multiple	23 (28.0%)
Method of ablation	
RFA	49 (39.2%)
MWA	30 (24.0%)
MWA + LC	3 (2.4%)

RFA Radiofrequency ablation, *MWA* Microwave ablation, *BMI* Body mass index, *ASA* American Society of Anesthesiologists, *Hb* Hemoglobin, *ALT* Alanine aminotransferase, *AST* Aspartate aminotransferase, *TBIL* Total bilirubin, a Continuous variables are reported as the median and interquartile range. Categorical variables are presented as number with percentage cm) and a cumulative diameter of 9.45 ± 0.45 cm (range: 5.0–29.6 cm).

Inclusion criteria were as follows: (1) a definitive diagnosis of large HH (> 5 cm) with an enlargement tendency based on CT or magnetic resonance imaging (MRI) typical enhancement patterns; and (2) the presence of clinical symptoms caused by HH, such as abdominal pain, nausea, vomiting, abdominal bloating, and anemia, with other causes ruled out. All patients refused resection operation during the same course of ablation. This study was conducted in accordance with the World Medical Association Declaration of Helsinki and IRB approved by the Ethics Committee of the Fourth Medical Center of the Chinese PLA General Hospital(Grant No.2022 KY068-KS001). All patients provided written informed consent.

Preoperative TAE procedure

Following skin preparation, the right femoral artery was successfully punctured using the Seldinger technique under local anesthesia. After the placement of a 5-French catheter (Cook, Bloomington, IN) for abdominal and superior mesenteric arteriography, the hepatic artery was catheterized. After confirming the HH feeding arteries, a 3-French microcatheter (Microferret 1, Cook) was used to perform super-selective catheterization of the tumor feeding artery. Branches of the feeding artery of HH were super-selected using a set of TERUMO MC-PE271 peripheral microcatheters and micro guidewires. The feeding artery of HH was embolized with lipiodol emulsion until it was occluded. Finally, the tumor feeding artery was embolized with gelfoam particles until its branches were occluded.

All patients received intravenous hepatoprotective therapy (magnesium isoglycyrrhizinate (100–200 mg in 250 mL 10% glucose) for 3 days post-TAE, adjusted for liver function tests. Furthermore, short-term glucocorticoids were given to patients who developed abdominal pain and fever. However, antibiotics were not routinely given unless there was an obvious source of infection. Patients underwent a plain abdominal CT scan 2–4 days following intervention to assess the embolization effect. Thermal ablation should be conducted as soon as possible for patients who have no contraindications to surgery.

Ultrasound-guided radiofrequency ablation procedure

The radiofrequency ablation (RFA) procedures were performed within an interval of 2–30 days after TAE, utilizing two distinct approaches(Ultrasound-guided percutaneous RFA,Laparoscopic-assisted RFA).All thermal ablation procedures were performed by a surgeon with 20 years of ablation experience. Following general anesthesia, the optimal puncture site was determined using a percutaneous approach guided by ultrasonography. The radiofrequency electrode (Covidien llc, Co, USA) was placed in the target HH via a percutaneous transhepatic approach. Radiofrequency ablation was performed as anticipated after the optimal electrode position was determined. The Cool-tip™ radiofrequency ablation system (Covidien llc, Co, USA) was used with US guidance. The energy feedback system automatically adjusted the RF impedance, and cooling water was injected through an external pump loop (Covidien llc, Co, USA) to maintain the electrode tip temperature below 20 °C. The Cool-tip™ RFA system was used for 6 min with an initial power of 90 W, and the maximum energy was adjusted to 200 W by an automatic balancing system. For any significant color difference between the affected liver area and the surrounding normal tissue, a cluster RF electrode with a cooled, 2.5 cm active tip (Covidien llc, Co, USA) was used for 12–24 min of ablation with maximum energy output, until complete ablation was confirmed.

To ensure a safe and feasible ablation of HH, RFA was performed strictly according to the following protocol: (1) To prevent bleeding, the radiofrequency electrode was advanced through the percutaneous transhepatic approach, and the probe went through the liver parenchyma; (2) Ablation was performed starting from the area with rich lipiodol deposition in HH to prevent the entry of blood flow into the tumor artery; (3) The overlapping ablation range was maintained by cross-placing double electrodes in multiple sections of the tumor to ensure complete tumor ablation and needle tract coagulation.

Microwave device and ablation technique

The microwave (MW) system with a frequency of 2450 MHz (KY-2000, Canyou Medical, China) was used. It is made up of two independent MW generators, two flexible coaxial cables, and two water pumps that can simultaneously drive two cooled-shaft antennas with a 15-gage diameter (2.2 cm antenna tip). The two MW generators can output a power range of 1–100 watts. The MWA procedure followed the same protocols as the RFA procedure.

Laparoscopic-assisted thermal ablation

A midline incision was made at the midpoint just below the umbilicus. A 12 mm trocar was inserted and the laparoscope was placed into the incision. Three further incisions were made below the xiphoid process at the midclavicular line on both sides to allow for the insertion of an aspirator and other supporting devices. Laparoscopy was used to assess the ablation range and ablate the residual tumor under direct vision until complete shrinkage and separation from adjacent structures, including the gallbladder, stomach, and colon, and promote intraoperative hemostasis.

Efficacy evaluation and follow-up care

Following therapy, contrast-enhanced imaging data were used to evaluate efficacy evaluation and follow-up. The technique was considered effective if the ablation area covered 90% to 100% of the HH volume based on a plain CT conducted 2–7 days after ablation. The goal is to minimize the risk of complications while reducing the HH volume. Clinical efficacy was defined as symptom improvement during the follow-up period. Complications were classified by outcome according to the complication classification system of the Society of Interventional Radiology [25]. [26] For all patients, the follow-up period was determined from the day of thermal ablation. Contrast-enhanced CT or MRI scans were performed at one month and every three months for the first year following ablation, and then every six months for the second year.

Statistical analysis

The data were analyzed using the Statistical Package for the Social Sciences (SPSS) for Windows, version 26 (SPSS IBM Inc., Chicago, IL, USA). Continuous data were expressed as mean and standard deviation (SD). The mean values were compared between the two groups using the paired t-test. A p-value of less than 0.05 was established as the level of statistical significance.

Results

In this study, all 82 patients were successfully treated with TAE combined with thermal ablation. The procedure was 100% feasible. During digital subtraction angiography (DSA), we found that HH was supplied by the right hepatic artery in 49 patients, the left hepatic artery in four, both the right and left hepatic arteries in 18, the superior mesenteric artery in three, and both right and left hepatic arteries as well as the right inferior phrenic artery in one, while the intervention data were incomplete in seven patients. Thermal ablation was performed after a mean of 5.02 ±5.1 days (median: 4 days; range: 1–30 days) of intervention. After receiving the invention and being discharged, four patients were re-admitted to receive thermal ablation for personal reasons. In these four cases, the time from intervention to ablation was 30, 28, 24, and 14 days. After intervention, one patient developed venous thrombosis in the lower extremities and underwent MWA 11 days after the anticoagulant therapy, with no other complications, and was discharged 6 days after surgery. As shown in Tables 1 and 2, 49 patients (39.2%) received RFA, 30 (24.0%) received MWA, and three (2.4%) underwent MWA combined with laparoscopic cholecystectomy for complicated gallstones.

Table 2 Embolization outcome

Variables	No./%
Vascularization from RHA only	49 (59.7%)
Vascularization from LHA only	4 (4.9%)
Vascularization from RHA + LHA	18 (22.0%)
Vascularization from RHA + LHA + RPA	1 (1.2%)
Vascularization from SMA	3 (3.7%)
Vascularization from vein	7 (8.5%)
Complication	
lower extremity venous thrombosis	1
Time from embolization to surgery (days)*	5.02 ± 5.1 mediate 4

RHA Right hepatic artery, *LHA* Left hepatic artery, *RPA* Right Phrenic Artery, *SMA* Superior Mesenteric Artery

Values expressed as mean ± SD

All patients have a mean operating time of 79.10 ± 2.59 min (range: 35–134 min). The plain CT of the abdomen conducted several days after ablation revealed that 112 treated lesions were totally covered (100%). During the follow-up period, the ablation area steadily shrank (Fig. 1). The median follow-up duration was 14 months (range: 2–48 months). The HH treatment technique was successful and clinically feasible in 82 patients (100%) where abdominal pain and nausea were totally relieved and abdominal bloating was improved after surgery.

After surgery, all patients were able to promptly resume their preoperative level of activity. There were no severe complications and HH growth during the perioperative or the follow-up period following ablation, such as acute renal failure, liver abscess, bile duct injury, gastrointestinal perforation, embolization, or bleeding. However, minor complications, including fever, transient elevation of transaminases, pleural effusion, and hemoglobinuria, were developed. After surgery, eight patients developed fever, while 32 developed pleural effusion that did not require drainage. Hemoglobinuria was detected in the urinary catheters of 28 patients (34.1%), and after being alkalinized and hydrated, the urine gradually returned to normal color. There were no cases of acute renal failure. Abdominal pain occurred in 40 patients (48.8%), while peritoneal effusion developed only in six (7.3%). Furthermore, acute cholecystitis developed in 11 patients (13.4%), constipation in five (6.1%), and nausea and vomiting in 14 (17.1%). According to the Clavien–Dindo classification, 54 patients (65.9%) had minor complications, while none had severe complications.

In most patients, liver function tests revealed a transient elevation of transaminases. The post-interventional white blood cell count (WBC) as well as alanine

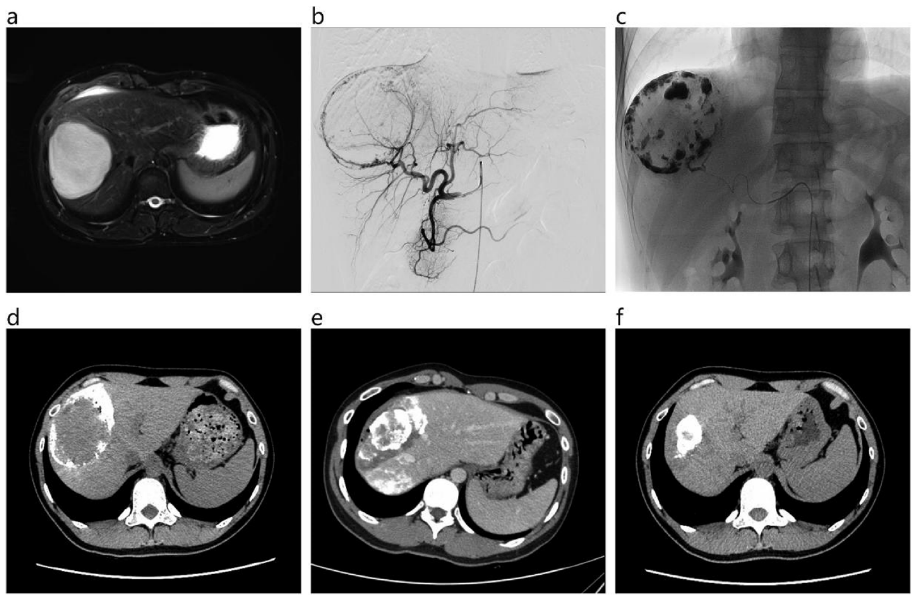

Fig. 1 A 28-year-old man presented with a hepatic hemangioma and rapidly enlarged for 2 years. The size of the HH in the S8 segment was about 88.8*71.3 mm in the preoperative MRI (**A**). DSA shows the right hepatic artery supplying blood, which was embolized with lipiodol combined with gelatin sponge (**B**, **C**). Four days after intervention, abdominal CT showed lipiodol deposition in the arterial supply of the HH border (**D**). CT showed complete ablation of HH after RFA (**E**). 4 months after surgery, HH can be seen shrinking to about 50*40 mm (**F**)

aminotransferase (ALT), aspartate aminotransferase (AST), total bilirubin, and serum creatinine levels all differed significantly from their preoperative levels; however, the post-interventional hemoglobin level and platelet count did not. The post-ablation WBC and platelet counts, as well as hemoglobin, ALT, AST, and total bilirubin levels, differed significantly from their post-intervention values, while the post-ablation serum creatinine level did not (Tables 3 and 4).

Discussion

The thermal ablation technique uses heat to destroy the vascular network within the HH. When exposed to temperatures above 49 °C, red blood cells begin to burst and fragment. Complications such as hemolysis, hemoglobinuria, and acute kidney injury are more likely to occur when the temperature around the ablation electrode rises and the ablation time is extended [17, 27, 28].

There are currently a number of strategies available to reduce the ablation time and frequency, which mostly include the following aspects: (1) step-by-step method in which a "three-step" RFA was proposed by Ma Kuansheng et al. as ablation of the HH feeding artery (step 1), aspiration of blood from the tumor (step 2), and finally, ablation of the lesion (step 3) [29]. The "three-step" RFA showed obvious advantages in RFA time, puncture frequency, complete ablation rate, postoperative pain score, and symptom relief when compared to conventional RFA. However, this method excluded patients with multiple HH and was only applied to single HH. As 30% of HH are multiple tumors, the application scope and treatment level of this method are limited. (2) The Pringle manoeuver is performed to stop blood flow into the liver and alleviate the "heat sink effect." In 2005, Fan et al. proposed using the Pringle manoeuver to obstruct hepatic blood flow during RFA for HH larger than seven cm in diameter. This method has significantly reduced the intraoperative blood loss and ablation time [30]. (3) Conversion of RFA to MWA. In short, the treatment of HH using RFA remains controversial. It is worthwhile to investigate whether RFA can totally ablate HH safely and feasibly without causing hemolysis-related complications.

In 2019, Zhai Bo et al. reported 13 patients treated with MWA. The average ablation time for a single HH was 39.0 ± 14.4 min. Two patients developed acute renal insufficiency following surgery, with no intra-abdominal bleeding, liver failure, or other complications, and the overall complete ablation rate was 84.6% (11/13) [31]. In terms of safety, Liang Ping et al. found that ablation time and the number of electrode insertions were independent risk factors for hemoglobinuria following MWA treatment [19]. To avoid hemoglobinuria, the ablation time should be less than 20 min and the number of electrode insertions should be less than five.

In our study, all patients received preoperative TAE to embolize the HH feeding artery, which was then occluded with a gel foam sponge and lipiodol mixture. Our method has the following advantages: (1) the feeding artery was

Table 3 Outcome after thermal ablation of hepatic hemangioma

Variables	No./%
Operative time (min) (mean ± SD)	79.10 ± 2.59
Estimated blood loss (ml) (mean ± SD)	28.23 ± 3.93
Blood transfusion	0
Post-operation Laboratory findings	
WBC level	11.32 ± 0.44
Hb level (g/L)	121.83 ± 1.82
Platelet	180.89 ± 6.05
ALT level (U/L)	291.97 ± 26.22
AST level (U/L)	398.10 ± 41.70
TBIL level (μmol/L)	32.88 ± 2.27
Creatinine level (μmol/L)	60.68 ± 2.55
Complications	
Fever (No/Yes)[a]	74/8 (90.2%/9.8%)
Asymptomatic pleural effusion (No/Yes)	50/32 (61.0%/39.0%)
Hemoglobinuria (No/Yes)	54/28 (65.9%/34.1%)
Abdominal pain (No/Yes)	42/40 (51.2%/48.8%)
Acute renal insufficiency	0
Peritoneal effusion (No/Yes)	76/6 (92.7%/7.3%)
Cholecystitis (No/Yes)	71/11 (86.6%/13.4%)
Constipation (No/Yes)	77/5 (93.9%/6.1%)
Nausea and vomiting (No/Yes)	68/14 (82.9%/17.1%)
Clavien-Dindo classification	
No/I/II/III/IV	0/16/38/28/0/ (19.5%/46.3%/34.1%/0%/0%)
Hospital stay (days)	6.00 ± 2.30
Follow-up(months)	19.40 ± 1.60

RFA Radiofrequency ablation, *MWA*, Microwave ablation, *AKI* Acute kidney injury, *SIRS* Systemic inflammatory response syndrome

[a] Fever≧38℃

[b] Creatinine > 200 lmol/L

evaluated using DSA; (2) once the feeding arteries were embolized, the tumor lacked blood, limiting the heat sink effect of thermal ablation, reducing the ablation time and power, and thereby minimizing heat injury; (3) thermal ablation could be performed in a short period of time, no more than one month, and usually within one week of intervention, to avoid the formation of the collateral circulation; (4) following intervention, a CT reexamination was performed and the embolization outcome was assessed based on the effect of lipiodol deposition; (5) no chemotherapeutic drugs were used to avoid the potential liver function impairment and other complications; and (6) the number of damaged red blood cells entering the blood stream during thermal ablation was reduced, minimizing the risk of hemoglobinuria or acute renal failure.

We did not adopt the US-guided percutaneous ablation of the feeding artery and aspiration of blood from the tumor, as reported by other teams. We also did not adopt the artificial hydrothorax or ascites procedure to protect nearby organs [18, 29]. We believe that it is difficult to precisely locate the feeding blood vessels using ultrasonography or a CT scan alone. In addition, the continuous heat sink effect during thermal ablation will diminish the ablation effect, exacerbate the heat injury, and result in severe complications. The laparoscopic-assisted ablation can reduce organ injury in an easier and more effective manner, and it has overcome the problem of needle insertion path blockage by gas.

The superficial HH that is difficult to treat with percutaneous US guidance can be ablated laparoscopically. However, for HH close to vital organs such as the gallbladder, colon, stomach, and diaphragm, separation devices or water injection can be used to reduce ablation-induced injury. Laparoscopic ablation has the additional benefit of being able to compress liver tissue via devices to achieve the Pringle maneuver's effect, alleviate the heat sink and irrigation effects, reduce the amount of

Table 4 Comparison of pre-procedure, post-TAE and postoperative laboratory test results

Variables	Pre-procedure(a)	Post-TAE (b)	*P**	*t*	Post-operation (c)	*P***	*t*
WBC level	5.26 ± 0.13	10.25 ± 0.41	0.000	−14.057	11.32 ± 0.44	0.002	−3.2162
Hb level (g/L)	127.75 ± 2.01	128.50 ± 2.24	0.322	−0.995	121.83 ± 1.82	0.000	4.950
Platelet	223.75 ± 5.44	221.86 ± 5.95	0.408	0.832	180.89 ± 6.05	0.000	8.152
ALT level (U/L)	13.80 ± 0.69	49.28 ± 6.07	0.000	−5.639	291.97 ± 26.22	0.000	−8.428
AST level (U/L)	15.01 ± 0.51	48.07 ± 5.70	0.000	−5.655	398.10 ± 41.70	0.000	−7.694
TBIL level (μmol/L)	11.52 ± 0.50	14.44 ± 0.81	0.000	−5.354	32.88 ± 2.27	0.000	−10.152
Creatinine level (μmol/L)	65.15 ± 1.48	58.20 ± 1.35	0.000	7.973	60.68 ± 2.55	0.269	−1.115

Paired t test was used to compare the mean values between the two groups. Statistical significance level set to $P < 0.05$

[*] Pre-procedure (a) vs Post-TAE (b)

[**] Post-TAE (b) vs Post-operation (c)

destroyed hemoglobin entering the blood stream, destroy the vascular intima, and induce micro-thrombosis rapidly. (Fig. 2).

In 2022, a multicenter retrospective study on 452 patients from China used only 72 pairs of patients who were matched based on their propensity scores and then divided into RFA and MWA groups, and reported an incidence of hemoglobinuria of 77.78% in the RFA group and 50.00% in the MWA group [16]. However, our results revealed a low incidence of hemoglobinuria (34.1%) and no severe complications, indicating the significance of blocking the tumor feeding artery prior to ablation.

This is the first study to investigate the use of preoperative TAE combined with laparoscopic-assisted percutaneous thermal ablation for the treatment of large HH. We believe that the primary goal of thermal ablation for treating HH is to restrict blood flow within the HH and completely destroy the vascular endothelium and red blood cells within it. In our study, preoperative TAE blocked the blood vessels of the HH, changed the hemodynamic state of the HH, closed the blood that was continuously flowing in the tumor, reduced the number of red blood cells destroyed during thermal ablation, and minimized the hemoglobinuria incidence. Lipiodol is frequently accumulated in areas with dense blood vessels following the intervention. To achieve complete ablation of HH blood vessels, the lipiodol deposition area is punctured with a cluster radiofrequency needle or microwave needle based on the effect of lipiodol deposition after the intervention [32]. In addition, the heat irrigation effect was rationally used. The heat perfusion effect of RFA is determined based on the heat sink effect, which claims that the large blood vessels close to the operated blood vessels carry away the RFA heat, reducing the ablation range and resulting in more incomplete ablation of liver cancer in clinical treatment. In the RFA of HH, the heat irrigation effect can precisely gasify the blood trapped in HH, destroy the vascular endothelial cells, and prevent red blood cells from entering the systemic circulation. This also explains our findings in which the operative time was 79.10 ± 2.59 min (range: 35–134 min), the incidence of hemoglobinuria (34.1%) was lower than that in another study, and no patient developed severe complications [15, 16].

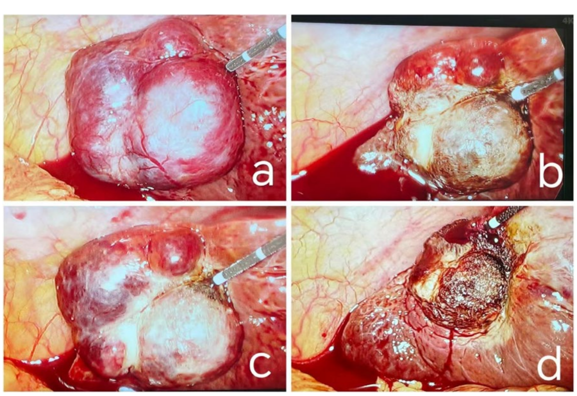

Fig. 2 A 45-year-old female patient was diagnosed with a hepatic hemangioma (HH) measuring 60 × 50 mm in segment VI. The patient underwent a sequential ablation procedure combining laparoscopic-assisted and ultrasound-guided percutaneous microwave ablation (MWA). Initial percutaneous MWA was performed for 8 min, followed by 6 min of laparoscopic MWA under direct visualization, achieving complete radiologic and macroscopic tumor ablation (**a**, **b**, **c**, **d**)

In this retrospective study, we enrolled outpatients treated by our team over the past four years, including those with multiple HH, a history of abdominal surgery, and giant HH larger than 10 cm in diameter. No specific exclusion criteria were applied during case selection. Patients who were eligible for surgery were treated with this strategy. Our study demonstrated that this strategy (preoperative TAE combined with thermal ablation) is minimally invasive, safe, simple, feasible, and replicable. In addition, there is no need for complicated preoperative preparation, intraoperative blood transfusions, or expensive or precise surgical equipment, such as laparoscopic US and electrosurgery equipment, and there is a very low risk of postoperative complications [9, 11, 25, 28, 33].

However, this study has the following shortcomings: (1) it is a single-center retrospective study; (2) it has a short follow-up period; (3) it is not a randomized controlled trial; and (4) it is dependent on the surgeon's technical ability. Therefore, multicenter prospective studies are warranted to demonstrate the therapeutic impact and generalizability of this strategy. As a single-arm retrospective study, our findings cannot establish causality. While the observed outcomes (e.g., symptom relief, low complication rates) suggest clinical utility, comparative studies are needed to confirm efficacy relative to other treatments.

As more experience has been gained in recent years, the advantages of this strategy have steadily been highlighted. Initially, we believed that combining TAE with thermal ablation would reduce surgical risk and complications, but this strategy has changed the dilemma in the treatment of HH. It is offered for symptomatic patients or patients with rapid tumor growth, regardless of tumor size (usually > 5 cm), in order to achieve the effect of early complete treatment of HH, minimize the risk of subsequent therapy, and acquire the long-term survival benefit [34, 35].

In conclusion, preoperative TAE combined with thermal ablation is a novel therapeutic strategy that not only combines the benefits of various treatment methods but also feasibly avoids the related hazards. Patients with giant HH can benefit from this strategy because the surgery is simple, less risky, and effective.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12957-025-03856-5.

Supplementary Material 1.

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Authors' contributions
1. Xin Jin ＊, Data curation, Formal analysis, Writing—original draft. 2. Ziman Zhu＊, Data curation, Formal analysis, Writing—original draft. 3. Wei Zhao, Investigation,Visualization 4. Liyuan Sun, Investigation 5. Bin Hu, Investigation,Visualization 6. Hongbo Huan, Methodology, Supervision 7. Yuliang Tu, Methodology, Supervision 8. Dadong Wang, Doctor,Conceptualization, Resources, Supervision, 9. Kai Jiang, Conceptualization,, Resources, Supervision, Writing—Review & Editing. Xin Jin and Ziman Zhu contributed equally to this article.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
This study was conducted in accordance with the World Medical Association Declaration of Helsinki and IRB approved by the Ethics Committee of the Fourth Medical Center of the Chinese PLA General Hospital (Grant No.2022 KY068-KS001). All patients provided written informed consent.

Consent to participate
Not applicable.

Competing interests
The authors declare no competing interests.

Author details
[1]Faculty of Hepato-Biliary-Pancreatic Surgery, Institute of Hepatobiliary Surgery of Chinese PLA, Key Laboratory of Digital Hepatobiliary Surgery, Chinese People's Liberation Army (PLA) General Hospital, No. 28 Fuxing Road, Beijing 100853, China.

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