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Original Article

Microwave ablation versus bleomycin-lipiodol emulsion with gelatin sponge embolization for hepatic hemangioma: efficacy and recovery outcomes in a retrospective cohort study

Yu Gong[1], Jian Zhang[2], Baohua Sun[3]

[1]Department of Interventional Medicine, Yantaishan Hospital, Yantai 264003, Shandong, China; [2]Department of Hepatobiliary Pancreatic Surgery, Third People's Hospital of Jinan, Jinan 250132, Shandong, China; [3]Department of Vascular Surgery, Fourth People's Hospital of Jinan, Jinan 250031, Shandong, China

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Abstract: Objective: To compare the efficacy and postoperative recovery outcomes of microwave ablation (MWA) and transcatheter arterial embolization (TAE) using a bleomycin-lipiodol emulsion combined with gelatin sponge particles in the treatment of hepatic hemangioma. Methods: In this retrospective study, 255 patients with hepatic hemangioma treated between January 2020 and June 2024 were analyzed. Patients were assigned to either the MWA group (n = 135) or the TAE group (n = 120). Evaluated parameters included operative characteristics, liver function changes, recovery metrics, complications, treatment efficacy, quality of life, and patient satisfaction. Results: MWA resulted in a higher overall efficacy rate compared to TAE (76.30% vs. 61.67%, P = 0.011), but was associated with significantly elevated postoperative alanine aminotransferase (ALT) levels (P < 0.001), indicating greater hepatocellular injury. Although ablation procedures were longer (P = 0.005), they were associated with reduced intraoperative blood loss (P = 0.010). TAE was linked to faster recovery, reflected in shorter hospital stays (P = 0.003). The MWA group experienced fewer overall complications, though hemolysis was uniquely observed in this cohort. The TAE group had higher rates of fever and ischemic events. Both groups showed improved quality of life post-treatment, with the MWA group demonstrating greater gains in physical functioning (P = 0.004). Patient satisfaction was comparable between groups. Conclusion: MWA and TAE are both effective treatment options for hepatic hemangioma, each with distinct advantages. MWA offers superior lesion control at the expense of greater hepatic stress, while TAE facilitates quicker recovery with a higher incidence of transient complications.

Keywords: Hepatic hemangioma, microwave ablation, transcatheter arterial embolization, bleomycin-lipiodol, postoperative outcomes, quality of life

Introduction

Hepatic hemangioma is the most common benign liver tumor, with a reported prevalence ranging from 0.4% to 20% across different populations [1-3]. It is frequently identified incidentally through imaging modalities such as ultrasound, computed tomography (CT), or magnetic resonance imaging (MRI) [4]. Although typically asymptomatic and requiring no intervention, large hemangiomas may cause abdominal pain, discomfort, or complications such as Kasabach-Merritt syndrome, thereby necessitating clinical management [5]. The pathogenesis involves complex vascular malformations. While these tumors are non-malignant, their growth can significantly affect quality of life, prompting the need for effective therapeutic strategies [6].

Treatment decisions depend on factors such as tumor size, location, symptoms, and risk of complications. Surgical resection has traditionally been the definitive option for symptomatic or enlarging hemangiomas. However, given its invasiveness and potential for morbidity, there has been a shift toward less invasive alternatives [7-9]. Interventional radiology has expanded the therapeutic landscape with techniques such as transcatheter arterial embolization

(TAE), which reduces tumor size by obstructing arterial blood flow and inducing ischemic necrosis [10, 11]. Another emerging option is microwave ablation (MWA), a localized, minimally invasive technique that uses electromagnetic energy to thermally destroy tumor tissue [12].

This study focuses on two minimally invasive approaches: MWA and an updated form of TAE utilizing a bleomycin-lipiodol emulsion combined with gelatin sponge particles. MWA generates coagulative necrosis via rapidly oscillating electric fields converted into heat, reaching cytotoxic temperatures that denature proteins and disrupt tumor architecture. It allows for precise targeting under real-time imaging guidance, reducing collateral damage to adjacent hepatic tissue and preserving more liver parenchyma compared to surgical resection [13]. Nonetheless, concerns remain regarding post-ablation liver function impairment due to localized tissue injury.

In contrast, TAE using a bleomycin-lipiodol emulsion and gelatin sponge particles combines embolization and local chemotherapy. The radiopaque emulsion enables sustained chemotherapeutic delivery within the tumor's arterial supply, while gelatin sponge particles provide temporary embolization, promoting ischemia and subsequent necrosis. This method has demonstrated favorable efficacy and safety profiles [14], particularly in patients unsuitable for surgery or in preoperative settings to reduce tumor vascularity and surgical risk.

Comparing these two approaches is essential, as clinical presentations vary and require individualized treatment plans. However, direct comparative data for MWA versus TAE in the treatment of hepatic hemangioma remain limited. Therefore, this study aims to comprehensively evaluate the efficacy and postoperative outcomes of MWA and TAE. By elucidating the benefits and limitations of each technique, we seek to inform clinical decision-making, support personalized treatment strategies, and improve patient outcomes.

Materials and methods

Case collection and selection

Inclusion and exclusion criteria: Inclusion Criteria: (1) Age ≥ 18 years; (2) Diagnosis of hepatic hemangioma confirmed by pathology, with the longest tumor diameter ≥ 5 cm; (3) Regular follow-up with color Doppler ultrasound, contrast-enhanced CT, or contrast-enhanced MRI after treatment; (4) Normal cognitive function (Mini-Mental State Examination [MMSE] score > 25) [15]; (5) Good physical condition (Eastern Cooperative Oncology Group [ECOG] score < 2 or Karnofsky Performance Status [KPS] score > 60) [16]; (6) Complete medical records available. Exclusion Criteria: (1) History of other abdominal surgeries; (2) Presence of Class A or B infectious diseases, including positive hepatitis B surface antigen, hepatitis C antibodies, or HIV antibodies; (3) Active infection, especially biliary tract inflammation; (4) Kasabach-Merritt syndrome with significant coagulopathy; (5) Severe dysfunction of major organs (liver, kidney, heart, lung, or brain); (6) Concurrent liver tumors, such as hepatocellular carcinoma; (7) Presence of fever, request for treatment discontinuation by family, or transfer to a higher-level hospital; (8) Communication difficulties or poor treatment compliance.

Study design and ethical statement: A retrospective analysis was conducted on 255 patients diagnosed with hepatic hemangioma at Yantaishan Hospital between January 2021 and June 2024. The required sample size was estimated using G*Power 3.1 software, assuming a medium effect size (d = 0.5), a two-tailed α = 0.05, and 95% power. Based on these parameters, at least 105 patients per group were needed to detect a statistically significant difference using a two-sided independent-samples t-test.

Initially, 280 patients were identified. Fourteen were excluded based on the inclusion criteria: 9 had tumors < 5 cm, and 5 had incomplete medical records. Subsequently, 11 patients were excluded based on the exclusion criteria: 6 due to Kasabach-Merritt syndrome with coagulopathy, and 5 due to communication difficulties or poor compliance. A total of 255 patients were included in the final analysis, with 135 in the MWA group and 120 in the TAE group. The study evaluated liver function parameters, treatment efficacy, quality of life, and patient satisfaction (**Figure 1**). Ethical approval was obtained from the Institutional Review Board and Research Ethics Committee of Yantaishan Hospital.

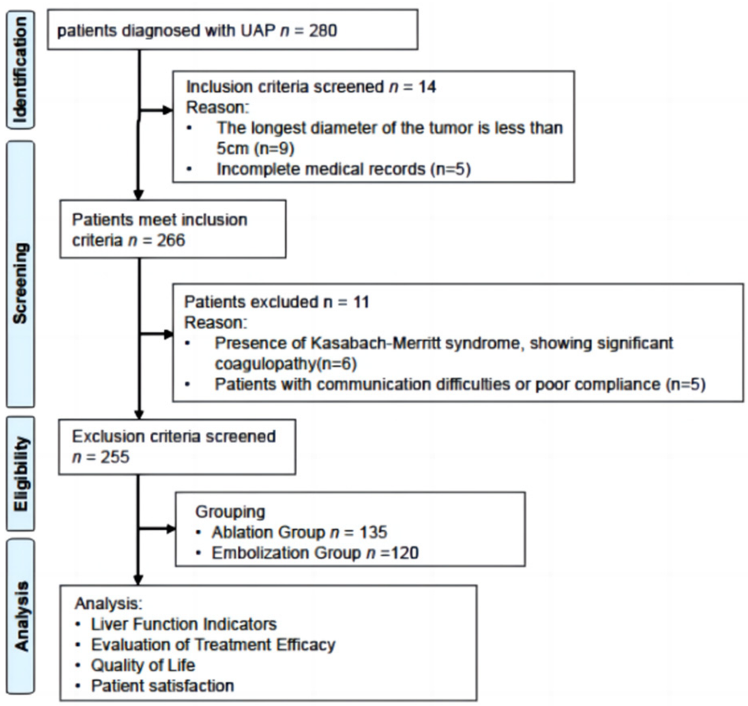

Figure 1. Research flowchart.

Surgical methods: MWA Group: Patients were placed in the supine position, and the surgical field was routinely disinfected. The puncture site and angle were determined by ultrasound guidance. Percutaneous MWA was performed using a real-time ultrasound-guided, water-cooled MWA system (Vision-China Medical Devices R&D Centre, Nanjing, China). A 15-gauge, 25 cm electrode was used. Power output and ablation time were adjusted according to tumor size and location, following the manufacturer's guidelines.

Following the standard protocol, two parallel electrodes were inserted into the lesion at a spacing of 2.5-3.0 cm within the same plane using a 3.5 MHz ultrasound probe (MyLab 60; Esaote, Genoa, Italy). The microwave generator was activated to maintain a tip temperature of 100°C for 3-10 minutes. Ablation commenced at the distal tumor margin, with electrodes repositioned proximally in 1.0-1.5 cm increments until the entire lesion was covered. To ensure complete coverage and an adequate margin, ablation extended 0.5 cm beyond the tumor into the surrounding hepatic parenchyma.

TAE Group: The procedure used a bleomycin-lipiodol emulsion (bleomycin:lipiodol ratio = 1:1.5), with the dosage tailored to lesion size, number, and vascularity, in combination with gelatin sponge particles. Patients were placed supine, and the right inguinal region was disinfected and draped. Under local anesthesia, the modified Seldinger technique was employed to puncture the right femoral artery, and a 5F vascular sheath was introduced.

A hepatic artery catheter was advanced to the hepatic artery origin. After confirming catheter placement, hepatic arteriography was performed to assess tumor location, size, and vascular supply. A microcatheter was then superselectively advanced to the feeding artery of the hemangioma. The bleomycin-lipiodol emulsion was infused under low-pressure flow control, followed by gelatin sponge particles to complete embolization. The procedure was deemed complete when flow cessation in the feeding artery occurred within three cardiac cycles.

Data extraction

Demographic and baseline clinical data were extracted from the hospital case system. Variables included surgical duration, cost, intraoperative blood loss, incision size, time to postoperative mobilization, length of hospital stay, liver function changes, postoperative complications, quality of life, and patient satisfaction.

Observational indicators

Liver function indicators: Fasting venous blood samples (5 mL) were collected one day before surgery, and on postoperative days 1 and 3. Samples were centrifuged at 3000 rpm for 10 minutes using a refrigerated high-speed centrifuge (TLD 12A, Xiangxi Scientific Instrument Factory, Hunan, China). Serum levels of alanine aminotransferase (ALT), aspartate aminotransferase (AST), albumin (ALB), and total bilirubin (TBIL) were measured using an automated biochemical analyzer (Hitachi 7600, Hitachi, Ltd., Japan). Analytical reagents were provided by Ningbo Meikang Biotechnology Co., Ltd., China (lot number: 20130821).

Evaluation of treatment efficacy: Treatment response was assessed six months postoperatively based on the World Health Organization criteria for solid tumors [17].

(1) Complete Response (CR): Disappearance of all measurable lesions for at least four weeks; (2) Partial Response (PR): ≥ 50% reduction in the product of the two largest tumor diameters, sustained for four weeks; (3) Minor Response (MR): 25-49% reduction without new lesion development; (4) Stable Disease (SD): Tumor size change between -25% and +25%, with no new lesions; (5) Recurrence (RE): ≥ 25% increase in tumor size or appearance of new lesions.

The response rate was calculated as (CR + PR)/total number of cases × 100%. All patients were followed for six months to assess hemangioma recurrence.

Comparison of quality of life and satisfaction between the two groups: At six months post-treatment, quality of life and patient satisfaction were assessed for both groups. Quality of life was evaluated using the European Organisation for Research and Treatment of Cancer Quality of Life Questionnaire Core 30 (EORTC QLQ-C30), which measures five domains: social relationships, emotional well-being, cognitive function, physical health, and role functioning [18]. Higher scores indicate better quality of life.

Patient satisfaction was assessed using the Press Ganey Satisfaction Survey [19], which evaluates five dimensions.

(1) Communication: Clarity and timeliness of healthcare staff communication; (2) Pain Management: Effectiveness of pain control; (3) Environment: Cleanliness and comfort of the care setting; (4) Waiting Time: Duration spent waiting for services or test results; (5) Overall Satisfaction: General satisfaction with the healthcare experience.

Responses were categorized into four levels: dissatisfied, somewhat satisfied, satisfied, and very satisfied.

Statistical methods

All data analyses were performed using SPSS version 29.0 (SPSS Inc., Chicago, IL, USA). Categorical variables were expressed as counts and percentages [n (%)]. Normality of continuous variables was tested using the Shapiro-Wilk test. Normally distributed data were expressed as mean ± standard deviation (sd) and analyzed using independent-samples t-tests. Variations between groups were computed using a t-test for continuous variables and chi-square tests for categorical variables. A *p*-value < 0.05 was considered statistically significant. Multivariate logistic regression was used to analyze factors influencing treatment efficacy (dependent variable), with treatment modality and other covariates ($P < 0.05$ in univariate analysis) entered as independent variables.

Results

Comparison of baseline characteristics

In this retrospective cohort study, 135 patients were assigned to the MWA group and 120 to the TAE group (**Table 1**). No statistically significant differences were observed between the two groups regarding demographic characteristics, including gender (male: 28.89% vs. 25.00%, $P = 0.485$), age (50.15 ± 5.61 vs. 51.38 ± 5.65 years, $P = 0.083$), or body mass index (BMI, all $P > 0.05$). Tumor size also showed no significant difference ($P = 0.169$). The primary symptoms - abdominal discomfort and pain - were comparable between groups (both $P > 0.05$), as were the number of hemangiomas (solitary vs. multiple) and disease duration.

Lesions predominantly involved the right hepatic lobe in both groups, with no significant difference in distribution ($P = 0.877$). Scores from the American Society of Anesthesiologists physical status classification and the ECOG performance status were similar. The prevalence of comorbidities, including chronic obstructive pulmonary disease (COPD), hypertension, and autoimmune diseases, did not differ significantly (all $P > 0.05$). There were also no

Table 1. Comparison of demographic characteristics between two groups

Characteristic	MWA Group (%) (n = 135)	Embolization Group (%) (n = 120)	t/χ²	P
Gender [n (%)]			0.487	0.485
Male	39 (28.89%)	30 (25%)		
Female	96 (71.11%)	90 (75%)		
Age (Mean ± SD, years)	50.15 ± 5.61	51.38 ± 5.65	1.744	0.082
BMI (kg/m²)	23.54 ± 0.62	23.61 ± 0.53	0.999	0.319
Tumor Diameter (Mean ± SD, cm)	9.80 ± 2.30	10.03 ± 2.41	0.772	0.441
Main Symptoms [n (%)]				
Abdominal Discomfort	54 (40%)	45 (37.5%)	0.167	0.683
Pain	30 (22.22%)	36 (30%)	2.003	0.157
Nausea/Vomiting	48 (35.56%)	48 (40%)	0.535	0.465
Number of Hemangiomas			1.891	0.169
Single	66 (48.89%)	69 (57.5%)		
Multiple	69 (51.11%)	51 (42.5%)		
Disease Duration (years)	1.24 ± 0.28	1.23 ± 0.35	0.170	0.865
Lesion Location [n (%)]				
Left Hepatic Lobe	45 (33.33%)	53 (44.17%)	3.151	0.076
Right Hepatic Lobe	75 (55.56%)	60 (50%)	0.787	0.375
Both Left and Right Lobe	15 (11.11%)	8 (6.67%)	1.529	0.216
Caudate Lobe	0 (0%)	5 (4.17%)	3.775	0.052
ASA Score [n (%)]			0.262	0.877
I	10 (7.41%)	9 (7.5%)		
II	120 (88.89%)	105 (87.5%)		
III	5 (3.7%)	6 (5%)		
Other Underlying Diseases [n (%)]				
COPD	2 (1.48%)	3 (2.5%)	0.018	0.894
Hypertension	6 (4.44%)	7 (5.83%)	0.253	0.615
Diabetes	5 (3.7%)	4 (3.33%)	0	1
Autoimmune Disease	0 (0%)	1 (0.83%)	None	0.471
ECOG Score [n (%)]			0.298	0.585
Grade 0	96 (71.11%)	89 (74.17%)		
Grade 1	39 (28.89%)	31 (25.83%)		
MMSE Score	27.31 ± 1.40	27.24 ± 1.20	0.378	0.705
Smoking History [n (%)]	14 (10.37%)	9 (7.5%)	0.638	0.424
Alcohol History [n (%)]	23 (17.04%)	18 (15%)	0.195	0.658
Education Level [n (%)]			0.252	0.616
Below College	101 (74.81%)	93 (77.5%)		
College Degree and Above	34 (25.19%)	27 (22.5%)		
Marital Status [n (%)]			0.968	0.325
Married	127 (94.07%)	109 (90.83%)		
Unmarried	8 (5.93%)	11 (9.17%)		

BMI: Body Mass Index; ASA: American Society of Anesthesiologists (classification system); COPD: Chronic Obstructive Pulmonary Disease; ECOG: Eastern Cooperative Oncology Group (performance status); MMSE: Mini-Mental State Examination; MWA: microwave ablation; TAE: transcatheter arterial embolization.

significant differences in education level, marital status, history of alcohol use, or smoking (all $P > 0.05$), confirming the demographic and clinical comparability between groups.

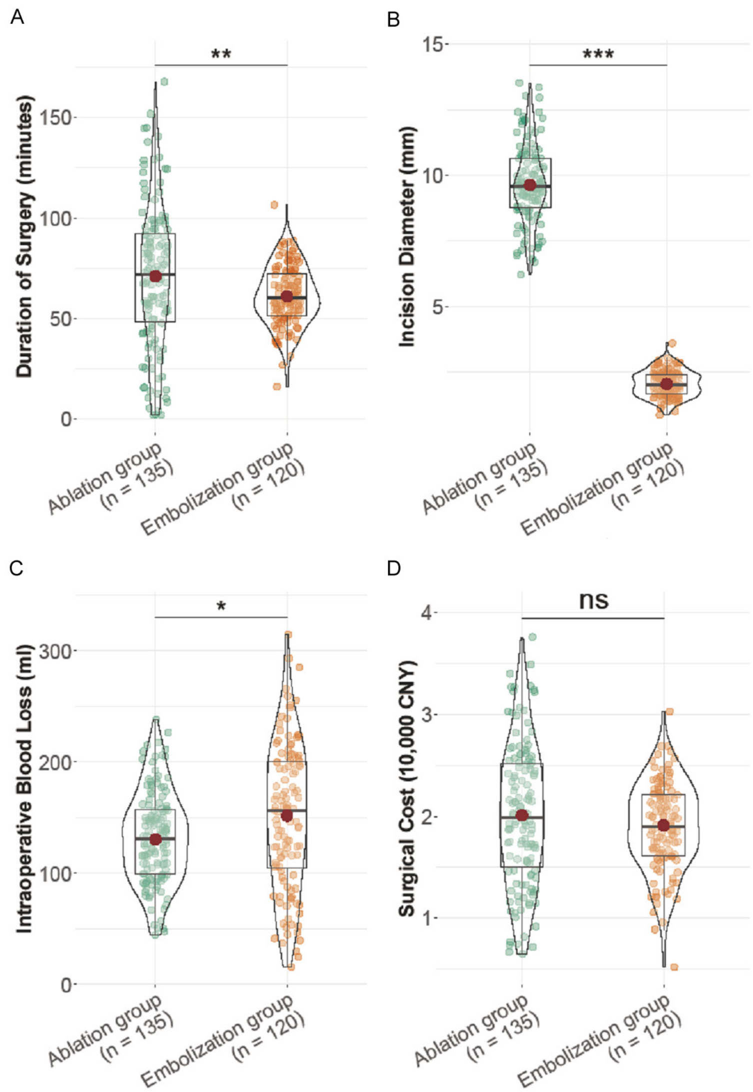

Figure 2. Comparison of surgical parameters between two groups. (A) Duration of surgery, (B) Incision diameter, (C) Intraoperative blood loss, (D) Surgical cost ns: no significant difference; *: P < 0.05; **: P < 0.01; ***: P < 0.001.

Comparison of surgical parameters

Surgical duration was significantly longer in the MWA group (70.86 ± 35.50 min) than in the TAE group (61.26 ± 14.90 min; t = 2.870, P = 0.005) (**Figure 2A**). Incision diameter was notably larger in the MWA group (9.68 ± 1.50 mm vs. 2.06 ± 0.50 mm; t = 55.503, P < 0.001) (**Figure 2B**). However, intraoperative blood loss was significantly lower in the MWA group (132.30 ± 41.50 mL vs. 150.35 ± 65.20 mL; t = 2.601, P = 0.010) (**Figure 2C**).

Although surgical cost was slightly higher in the MWA group (2.01 ± 0.69 × 10^4 CNY) compared to the TAE group (1.89 ± 0.43 × 10^4 CNY), the difference was not statistically significant (t = 1.682, P = 0.094) (**Figure 2D**).

Comparison of liver function

Liver function indicators differed significantly postoperatively between the ablation (n = 135) and TAE (n = 120) groups (**Table 2**).

ALT: No significant difference was observed preoperatively (19.05 ± 4.50 vs. 18.76 ± 2.30 U/L; t = 0.676, P = 0.500). However, ALT levels were markedly elevated in the MWA group one day postoperatively (221.03 ± 43.50 vs. 25.00 ± 13.50 U/L; t = 49.738, P < 0.001) and remained significantly higher on day three (108.24 ± 36.17 vs. 21.92 ± 7.48 U/L; t = 27.086, P < 0.001).

AST: Baseline levels were equivalent (18.01 ± 2.10 vs. 18.00 ± 1.60 U/L; t = 0.004, P = 0.997). Interestingly, AST was higher in the TAE group on both day one (29.00 ± 6.50 vs. 26.89 ± 3.20 U/L; t = 3.226, P = 0.002) and day three (23.78 ± 3.47 vs. 22.35 ± 4.61 U/L; t = 2.831, P = 0.005).

ALB: No difference preoperatively (37.84 ± 3.30 vs. 38.03 ± 1.60 g/L; t = 0.585, P = 0.559). Postoperatively, ALB levels were higher in the MWA group on both day one (16.37 ± 2.30 vs. 15.47 ± 3.3 g/L; t = 2.513, P = 0.013) and day three (24.56 ± 3.41 vs. 23.22 ± 3.24 g/L; t = 3.191, P = 0.002).

TBIL: Baseline levels were comparable (10.85 ± 1.60 vs. 11.04 ± 2.10 μmol/L; t = 0.822, P = 0.412). TBIL was significantly higher in the MWA group on day one (40.99 ± 3.10 vs. 39.86 ± 2.60 μmol/L; t = 3.145, P = 0.002) and day three (22.36 ± 5.87 vs. 20.27 ± 5.31 μmol/L; t = 2.969, P = 0.003).

Table 2. Comparison of liver function between two groups

Characteristic	MWA Group (%) (n = 135)	Embolization Group (%) (n = 120)	t/χ^2	P
ALT (U/L)				
Pre-operation	19.05 ± 4.50	18.76 ± 2.30	0.676	0.500
1 day after operation	221.03 ± 43.50	25.00 ± 13.50	49.738	< 0.001
3 days after operation	108.24 ± 36.17	21.92 ± 7.48	27.086	< 0.001
AST (U/L)				
Pre-operation	18.01 ± 2.10	18.00 ± 1.60	0.004	0.997
1 day after operation	26.89 ± 3.20	29.00 ± 6.50	3.226	0.002
3 days after operation	22.35 ± 4.61	23.78 ± 3.47	2.831	0.005
ALB (g/L)				
Pre-operation	37.84 ± 3.30	38.03 ± 1.60	0.585	0.559
1 day after operation	16.37 ± 2.30	15.47 ± 3.30	2.513	0.013
3 days after operation	24.56 ± 3.41	23.22 ± 3.24	3.191	0.002
TBIL (μmol/L)				
Pre-operation	10.85 ± 1.60	11.04 ± 2.10	0.822	0.412
1 day after operation	40.99 ± 3.10	39.86 ± 2.60	3.145	0.002
3 days after operation	22.36 ± 5.87	20.27 ± 5.31	2.969	0.003

ALT: Alanine aminotransferase; AST: Aspartate aminotransferase; ALB: Albumin; TBIL: Total bilirubin; MWA: microwave ablation; TAE: transcatheter arterial embolization.

Table 3. Comparison of postoperative recovery time between two groups

Parameter	MWA Group (n = 135)	Embolization Group (n = 120)	t	P
Hospital Stay (days)	5.95 ± 1.50	5.52 ± 0.61	3.011	0.003
Time to Ambulation (hours)	25.03 ± 4.09	24.03 ± 3.23	2.184	0.030

MWA: microwave ablation; TAE: transcatheter arterial embolization.

Table 4. Comparison of complications between two groups

Complication	MWA Group (%) (n = 135)	Embolization Group (%) (n = 120)	χ^2	P
Fever	9 (6.67)	21 (17.50)	7.182	0.007
Postoperative Infection	3 (2.22)	0 (0.00)	1.126	0.289
Pain in Liver Area	20 (14.81)	27 (22.50)	2.496	0.114
Hemolysis	7 (5.19)	0 (0.00)	4.603	0.032
Ischemic Cholecystitis	0 (0.00)	3 (2.50)	1.603	0.205
Overall Complication Rate	39 (28.89)	51 (42.50)	5.154	0.023

MWA: microwave ablation; TAE: transcatheter arterial embolization.

Comparison of postoperative recovery

Patients in the MWA group had a significantly longer hospital stay (5.95 ± 1.50 vs. 5.52 ± 0.61 days; t = 3.011, P = 0.003) (**Table 3**). Time to postoperative ambulation was also slightly prolonged (25.03 ± 4.09 vs. 24.03 ± 3.23 hours; t = 2.184, P = 0.03).

Comparison of postoperative complications

Fever was less frequent in the MWA group (6.67%) than in the TAE group (17.50%; χ^2 = 7.182, P = 0.007) (**Table 4**). Postoperative infections occurred in 3 patients (2.22%) in the MWA group and none in the embolization group (χ^2 = 1.126, P = 0.289). Liver pain was reported in 14.81% (MWA) vs. 22.50% (TAE), without statistical significance (χ^2 = 2.496, P = 0.114).

Hemolysis was observed exclusively in the MWA group (5.19%), yielding a significant difference (χ^2 = 4.603, P = 0.032). Ischemic cholecystitis was reported only in the TAE group (2.50%), but without significance (χ^2 = 1.603, P = 0.205). The overall complication rate was sig-

Table 5. Comparison of efficacy between two groups

Outcome	MWA Group (%) (n = 135)	Embolization Group (%) (n = 120)	χ^2	P
Remission Status			7.316	0.120
Complete Remission	64 (47.41)	51 (42.50)		
Partial Remission	39 (28.89)	23 (19.17)		
Improvement	19 (14.07)	26 (21.67)		
Stable Disease	11 (8.15)	17 (14.17)		
Recurrence	2 (1.48)	3 (2.50)		
Overall Efficacy Rate	103 (76.30)	74 (61.67)	6.404	0.011

MWA: microwave ablation; TAE: transcatheter arterial embolization.

Table 6. Comparison of quality of life before and after treatment

Quality of Life Aspect	MWA Group (n = 135)	Embolization Group (n = 120)	t/χ^2	P
Social Relationships				
Pre-treatment	50.61 ± 4.41	50.69 ± 3.10	0.183	0.855
Post-treatment	60.83 ± 3.81	59.98 ± 3.50	1.854	0.065
Cognition				
Pre-treatment	65.35 ± 2.20	65.41 ± 2.30	0.224	0.823
Post-treatment	88.97 ± 3.41	88.73 ± 2.40	0.659	0.511
Physical Functioning				
Pre-treatment	59.78 ± 2.49	60.05 ± 2.30	0.920	0.358
Post-treatment	88.82 ± 3.11	87.68 ± 3.10	2.944	0.004
Emotional Well-being				
Pre-treatment	54.31 ± 2.40	53.69 ± 3.10	1.777	0.077
Post-treatment	68.80 ± 3.10	68.28 ± 3.60	1.254	0.211
Role Functioning				
Pre-treatment	64.82 ± 2.21	64.37 ± 3.20	1.310	0.192
Post-treatment	84.26 ± 3.20	83.59 ± 3.50	1.583	0.115
Overall Health Status				
Pre-treatment	58.89 ± 5.81	59.20 ± 4.60	0.477	0.634
Post-treatment	72.47 ± 5.70	71.49 ± 5.10	1.446	0.149

MWA: microwave ablation; TAE: transcatheter arterial embolization.

nificantly lower in the MWA group (28.89%) compared to the TAE group (42.50%; χ^2 = 5.154, P = 0.023).

Comparison of treatment efficacy

The complete remission (CR) rate was slightly higher in the MWA group at 47.41% (64 patients) compared to 42.50% (51 patients) in the TAE group (**Table 5**). Partial remission (PR) was observed in 28.89% (39 patients) of the MWA group versus 19.17% (23 patients) in the TAE group, suggesting a favorable trend toward ablation. In contrast, the minor response (MR) rate was higher in the TAE group (21.67%, 26 patients) than in the MWA group (14.07%, 19 patients). Stable disease (SD) was observed in 8.15% (11 patients) of the MWA group and 14.17% (17 patients) of the TAE group, indicating relatively similar disease control. Recurrence (RE) was rare in both groups, occurring in 1.48% (2 patients) of the MWA group and 2.50% (3 patients) of the TAE group, with no significant difference (χ^2 = 7.316, P = 0.120).

Importantly, the overall efficacy rate (CR + PR) was significantly higher in the MWA group at 76.30% (103 patients), compared to 61.67% (74 patients) in the TAE group (χ^2 = 6.404, P = 0.011).

Comparison of quality of life

Both groups showed improvement in quality of life post-treatment. Social functioning improved comparably between groups (ablation: 60.83 ± 3.81 vs. TAE: 59.98 ± 3.50; t = 1.854, P = 0.065, **Table 6**). Cognitive functioning scores also improved significantly in both groups without intergroup differences (ablation: 88.97 ± 3.41 vs. embolization: 88.73 ± 2.40; t = 0.659, P = 0.511). Notably, physical functioning was significantly better in the MWA group (88.82 ± 3.11) than in the TAE group (87.68 ± 3.10; t = 2.944, P = 0.004).

Although emotional well-being and role functioning improved in both groups, the differences between them were not statistically significant (emotional well-being: t = 1.254, P = 0.211; role functioning: t = 1.583, P = 0.115).

Table 7. Postoperative patient satisfaction rates

Satisfaction Level	MWA Group (%) (n = 135)	Embolization Group (%) (n = 120)	t	P
Very Satisfied	84 (62.22)	79 (62.22)	0.518	0.915
Somewhat Satisfied	31 (22.96)	26 (22.96)		
Moderately Satisfied	18 (13.33)	13 (13.33)		
Dissatisfied	2 (1.48)	2 (1.48)		

MWA: microwave ablation; TAE: transcatheter arterial embolization.

Overall health status also improved, though again without a statistically significant difference between groups (t = 1.446, P = 0.149).

Comparison of patient satisfaction

A majority of patients in both groups reported being "Very Satisfied", with identical proportions of 62.22% (84 patients in the MWA group; 79 in the TAE group) (**Table 7**). The proportion of "Somewhat Satisfied" patients was also equal across groups (22.96%; 31 in the MWA group, 26 in the TAE group). Similarly, the rates of "Moderately Satisfied" and "Dissatisfied" were identical: 13.33% (18 ablation, 13 embolization) and 1.48% (2 patients each), respectively.

No statistically significant difference in overall satisfaction was observed (t = 0.518, P = 0.915), indicating comparable levels of treatment satisfaction between the two groups (**Table 7**).

Multivariate logistic regression analysis

To further investigate factors influencing treatment efficacy, multivariate logistic regression was conducted using treatment outcome as the dependent variable (**Table 8**). Independent variables included treatment modality and other factors with P < 0.05 from univariate analyses. Continuous variables such as ALT, AST, ALB, and TBIL were converted into binary categories based on clinical thresholds:

ALT: Postoperative day 1 > 200 U/L vs. ≤ 200 U/L; postoperative day 3 > 100 U/L vs. ≤ 100 U/L. AST: Postoperative day 1 > 25 U/L vs. ≤ 25 U/L; postoperative day 3 > 20 U/L vs. ≤ 20 U/L. ALB: Postoperative day 1 < 16 g/L vs. ≥ 16 g/L; postoperative day 3 < 24 g/L vs. ≥ 24 g/L. TBIL: Postoperative day 1 > 40 μmol/L vs. ≤ 40 μmol/L; postoperative day 3 > 20 μmol/L vs. ≤ 20 μmol/L.

Key findings from the logistic regression include:

Treatment with MWA was associated with higher odds of a favorable outcome (OR = 2.17, 95% CI: 1.36-3.48, P = 0.002).

Incision diameter > 5 mm (OR = 1.89 [1.23-2.91], P = 0.004) and intraoperative blood loss > 140 mL (OR = 1.56 [1.02-2.38], P = 0.04) were significantly associated with treatment outcome.

Elevated ALT levels on day 1 (> 2 00 U/L, OR = 2.25 [1.45-3.50], P < 0.001) and day 3 (> 100 U/L, OR = 1.92 [1.23-3.01], P = 0.004) were also significant predictors.

AST on day 1 > 25 U/L was associated with poorer outcomes (OR = 1.67 [1.03-2.71], P = 0.04).

Low ALB levels on day 1 (< 16 g/L, OR = 1.89 [1.12-3.21], P = 0.02) and day 3 (< 24 g/L, OR = 1.75 [1.05-2.91], P = 0.03) were risk factors.

Elevated TBIL on day 1 (> 40 μmol/L, OR = 1.56 [1.02-2.38], P = 0.04) also correlated with worse outcomes.

Fever (OR = 1.75 [1.05-2.91], P = 0.03) and overall complication rate (OR = 1.67 [1.03-2.71], P = 0.04) were significantly associated with treatment outcome.

Post-treatment physical functioning score > 88 was positively associated with better outcomes (OR = 2.17 [1.36-3.48], P = 0.002).

These results underscore the importance of treatment modality, intraoperative factors, postoperative liver function markers, complications, and recovery quality in determining treatment efficacy. Effective management of these variables may enhance patient outcomes and prognosis.

Discussion

In this retrospective cohort study, we evaluated the efficacy and postoperative recovery outcomes of two therapeutic strategies for hepatic hemangioma: MWA and TAE using a bleomycin-lipiodol emulsion combined with gelatin sponge particles.

Table 8. Multivariate logistic regression analysis results

Variable	OR (95% CI)	*P*-value
Treatment Method (MWA vs. TAE)	2.17 (1.36-3.48)	0.002
Duration of Surgery (minutes) (> 70 vs. ≤ 70)	1.34 (0.98-1.84)	0.060
Incision Diameter (mm) (> 5 vs. ≤ 5)	1.89 (1.23-2.91)	0.004
Intraoperative Blood Loss (ml) (> 140 vs. ≤ 140)	1.56 (1.02-2.38)	0.040
ALT-1 day after operation (U/L) (> 200 vs. ≤ 200)	2.25 (1.45-3.50)	< 0.001
ALT-3 days after operation (U/L) (> 100 vs. ≤ 100)	1.92 (1.23-3.01)	0.004
AST-1 day after operation (U/L) (> 25 vs. ≤ 25)	1.67 (1.03-2.71)	0.040
AST-3 days after operation (U/L) (> 20 vs. ≤ 20)	1.45 (0.92-2.27)	0.110
ALB-1 day after operation (g/L) (< 16 vs. ≥ 16)	1.89 (1.12-3.21)	0.020
ALB-3 days after operation (g/L) (< 24 vs. ≥ 24)	1.75 (1.05-2.91)	0.030
TBIL-1 day after operation (μmol/L) (> 40 vs. ≤ 40)	1.56 (1.02-2.38)	0.040
TBIL-3 days after operation (μmol/L) (> 20 vs. ≤ 20)	1.45 (0.92-2.27)	0.110
Hospital Stay (days) (> 5 vs. ≤ 5)	1.34 (0.98-1.84)	0.060
Time to Ambulation (hours) (> 24 vs. ≤ 24)	1.25 (0.92-1.71)	0.150
Fever (Yes vs. No)	1.75 (1.05-2.91)	0.030
Overall Complication Rate (Yes vs. No)	1.67 (1.03-2.71)	0.040
Post-treatment Physical Functioning Score (High (> 88) vs. Low (≤ 88))	2.17 (1.36-3.48)	0.002

ALT: Alanine aminotransferase; AST: Aspartate aminotransferase; ALB: Albumin; TBIL: Total bilirubin; MWA: microwave ablation; TAE: transcatheter arterial embolization.

The results demonstrated that the MWA group achieved a significantly higher overall efficacy rate than the TAE group. This enhanced efficacy may be attributed to the direct, localized destruction of hemangioma tissue afforded by MWA. MWA generates high-frequency electromagnetic waves that produce thermal energy, resulting in coagulative necrosis of target tissues [20]. The process induces cellular dehydration and protein denaturation, enabling effective tumor elimination with minimal collateral thermal damage [21]. The precision of this technique-facilitated by real-time ultrasound guidance-ensures accurate targeting of the lesion, likely contributing to the higher rates of complete and partial remission observed in the MWA group [22, 23].

Despite its superior tumoricidal efficacy, MWA was associated with more pronounced postoperative liver function alterations, particularly elevated ALT levels, indicative of hepatocellular injury. These elevations likely reflect the high-intensity thermal insult delivered to the local liver parenchyma during ablation. Although transient, such changes highlight the need for careful perioperative monitoring. Fortunately, ALT levels typically normalized during follow-up, underscoring the liver's regenerative potential. Nonetheless, patient selection should consider baseline hepatic reserve when opting for MWA.

In contrast, the TAE group exhibited faster postoperative recovery, as reflected by shorter hospital stays and earlier postoperative ambulation. This advantage is likely due to the less invasive nature of embolization, which achieves therapeutic effects through selective occlusion of arterial supply to the hemangioma, inducing ischemia and tumor necrosis [24-26]. Although this approach causes less direct damage to hepatic parenchyma, it still provides meaningful tumor volume reduction, as evidenced by comparable partial remission rates. The therapeutic efficacy of embolization is enhanced by the combination of bleomycin and lipiodol - where the lipophilic carrier prolongs drug retention at the tumor site - and by gelatin sponge particles, which provide transient yet effective embolic occlusion [27].

Regarding complications, the MWA group experienced a lower overall complication rate. However, hemolysis occurred exclusively in this group, possibly due to thermal injury-induced oxidative stress leading to red blood cell lysis. In contrast, the TAE group had a higher incidence of fever and ischemic complications such as cholecystitis, likely resulting from non-target embolization or collateral ischemia. These findings underscore the importance of close postoperative monitoring and timely management of procedure-specific adverse events.

Quality of life assessments favored the MWA group in terms of post-treatment improvements in physical functioning. This advantage may stem from the complete resolution of local symptoms following effective lesion eradication, thereby facilitating better physical performance and daily functioning. In contrast, emotional and social dimensions did not significantly differ between the groups, suggesting that quality-of-life improvements were more closely related to physical recovery than to psychological factors. Pain management and patient satisfaction scores were comparable between the two groups, indicating that neither procedure imposed undue burdens beyond the expected challenges associated with standard interventional therapies.

From a clinical perspective, treatment selection between ablation and embolization should be individualized based on patient characteristics and the clinical scenario. For example, patients with large solitary hemangiomas, where complete ablation is achievable, may derive greater benefit from MWA due to its higher efficacy in complete lesion clearance. Conversely, patients with smaller or multiple lesions may experience a smoother recovery and fewer acute complications with embolization, making it a preferred option when rapid postoperative recovery is a priority [28-30].

These findings also highlight opportunities for future research. Efforts could focus on optimizing ablation parameters to minimize hepatocellular injury while maintaining efficacy, or on enhancing embolization protocols through improved chemotherapeutic formulations. Additionally, advancements in imaging technology and procedural guidance may further improve precision and clinical outcomes for both techniques.

This study offers reliable, evidence-based insights to inform treatment decisions for hepatic hemangioma. Nevertheless, as a retrospective, single-center analysis, it is subject to inherent limitations, including potential selection bias and limited generalizability. Future prospective, multicenter trials are warranted to validate these findings and to explore the potential of combination or hybrid therapeutic strategies aimed at maximizing efficacy while minimizing risk.

In conclusion, both MWA and TAE represent effective therapeutic options for hepatic hemangioma, each with distinct strengths and trade-offs. MWA provides superior lesion resolution but is associated with greater hepatic stress, whereas embolization offers a less invasive alternative with faster recovery. Tailoring treatment strategies to individual patient profiles and preferences is essential for optimizing therapeutic efficacy and improving postoperative quality of life.

Disclosure of conflict of interest

None.

Address correspondence to: Baohua Sun, Department of Vascular Surgery, Fourth People's Hospital of Jinan, Jinan 250031, Shandong, China. E-mail: surgeonsun@163.com

References

[1] Evans J, Willyard CE and Sabih DE. Cavernous Hepatic Hemangioma. In: editors. StatPearls. Treasure Island (FL) ineligible companies. Disclosure: Charles Willyard declares no relevant financial relationships with ineligible companies. Disclosure: Durr Sabih declares no relevant financial relationships with ineligible companies.: StatPearls Publishing Copyright © 2024, StatPearls Publishing LLC.; 2024.

[2] Feng ZH, Chen XF and Jiang JS. Giant hepatic hemangioma. Clin Gastroenterol Hepatol 2024; 22: A24-A25.

[3] Erickson LA, Gupta S and Torres-Mora J. Hepatic hemangioma. Mayo Clin Proc 2023; 98: 489-491.

[4] Kacała A, Dorochowicz M, Matus I, Puła M, Korbecki A, Sobański M, Jaców-Nowicka J, Patrzałek D, Janczak D and Guziński M. Hepatic hemangioma: review of imaging and therapeutic strategies. Medicina (Kaunas) 2024; 60: 449.

[5] Aziz H, Brown ZJ, Baghdadi A, Kamel IR and Pawlik TM. A comprehensive review of hepatic hemangioma management. J Gastrointest Surg 2022; 26: 1998-2007.

[6] Leon M, Chavez L and Surani S. Hepatic hemangioma: what internists need to know. World J Gastroenterol 2020; 26: 11-20.
[7] Goncharuk RA, Rakhmonov ZA, Stegnii KV, Krekoten AA, Shulga IV and Dvoinikova ER. Combined surgical treatment of giant cavernous hepatic hemangioma: a case report. Int J Surg Case Rep 2022; 94: 107012.
[8] Shin YC, Cho EJ, Na HY, Cho JY, Han HS, Lee YJ, Kim H, Jang S, Choi GH, Jang ES, Kim JW and Jeong SH. Hepatic hemangioma: proportion and predictor of surgical treatment with emphasis on its growth rate. Korean J Intern Med 2023; 38: 818-830.
[9] Farhat W, Ammar H, Said MA, Mizouni A, Ghabry L, Hammami E, Gupta R, Habiba Ben Hamada, Mabrouk MB and Ali AB. Surgical management of giant hepatic hemangioma: A 10-year single center experience. Ann Med Surg (Lond) 2021; 69: 102542.
[10] Wang L, Li J, Song D and Guo L. Clinical evaluation of transcatheter arterial embolization combined with propranolol orally treatment of infantile hepatic hemangioma. Pediatr Surg Int 2022; 38: 1149-1155.
[11] Torkian P, Li J, Kaufman JA and Jahangiri Y. Effectiveness of transarterial embolization in treatment of symptomatic hepatic hemangiomas: systematic review and meta-analysis. Cardiovasc Intervent Radiol 2021; 44: 80-91.
[12] Zhang HL, Meng HB, Li XL, Sun LP, Lu F, Xu HX and Yu SY. Laparoscopy-guided percutaneous microwave ablation for symptomatic 12.8cm hepatic hemangioma with low blood loss and short hospital stay post-operation: a case report and literature review. Clin Hemorheol Microcirc 2021; 77: 165-171.
[13] Cai Q, Qian TG, Zhao QY, Feng SY, Yang Q, Luo YC, Dai YQ, Liang P, Yu XL, Liu FY, Han ZY, Du QW, Li X and Yu J. Percutaneous microwave ablation versus sclerotherapy for large hepatic hemangioma: a multi-center cohort study. Int J Hyperthermia 2024; 41: 2285705.
[14] Özgür Ö and Sindel HT. Giant hepatic hemangioma treatment with transcatheter arterial embolisation and transcatheter arterial chemoembolisation; Comparative results. Turk J Med Sci 2021; 51: 2943-2950.
[15] Li H, Jia J and Yang Z. Mini-mental state examination in elderly chinese: a population-based normative study. J Alzheimers Dis 2016; 53: 487-496.
[16] Friendlander AH and Ettinger RL. Karnofsky performance status scale. Spec Care Dentist 2009; 29: 147-148.
[17] Ghobrial FEI, Eldin MS, Razek AAKA, Atwan NI and Shamaa SSA. Computed tomography assessment of hepatic metastases of breast cancer with revised response evaluation criteria in solid tumors (RECIST) Criteria (Version 1.1): inter-observer agreement. Pol J Radiol 2017; 82: 593-597.
[18] Liu Q, Liu F, Ding J, Wei Y and Li B. Surgical outcomes and quality of life between laparoscopic and open approach for hepatic hemangioma: a propensity score matching analysis. Medicine (Baltimore) 2019; 98: e14485.
[19] Boissy A, Windover AK, Bokar D, Karafa M, Neuendorf K, Frankel RM, Merlino J and Rothberg MB. Communication skills training for physicians improves patient satisfaction. J Gen Intern Med 2016; 31: 755-761.
[20] Fei L and Hongsong X. Effectiveness of microwave ablation for the treatment of hepatic hemangioma - meta-analysis and meta-regression. Int J Hyperthermia 2023; 40: 2146214.
[21] Kong J, Gao R, Wu S, Shi Y, Yin T, Guo S, Xin Z, Li A, Kong X, Ma D, Zhai B, Sun W and Gao J. Safety and efficacy of microwave versus radiofrequency ablation for large hepatic hemangioma: a multicenter retrospective study with propensity score matching. Eur Radiol 2022; 32: 3309-3318.
[22] Liang J, Zhang S, Han Z, Li Y, Sun H, Kim Y and Kim T. Comparative study of application of computed tomography/ultrasound and computed tomography imaging guidance methods in the microwave ablation of liver cancer. J Comput Assist Tomogr 2023; 47: 24-30.
[23] Bruners P. CT-guided local ablative interventions. Radiologie (Heidelb) 2023; 63: 490-496.
[24] Zhang L, Shi H, Zheng C and Liang B. Bleomycin-ethiodized oil transarterial embolization of a giant hepatic hemangioma. J Vasc Interv Radiol 2023; 34: 514-514, e511.
[25] Yun HG and Yun JH. Preoperative embolization of intraosseous hemangioma in zygoma: a case report. Asian J Surg 2023; 46: 2485-2486.
[26] Shah ND, Reddy NK, Bricker J, Rajeswaran S and Yamada A. Management of a gluteal non-involuting hemangioma with glue embolization and excision. J Craniofac Surg 2023; 34: e65-e67.
[27] Zhao D, Xie L, Makamure J, Liu Z, Zhang L, Li Q, Zhang X, Zhao Y, Zheng C, Shi L and Liang B. Transcatheter arterial embolization with bleomycin-lipiodol of hepatic hemangiomas: safety, efficacy and predictors of response. Cardiovasc Intervent Radiol 2024; 47: 931-942.
[28] Hersh AM, Jin Y, Xu R, Davidar AD, Weber-Levine C, Gonzalez LF and Theodore N. Transpedicular Onyx embolization of a thoracic hemangioma with robotic assistance: illustrative case. J Neurosurg Case Lessons 2023; 5: CASE2348.

[29] Gloria-Rivas AM, Pérez-Carrillo N and O'Farril-Anzures R. Treatment of rectal hemangioma through embolization. Rev Gastroenterol Mex (Engl Ed) 2021; 86: 305-306.

[30] Siderakis M, Dodoura S, Gkeneralis G, Kartsouni V and Gkeli M. Organ-preserving embolization of a giant splenic hemangioma in an adult. CVIR Endovasc 2024; 7: 79.