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The role of transarterial embolization in the management of hepatic hemangiomas: A retrospective analysis

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MAIN POINTS

- Transarterial embolization with bleomycin–lipiodol emulsion is a safe and effective treatment for giant hepatic hemangiomas.
- Significant volumetric reduction was achieved, with 90% of patients reaching a volume reduction ratio (VRR) ≥50% at 12 months.
- Symptom resolution was observed in 93.5% of patients, with no major complications reported.
- Equal or greater than 75% peripheral contrast filling during embolization predicted higher volumetric response.

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ABSTRACT

Aim: Hepatic hemangiomas (HHs) are the most common benign liver tumors, and giant lesions may cause symptoms or complications requiring intervention. Surgical resection carries significant morbidity, and minimally invasive alternatives such as transarterial embolization (TAE) have gained importance. This study aimed to evaluate the clinical and radiological outcomes of TAE with bleomycin–lipiodol emulsion for giant HHs and to examine the relationship between peripheral contrast filling and volumetric response.

Materials and Methods: This retrospective, dual-center study included 41 patients who underwent TAE between January 2019 and June 2024. Indications for treatment were symptomatic lesions ≥5 cm, progressive growth of hemangiomas, or all lesions ≥10 cm. Contrast-enhanced MRI or CT was performed at 1, 3, 6, and 12 months post-treatment. Volumetric reduction ratio (VRR) and size reduction were calculated, and angiographic peripheral contrast filling was categorized into four groups (<25%, 25–49%, 50–74%, 75%). Clinical outcomes, technical success, and complications were analyzed.

Results: One patient was identified as a statistical outlier and excluded from the final analysis, which therefore comprised 40 patients (73 HHs). The mean baseline lesion diameter was 8.6±0.5 cm, with a median volume of 178.3 cc (IQR 62.5–376.0). At 12 months, the mean VRR reached 75%, and 90% of patients achieved VRR ≥50%. Patients with ≥75% peripheral contrast filling had significantly greater volume reduction compared with lower filling groups (p<.001). Symptom resolution occurred in 93.5% of symptomatic patients. The overall complication rate was 25%, all of which were minor (SIR Grade A–B), and no major or persistent complications were observed.

Conclusion: TAE with bleomycin–lipiodol emulsion is a safe and effective treatment for giant hepatic hemangiomas, providing substantial volume reduction and symptom relief. The degree of peripheral contrast filling may serve as a predictor of treatment success.

Keywords: Liver hemangioma, Therapeutic embolization, Bleomycin, Treatment outcome, Volume reduction rate

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INTRODUCTION

Hepatic hemangiomas (HHs) are the most common benign neoplasms of the liver, with a reported prevalence ranging from 0.4% to 20% in population-based studies [1]. Most HHs are detected incidentally; due to their small size and asymptomatic nature, they typically require no intervention [2–4]. However, "giant" hemangiomas—defined by a large diameter, rapid progression, or compression of adjacent structures—may cause symptoms such as abdominal pain, distension, pressure sensation, and early satiety [5–7]. Although rare, spontaneous rupture is also a potential complication [8].

While surgical resection has traditionally been the standard treatment for giant HHs, the associated risks of significant intraoperative bleeding and postoperative morbidity have underscored the need for minimally invasive alternatives [1,9,10]. In this context, transarterial embolization (TAE), particularly using a bleomycin–lipiodol mixture, has emerged

as an effective method for achieving symptom control and lesion size reduction [3,6,7,9].

Recent large series, meta-analyses, and regional case reports demonstrate that bleomycin–lipiodol TAE yields an average volume reduction of approximately 70% to 90% within 6 to 12 months, accompanied by substantial symptomatic improvement [6,7,11]. Furthermore, studies by Zhao et al., Torkian et al., and Akhlaghpoor et al. indicate that, unlike surgery, TAE offers a superior safety profile, shorter recovery time, and the feasibility of repeat sessions [3,6,7]. Cumulative data [4] highlight the emerging role of transarterial approaches as viable alternatives to surgery for giant hepatic hemangiomas. Within this framework, we retrospectively evaluated the clinical and radiologic efficacy of TAE in a two-center cohort and compared our findings with the current literature.

MATERIALS AND METHODS

Study design and ethical approval

This retrospective study included patients with HHs who underwent TAE between January 2019 and June 2024 at two tertiary interventional radiology centers. Ethical approval was obtained from the institutional non-interventional research ethics committee (Kütahya Health Sciences University Non-Interventional Clinical Research Ethics Committee, approval number: 2025/09-23, July 14, 2025). The study was conducted in accordance with the Declaration of Helsinki.

Inclusion and exclusion criteria

Eligible patients met the following criteria: age ≥18 years, at least one hepatic hemangioma diagnosed radiologically by dynamic MRI (or CT in cases of contraindication) [12] (Figure 1), and a minimum lesion diameter of 5 cm. For lesions measuring 5–10 cm, treatment was indicated in symptomatic patients (e.g., abdominal pain, fullness) or in cases showing ≥1 cm growth within one year. For lesions ≥10 cm, treatment was indicated regardless of symptoms or progression status.

Exclusion criteria included known malignancy, active coagulopathy (INR ≥1.5 and platelet count <50,000/mm^3), advanced hepatic or renal dysfunction, iodine contrast allergy, or incomplete clinical and imaging data at baseline or follow-up.

Preprocedural assessment

All patients were reassessed by the interventional radiologist who was to perform the procedure. Pre-existing imaging (MRI or CT) was reviewed, and volumetric as well as triaxial measurements were obtained. Four experienced interventional radiologists (two per center) participated in the study, each responsible for performing the procedure and overseeing follow-up. Pre- and post-procedural lesion dimensions were obtained retrospectively from radiology reports, which had been documented by the interventional radiologist who performed each procedure. Each report included the lesion's

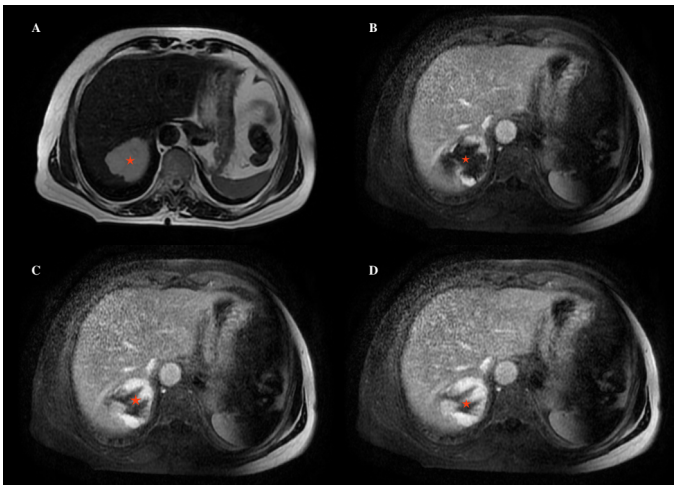

Figure 1. Contrast-enhanced dynamic MRI of the liver in a patient with a right-lobar hepatic hemangioma. A) On the precontrast T2-weighted image, a hyperintense lesion is observed in the right hepatic lobe (marked with a red star). (B–D) Dynamic postcontrast images demonstrate progressive, discontinuous centripetal enhancement, which is characteristic of hepatic hemangioma.

longest diameter and triaxial measurements, from which volumetric data had been calculated using the ellipsoid formula (Volume = 0.52 × length × width × height). These values were verified and recorded from the institutional picture archiving and communication systems (PACS) of both centers.

Embolization procedure

All procedures were performed under local anesthesia without sedation. Vascular access was obtained via the common femoral artery using an 18G needle, followed by placement of a 5–6F vascular sheath with the Seldinger technique. The celiac trunk and/or superior mesenteric artery were catheterized with a Simmons 1 or Cobra 2 catheter over a .035–.038-inch guidewire. Digital subtraction angiography (DSA) was used to evaluate hepatic arterial anatomy. The feeding arteries were catheterized superselectively using a 2.1–2.7F microcatheter and a .014-inch guidewire.

The embolic mixture consisted of 15 mg bleomycin dissolved in 5 mL saline and emulsified with 10 mL lipiodol, yielding a total volume of 15 mL. The solution was prepared by continuous agitation between two syringes connected via a three-way stopcock. It was administered slowly into each feeding artery until reflux was observed (Figure 2). Technical success was defined as full opacification of all feeding arteries and stasis at the end of embolization. No additional embolic materials (particles, coils, or plugs) were used.

Peripheral contrast filling assessment

Angiographic data were retrospectively reviewed from institutional archives. Two interventional radiologists independently evaluated the peripheral distribution of the bleomycin–lipiodol mixture. For standardization, the lesion circumference was divided conceptually into four quad-

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rants, and peripheral filling was categorized as <25%, 25–49%, 50–74%, or ≥75% (Figure 2). Interobserver agreement was assessed using Cohen's kappa coefficient.

Periprocedural monitoring

All patients were monitored for at least 24 hours post-procedure. Vital parameters and potential periprocedural complications were continuously assessed during and after the embolization. Prophylactic antibiotics were administered when indicated. Analgesics and antiemetics were given as needed. No patients required sedation or general anesthesia.

Both acute and delayed complications were prospectively recorded and retrospectively reviewed in accordance with the Society of Interventional Radiology (SIR) Adverse Event Classification System, which enables standardized grading of procedure-related events.

Follow-up protocol

Follow-up was conducted at 1, 3, 6, and 12 months using dynamic contrast-enhanced MRI (or CT if MRI was contraindicated). At each visit, the longest axis, triaxial measurements, and lesion volume were recorded. Symptomatic patients were also assessed for persistence or resolution of clinical complaints. All patients were followed for at least 12 months after the procedure, and imaging assessments were standardized to the 12-month time point to ensure consistent evaluation across the cohort.

Statistical analysis

No a priori sample size calculation was performed because of the retrospective design. Post-hoc power analysis was conducted using G*Power 3.1 to evaluate the achieved statistical power based on the observed effect size between peripheral filling subgroups.

All statistical analysis was performed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). The normality of continuous variables was assessed using the Kolmogorov–Smirnov or Shapiro–Wilk tests depending on sample size, complemented by visual inspection of histograms and Q–Q plots. Normally distributed variables were expressed as mean ± standard deviation (SD), whereas non-normally distributed variables were summarized as median [interquartile range (IQR)]. Categorical variables were expressed as counts and percentages.

Temporal changes in lesion VRR and diameter reduction ratio were evaluated using repeated-measures ANOVA, followed by Bonferroni-adjusted pairwise comparisons. The independent-samples t-test was applied to compare 12-month VRR values according to the number of treatment sessions, baseline symptom status, and lesion size categories (5–10 cm vs >10 cm). Comparisons among peripheral filling pattern groups (<25%, 25–50%, 50–75%, >75%) were performed using one-way ANOVA, followed by post-hoc Tukey tests.

For non-normally distributed parameters the Mann–Whitney U test was used. Chi-square testing assessed associations between categorical variables. Correlations between continuous variables were analyzed with Spearman's rank-order and Pearson's correlation coefficient. To further evaluate the predictive role of peripheral contrast filling on 12-month VRR, a simple linear regression analysis was performed. Interobserver agreement between the two radiologists who categorized peripheral filling was assessed using Cohen's kappa ($\varkappa$). Statistical significance was defined as $p<.05$.

RESULTS

A total of 74 HHs were treated in 41 patients included in the inital study cohort; however, one patient was identified as a statistical outlier and excluded from the final analysis. Accordingly, 73 HHs in 40 patients were included in the evaluated dataset. The median age of the patients was 51 years (IQR: 47-56), and the majority were female (32/40; 80%), while 8 patients (20%) were male. The mean pre-procedural longest lesion diameter was 8.57±0.53 cm (range: 5.1–17.0 cm), and the median baseline lesion volume was 178.32 cc (IQR: 62.49–376.02). When evaluated on a per-patient basis, lesion location was right-lobar in 28 patients (70 %), left-lobar in 9 patients (22.5%), and bilateral in 3 patients (7.5%). A single lesion was detected in 24 patients (60.0%), while multiple lesions were present in 16 patients (40.0%) (Table 1).

The mean follow-up duration for the entire cohort was 21.7±10.3 months (range, 12–48 months). For uniformity of analysis, outcomes were primarily evaluated at the 12-month time point, which was completed by all patients. During the available follow-up period, no lesion regrowth or new lesion development was observed. Across all procedures, the mean administered volume of the prepared bleomycin–lipiodol mixture was 15.93 ± 9.71 mL (median: 15 mL; range: 5–41 mL), and the average bleomycin dose per session was calculated as 12.06 mg (Table 2).

A single-session TAE was sufficient in 30 patients (75.%), whereas 10 patients (25%) underwent multiple treatment sessions. Among those requiring more than one session, five had multiple lesions; in three patients, a single lesion could not be fully embolized in one session due to the recommended maximum dose per procedure; and in two patients, additional sessions were performed due to insufficient volume reduction observed during follow-up.

At least one symptom was observed in 31 patients (77.5%). The most commonly reported symptom was pain, present in 27 patients (67.5%), followed by a sense of pressure in 15 patients (37.5%), abdominal distension in 10 patients (25%), and early satiety in 5 patients (12.5%) (Table 2). Patients presenting with a sensation of pressure or abdominal distension had significantly larger pre-procedural lesion volumes ($p=.02$ and $p<.01$, respectively). In contrast, lesion volume was not significantly associated with the presence of pain ($p=.18$) or early satiety ($p=.17$). Additionally, pressure sensation ($p<.01$), distension ($p<.01$), and early satiety ($p=.04$)

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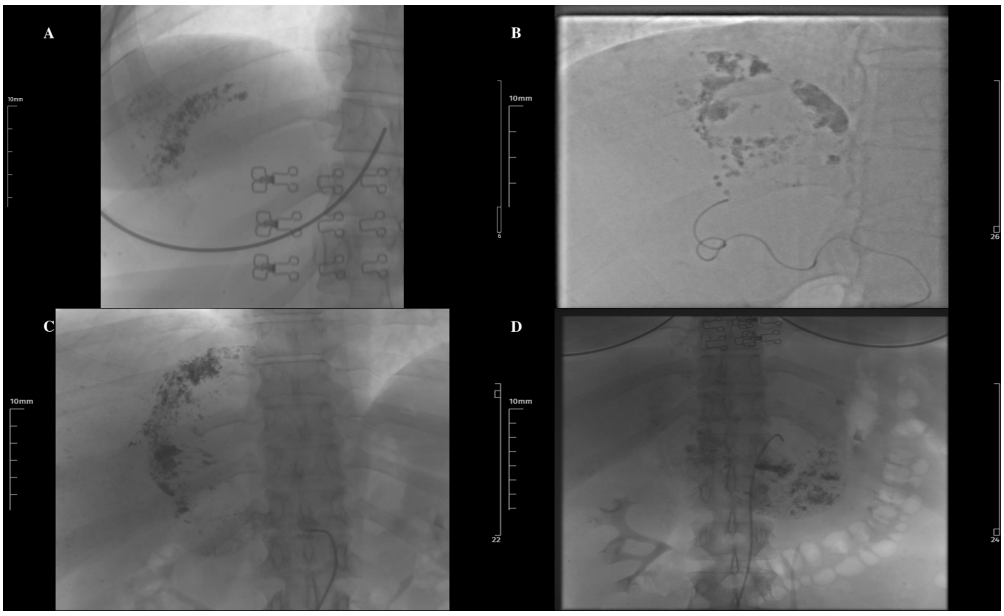

Figure 2. Angiographic images demonstrating variations in peripheral enhancement patterns of hepatic hemangiomas treated with bleomycin–lipiodol embolization. (A) In a patient with a lobulated hemangioma located in the right hepatic lobe, peripheral enhancement was assessed as 50–74%. (B) In another patient, the lesion demonstrated peripheral enhancement greater than 75%. (C–D) Images from a patient who underwent embolization in two separate sessions for a hemangioma supplied by branches of both the right and left hepatic arteries. Peripheral enhancement ranged between 25% and 49% on different angiographic projections.

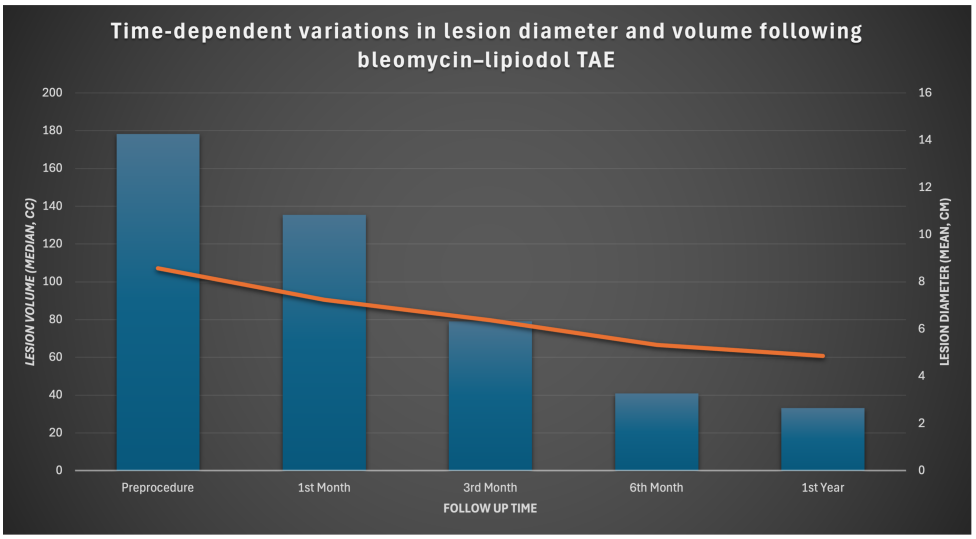

Figure 3. Temporal changes in median lesion volume and maximum diameter following transarterial embolization. The chart depicts median lesion volume (left Y-axis, blue bars) and mean maximum diameter (right Y-axis, orange line) at five time points: baseline (pre-procedure), and 1st, 3rd, 6th, and 12th months post-embolization. Both parameters demonstrated a gradual and consistent decline throughout the follow-up period, indicating a sustained volumetric and morphologic response to embolization.

were more frequently observed in patients with large lesions located in the left hepatic lobe. At the 12-month follow-up, complete symptomatic resolution was achieved in 29 of 31 symptomatic patients (93.5%), while partial improvement was observed in 2 patients.

The mean VRR values at 1, 3, 6, and 12 months were calculated as .32 ± .22, .53 ± .23, .69 ± .19, and .75 ± .16, respectively (Table 3). Repeated-measures ANOVA showed a statistically significant increase in VRR over time ($F[3,120] = 144.29$, $p<0.001$, $\eta^2 = 0.79$). Pairwise comparisons revealed significant improvement between each consecutive time point ($p<0.001$ for all). In parallel, mean diameter reduction ratios were recorded as .17 ± .13, .27 ± .14, .39 ± .16, and .44 ± .15 at the same follow-up intervals, showing a similarly significant trend over time ($F[3,120] = 86.19$, $p<0.001$, $\eta^2 = 0.69$). At the one-year follow-up, the mean long-axis diameter of the lesions was approximately 4.86 ± 2.27 cm, and the median lesion volume was calculated as 33.14 cc (IQR 8.87-102.76) (Figure 3 and 4). The number of cases with a VRR ≥50% was 36 (90%) at 12 months, 32 (80.0%) at 6 months, 22

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Table 1. Patient demographics and baseline lesion characteristics.

Variable	Value
Total number of patients	40
Total number of lesions	73
Age (years)	51 [47–56]
Gender (F/M)	32 / 8
Presence of symptoms (at least one)	31 (77.5%)
Pain	27 (67.5%)
Sense of compression	15 (37.5%)
Distention	10 (25%)
Early satiety	5 (12.5%)
Preprocedural maximum lesion diameter (cm)	8.57 ± 0.53 (range: 5.1–17.0)
Preprocedural lesion volume (cc)	178.32 [62.49–376.02]
Lesion location (Right/Left/Bilateral)	28 / 9 / 3
Number of lesions (Single/Multiple)	24 / 16

Table 2. Procedural protocol, technical parameters, peripheral distribution pattern, and complication analysis.

Parameter	Details
Embolic agent	Bleomycin–lipiodol emulsion
Total bleomycin amount (mg)	15.93 ± 9.71 (range: 5–41)
Average bleomycin dose per session (mg)	12.06
Number of sessions (Single / Multiple)	30 / 10
Technical success	100%
Postprocedural monitoring	Average 24-hour hospitalization
Prophylactic medication	Antibiotics ± analgesics / antiemetics
Peripheral enhancement pattern (%)	
25–49%	7 patients (17.5%), mean VRR: .61
50–74%	12 patients (30%), mean VRR: .66
≥75%	18 patients (45%), mean VRR: .85
Complications	Pain (15%), PES (10%), total: 25%; no long-term events

PES = Postembolizasyon sendromu; VRR = Volume Reduction Ratio.

Table 3. Volumetric reduction ratio, diameter reduction rate, and time-series analysis.

Follow-up Time Point	Diameter (cm, mean±SD)	Volume (cc, median [IQR])	Diameter Reduction Rate (mean±SD)	Mean VRR (mean ±SD)	Patients with VRR ≥50% (n, %)
1st month	7.24 ± 3.19 (2.7–14.0)	135.46 [34.32-287.07]	.17 ± .14	.32 ± .24	8 (20.0%)
3rd month	6.37 ± 2.83 (2.2–12.5)	79.05 [19.03-200.24]	.27 ± .14	.53 ± .23	22 (55.0%)
6th month	5.32 ± 2.53 (1.5–11.5)	40.87 [11.73-131.04]	.39 ± .16	.69 ± .19	32 (80.0%)
12th month	4.86 ± 2.27 (1.3–11.5)	33.14 [8.87-102.76]	.44 ± .15	.75 ± .16	36 (90.0%)

(55%) at 3 months, and 8 (20%) at 1 month.

Twelve-month VRR outcomes did not differ significantly according to the number of TAE sessions performed (single vs. multiple, p=0.92) or the categorized lesion sizes (5–10 cm vs. >10 cm, p = 0.46). When patients were stratified by baseline symptom status, those who presented with clinical symptoms tended to show higher volumetric reduction ratios at 12 months compared with asymptomatic individuals; however, this difference did not reach statistical significance (p=0.06).

A statistically significant difference was observed in 12-month VRR values across peripheral filling pattern groups (one-way ANOVA, p<.01). Accordingly, the mean VRR was calculated as .85 in patients with 75% peripheral filling, .66 in the 50–74% group, and .61 in the 25–49% group. Subgroup analysis revealed that patients with ≥75% peripheral filling exhibited significantly greater VRR values than those in the 50–74% and 25–49% groups (p<.001) (Figure 5). A strong positive correlation was observed between VRR and the degree of peripheral contrast filling (r=0.64, p<0.001). Linear regression analysis further confirmed that the extent of peripheral contrast filling was a significant predictor of 12-month VRR (β=0.627, p<0.001). The overall regression model was statistically significant (F[1,38] = 24.67, p<0.001), explaining approximately 39% of the variance in volumetric response (R^2=0.39). Interobserver agreement between the two radiologists who performed the peripheral filling pattern classification was very high, with a Cohen's kappa coefficient of .875 (p<.01). Post-hoc power analysis for the comparison

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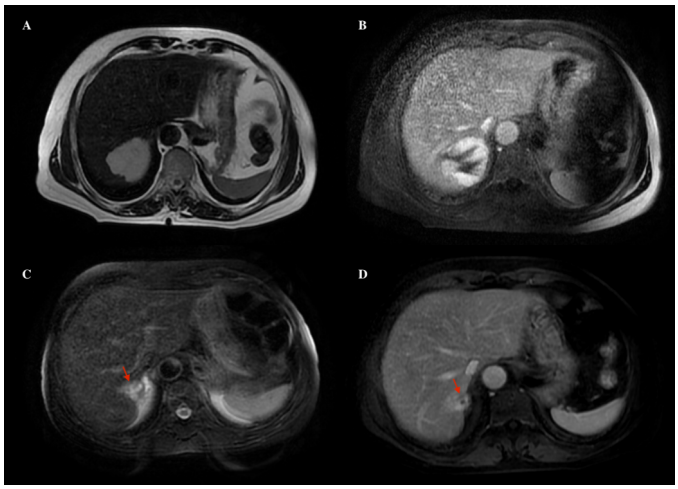

Figure 4. MRI follow-up of the same patient shown in Figure 1, demonstrating treatment response after TAE with a bleomycin–lipiodol emulsion. (A, B) Pre-procedural MRI reveals a lobulated, hyperintense hemangioma in the right hepatic lobe on axial T2-weighted imaging (A) and typical peripheral nodular enhancement on post-contrast T1-weighted imaging (B). (C, D) Corresponding 12-month follow-up images show marked volumetric regression, with near-complete resolution of the lesion on both T2-weighted (C) and post-contrast T1-weighted (D) sequences, consistent with a favorable therapeutic response.

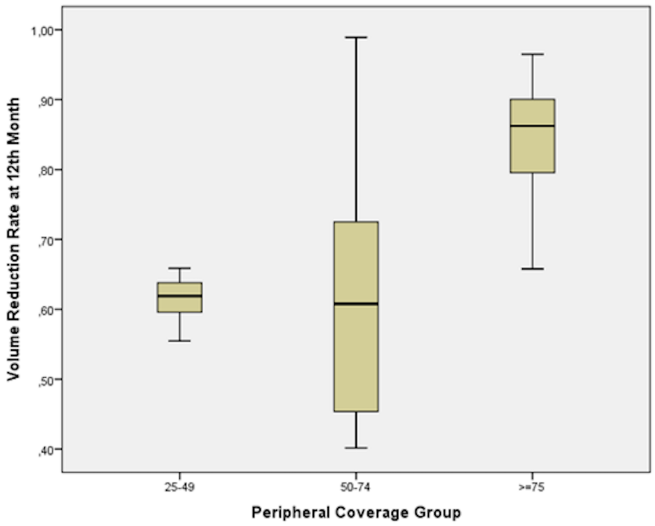

Figure 5. Box plot of 12-month volume reduction ratio (VRR) according to peripheral Lipiodol--bleomycin coverage. Significantly higher VRR was observed in patients with ≥75% peripheral coverage compared to lower coverage groups (p<.01).

of ≥75% and <75% peripheral filling groups demonstrated a large effect size (Cohen's d=1.54) and an achieved power of 0.999 at α=0.05 (two-tailed).

The most common acute complications observed in the post-procedural period were postprocedural pain (n = 6; 15%) and postembolization syndrome (n = 4; 10%), while no acute complications were noted in 30 patients (75%). There was no statistically significant difference in 12-month VRR values between patients with and without acute complications (t test, p=.52). Symptomatic management for patients with complications included paracetamol or NSAIDs, with opioid analgesics and antiemetics added as needed. Complete clinical recovery was achieved in all patients within 24–48 hours, and no long-term complications, including bleomycin-related pulmonary toxicity, were reported during follow-up. All complications were classified as minor (Grade A–B) according to the SIR Adverse Event Classification System, and no major adverse events were encountered.

DISCUSSION

This two-center retrospective study demonstrated that TAE with a bleomycin–lipiodol emulsion is a safe and effective treatment for giant HHs. At the 12-month follow-up, the mean volumetric reduction ratio (VRR) reached 75%, with nearly 90% of patients achieving a VRR ≥50%, accompanied by complete resolution of symptoms in 93.5% of symptomatic patients. Importantly, a significant correlation was found between the extent of peripheral contrast filling and VRR, suggesting that this angiographic parameter may predict treatment response.

The findings of this study are consistent with previous reports in the literature. The study population had a median age of 51 years, and females represented 80% of the enrolled cases. This demographic distribution is consistent with previously reported data in the literature [3,5,6,10,11,13]. The mean pre-procedural long-axis diameter of the lesions was 8.6 cm (range: 5.1–17.0 cm), and the median volume was 178 cc, both of which are comparable to findings reported in similar studies [3,5,14].

Among the 40 patients who underwent bleomycin–lipiodol–based TAE, the proportion of cases achieving ≥50% volume reduction at 12 months was calculated as 90%. This rate is in line with previous studies in the literature, which have reported similar outcomes ranging between 70% and 90% [3,5,6,10,11,14–16]. In a meta-analysis by Torkian et al. [7], the proportion of cases achieving >50% volumetric response within 6–12 months of follow-up was reported to range between 70% and 92%. These findings indicate that the 90% response rate observed in the present series is consistent with large Asian and Western cohorts, as well as with regional case series.

Evaluation of the sequential follow-up data in the present study demonstrated a gradual increase in mean VRR values, measured as 32% at 1 month, 53% at 3 months, 69% at 6 months, and 75% at 12 months, with the difference found to be statistically significant. Similarly, Zhao et al. [6] reported VRR values of 28%, 50%, 70%, and 78% at the corresponding follow-up intervals. In the series by Pehlivan et al. [11], mean VRRs were reported as 65% at 6 months and 74.6% at 12 months. The study by Yuan et al. [16] further supports this gradual trend in early volume reduction, with VRRs of 53% and 69% reported at 3 and 6 months, respectively. This sequential pattern of volume reduction suggests that the bleomycin–lipiodol TAE protocol may provide

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a time-dependent and sustained volumetric response in the treatment of giant HHs. However, additional long-term data beyond 12 months, supported by larger case series, are warranted to more accurately evaluate the durability of treatment efficacy and the potential risk of lesion regrowth.

A recent study by Kutlu et al. [17] reported that significant volume reduction may also occur in nontarget hemangiomas following bleomycin–ethiodized oil embolization, suggesting a possible systemic or microcirculatory effect of the agent. Although our analysis focused on embolized target lesions, some patients in our cohort had multiple hemangiomas, and retrospective volumetric data of untreated lesions were not systematically collected. Future studies designed to evaluate both target and nontarget lesion responses could further clarify the broader therapeutic impact of this technique.

In the present series, at least one symptom was present in 77.5% of patients prior to the procedure. The most frequently reported complaint was pain (67.5%), followed by a sense of pressure (37.5%), abdominal distension (25%), and early satiety (12.5%). This symptom distribution is consistent with the clinical profiles reported in the series by Zhao et al. and Akhlaghpoor et al., in which pain and a sense of pressure were among the most common symptoms, whereas distension and early satiety were observed less frequently [3,6].

In this study, the finding that patients experiencing a sense of pressure and abdominal distension had significantly higher mean lesion volumes is consistent with previous reports by Akhlaghpoor et al. and Kacała et al., which suggest that mechanical compression in large-volume giant hepatic hemangiomas may play a key role in the development of symptoms [3,5]. Additionally, symptoms such as a sense of pressure, distension, and early satiety were more frequently observed in patients with large lesions located in the left hepatic lobe compared to those with right-lobe involvement. This observation is in line with the interpretation provided by Kacała et al. [5], which emphasized a potential association between lesion location and symptomatology.

The rate of symptomatic improvement following treatment was 93.5%, which aligns with many previous studies reporting rates above 90% [3,6,11,13–15]. Recent literature also highlights that the majority of symptoms resolve after TAE, and any remaining minor complaints are typically manageable with conservative treatment approaches [2,5,18]. Although not statistically significant, symptomatic patients showed a trend toward greater volumetric reduction compared with asymptomatic individuals. Previous studies have not analyzed volumetric outcomes in relation to symptom status, and our findings provide preliminary data on this relationship.

In recent years, technical factors have been increasingly emphasized as critical determinants of volumetric treatment success. In this study, the extent of bleomycin–lipiodol distribution around the lesion was evaluated based on a visually assessed peripheral filling score. The proportion of cases demonstrating ≥75% peripheral distribution was 55%, and this group showed significantly higher 12-month VRR values compared to the 50–74% and 25–49% groups (p<.001). Similarly, in the study by Akhlaghpoor et al., complete circumferential distribution of the lipiodol–bleomycin emulsion was achieved in 37.9% of cases, and this subgroup demonstrated significantly higher rates of volume reduction than other distribution pattern groups (p=.04) [3]. In the series by Kacała et al., extensive (>75%) peripheral distribution of the bleomycin–lipiodol mixture was reported in 77.5% of cases, and this was emphasized as a potential determinant of technical success [5]. The findings of the present study are consistent with these reports and further support them with quantitative subgroup analyses.

Consistent with these reports, the findings of the present study further support the role of peripheral contrast filling as a potential determinant of volumetric response. In our analysis, the degree of peripheral contrast filling showed a significant positive correlation with 12-month VRR (r = 0.64, p<0.001). Linear regression analysis also indicated that peripheral filling was significantly associated with VRR, accounting for approximately 39% of the observed variance (R^2=0.39, β = 0.63, p<0.001). These results suggest that a more extensive peripheral distribution of the bleomycin–lipiodol emulsion during embolization may contribute to greater volume reduction, although additional studies with larger cohorts are needed to confirm this relationship.

The overall postprocedural complication rate was 25%, with the most common adverse events being postprocedural pain (15%) and postembolization syndrome (10%). In the literature, complication rates have been reported to range between 18% and 25% [3,6,11,13]. All complications in this series were managed conservatively, and no long-term persistent complications were observed. Although systemic bleomycin exposure is theoretically associated with pulmonary toxicity, the intraarterial route and low total dose used in embolization procedures substantially minimize this risk. Previous series have also reported no cases of pulmonary fibrosis or systemic toxicity after bleomycin–lipiodol embolotherapy [3,6,13]. Consistent with these findings, no respiratory complications or laboratory abnormalities suggestive of bleomycin toxicity occurred in our study population.

Limitations

The primary limitations of this study stem from its retrospective nature, the inherent subjectivity of symptom evaluation, and the operator-dependent interpretation of peripheral contrast distribution. Although all patients completed at least 12 months of clinical and imaging follow-up, long-term outcomes beyond this period were not systematically assessed; therefore, potential late regrowth could not be fully evaluated. Volumetric measurements were derived from manual calculations obtained from radiology reports, and automated or semi-automated segmentation software was not em-

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ployed, which may have introduced minor variability in measurement reproducibility. Furthermore, in patients with multiple lesions, the potential volumetric response of nontarget hemangiomas could not be assessed, as quantitative data were available only for embolized target lesions. Despite these limitations, the relatively large sample size, consistent volumetric follow-up, a high rate of VRR success exceeding 50%, and the strong concordance with published literature support the contribution of this series to the existing body of evidence on bleomycin–lipiodol–based TAE protocols. Future prospective, multicenter studies with extended follow-up are warranted.

CONCLUSION

Our findings demonstrate that TAE with a bleomycin–lipiodol emulsion is an effective non-surgical treatment option for giant hepatic hemangiomas, achieving substantial volume reduction (≥50%), marked symptomatic improvement, and a favorable safety profile.

Ethics Committee Approval: The study was approved by Kütahya Health Sciences University Non-Interventional Clinical Research Ethics Committee (Decision number: 2025/09-23, July 14, 2025).

Informed Consent: This was a retrospective study based on anonymized medical records. Therefore, informed consent was not required.

Peer-review: Externally peer-reviewed.

Conflict of Interest: The authors declare that they have no conflict of interest.

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