

Clinical Presentation and Surgical Management of Liver Hemangioma: A Single-center Retrospective-prospective Study of 101 Cases

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Abstract: The aim of this study was to evaluate the correlation between tumour size and the clinical manifestation of hepatic hemangiomas, with the overarching goal of improving criteria for surgical decision-making. This study was conducted at the Surgery Clinics of the Military Medical Academy in Sofia, Bulgaria, between 2010 and 2023, and analysed clinical presentation, imaging diagnosis, and surgical management of hepatic hemangiomas in 101 patients based on prospective and retrospective data. Approximately 58.42% of patients presented with such symptoms as abdominal discomfort, and palpable masses during examination, while another 31.68% incidentally discovered the condition, highlighting the importance of routine imaging. Statistical analyses revealed a very strong positive correlation between the tumour size and the intensity of clinical symptoms (Spearman's $r_s=0.628$, $p<0.001$) and hence, larger lesions were more likely to produce symptomatic manifestations. It was further shown through logistic regression that patients above 75 years had an 18-fold increase in the chances of diagnostic uncertainty than younger patients (odds ratio = 18.8%, confidence interval: 1.5–217.8, $p=0.023$). Despite the presence of variations in tumour size and presentation, operative outcomes remained consistent across both symptomatic and asymptomatic groups. These findings provided a robust rationale for the implementation of a standardized, size-based classification system to guide clinical decision-making and personalized treatment strategies. The results of this study provide practical guidance for improving the selection criteria for surgical intervention in hepatic hemangiomas, enabling clinicians to better stratify patients based on tumour size, symptomatology, and diagnostic clarity.

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Introduction

Hepatic hemangiomas remain the most common benign tumours of the liver, with detection rates having significantly increased due to the widespread adoption of modern imaging technologies. Their incidence ranges from 0.4 to 20%, with small lesions often asymptomatic and found incidentally during routine imaging. Larger hemangiomas (>5 cm) pose a higher risk of complications, such as hemorrhage and organ compression (Kacała et al., 2024). Despite their predominantly asymptomatic course, large lesion size, atypical localization, or nonspecific clinical manifestations create considerable diagnostic and management challenges for clinicians (Garnica Moreno et al., 2025; Klymenko, 2025). The lack of unified risk stratification criteria, variations in recommendations regarding active intervention or surveillance, and insufficient standardization of diagnostic algorithms underscore the need for a deeper analysis of this issue.

Management approaches for hepatic hemangiomas vary considerably across countries (Tutchenko et al., 2024b; Díaz-Pérez, 2025). According to Cai et al. (2020), in clinical practice across Asia, a tumour size greater than 5 cm is considered the primary indication for surgical intervention, regardless of clinical symptomatology. In contrast, Aziz et al. (2022) report that in the United States, a conservative surveillance strategy is favoured for tumours up to 10 cm in size, provided that imaging findings remain stable over time. In European centres, as outlined by Mamone et al. (2020), particular emphasis is placed on accurate differential diagnosis using contrast-enhanced ultrasound and magnetic resonance imaging (MRI), which helps to minimize the number of unnecessary surgical interventions. A multidisciplinary approach that integrates clinical, morphological, and patient age-related factors into decision-making has also been increasingly adopted, as demonstrated by Reguram et al. (2024).

Among the most notable advances, the development of minimally invasive surgical techniques has received particular attention. Based on the findings of Yan et al. (2021), laparoscopic resections of hepatic hemangiomas are associated with reduced intraoperative blood loss, shorter hospitalization times, and lower rates of postoperative complications compared to traditional open procedures. The advantages of robot-assisted surgery have been confirmed by Zhang et al. (2023a), who demonstrated that, in cases of large hemangiomas or complex anatomical localization, the use of robotic technologies allows for better functional outcomes. The role of modern imaging modalities is highlighted by the study

of Zhang and Liu (2021), which demonstrated that the use of contrast-enhanced ultrasound, computed tomography (CT), and MRI significantly improves the accuracy of initial verification of hemangiomas and reduces the number of diagnostic errors.

Despite significant progress in the refinement of diagnostic methods and surgical technologies, current studies on hepatic hemangiomas present several limitations. As noted by Maruyama et al. (2023), data on the long-term outcomes of surveillance for asymptomatic lesions remain limited, complicating the formulation of unified management recommendations for this patient group. According to Triana et al. (2020), the absence of standardized diagnostic criteria across different imaging modalities contributes to an increased risk of diagnostic errors. At the same time, the study by Zhang et al. (2023b) was the first to comprehensively highlight the importance of updated surgical indications and multidisciplinary assessment for the management of benign hepatic tumours, although the consistent application of such models remains limited due to variability among clinical centres.

The gaps in current research on hepatic hemangiomas involve the absence of clear risk stratification criteria for the development of symptoms and complications, insufficient standardization of diagnostic algorithms, and incomplete unification of approaches for choosing between conservative and surgical treatment. The objective of this study was to establish the relationship between hepatic hemangioma size and the presence of clinical symptoms in order to optimize treatment decision-making. The tasks of the study included evaluating the diagnostic accuracy of modern imaging methods, analysing the effectiveness of different surgical approaches, and determining the role of size-based tumour classification in improving treatment outcomes.

Literature review

Hepatic hemangiomas were defined as the most common benign tumours of the liver, originating from congenital vascular malformations (Figure 1). According to Leon et al. (2020), these lesions were characterized by slow growth and a predominantly asymptomatic course, although large tumours could cause clinical symptoms such as pain, compression of adjacent structures, or risk of rupture. A significant contribution to the development of hepatic hemangioma diagnostics was made by Mamone et al. (2020), who demonstrated the effectiveness of modern imaging methods, particularly contrast-enhanced ultrasound and magnetic resonance imaging using dynamic contrast protocols. The characteristic

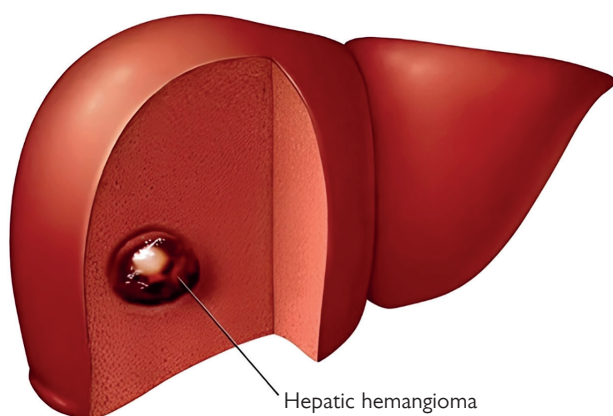


Figure 1: Hepatic hemangioma. Source: Mayo Clinic (2025).

contrast enhancement during the venous phase was shown to allow highly accurate differentiation of hemangiomas from other focal liver lesions.

The improvement of differential diagnosis was further explored by Liu et al. (2020), who compared the clinical and MRI features of hepatic hemangiomas, epithelioid hemangioendotheliomas, and angiosarcomas. Their findings revealed that specific contrast-enhancement patterns and morphological characteristics effectively distinguished hemangiomas from malignant liver tumours. Complementary to these advancements, Wu et al. (2020) first demonstrated the high diagnostic value of colour contrast-enhanced ultrasound for differentiating atypical hemangiomas from liver metastases, using a novel type of contrast agent that provided detailed hemodynamic profiles and significantly improved diagnostic precision in challenging clinical cases.

The application of a multidisciplinary diagnostic approach was emphasized by Sandulescu et al. (2021), who proposed the “one-stop-shop” concept, integrating ultrasound, computed tomography, and MRI findings into a unified diagnostic pathway. This method was shown to shorten diagnostic times and enhance diagnostic reliability. Meanwhile, the prevalence of hepatic hemangiomas was comprehensively assessed by Vojnović et al. (2024), who identified a frequency ranging from 0.4 to 7.3% among the general population based on ultrasound examinations. Most lesions were asymptomatic, reinforcing the need for standardized risk stratification to guide management decisions.

The establishment of treatment strategies for hepatic hemangiomas remained a significant area of investigation. Cai et al. (2020) demonstrated that tumour size played a decisive role in clinical outcomes, with hemangiomas larger than 5 cm associated with higher risks of symptoms and complications, thereby often requiring surgical intervention. Aziz et al.

(2022) expanded on this understanding by advocating conservative management for asymptomatic tumours up to 10 cm, provided no growth or changes were detected during surveillance, while also highlighting the critical need for vigilant monitoring.

The comparison of surgical techniques was comprehensively analysed by Jien and Xiaohua (2021), who demonstrated that laparoscopic resections were superior to open surgeries in terms of lower intraoperative blood loss, shorter hospital stays, and reduced postoperative complications. Further technological advancements were detailed by Cassese et al. (2024), who highlighted the benefits of robot-assisted liver resections, including enhanced surgical precision, better visualization of anatomical structures, and lower complication rates, particularly in anatomically complex cases.

Alternative minimally invasive strategies were proposed by Brancel and Massa (2024), who emphasized the role of vascular pedicle embolization and radiofrequency ablation in managing large hepatic hemangiomas. These approaches were shown to reduce tumour volume, facilitate subsequent surgeries, or, in some cases, obviate the need for surgical resection altogether. However, these methods were not used in the current study. The decision to exclude these alternatives was based on the characteristics of the patients and the size of the tumours. Given the size of the hemangiomas in the study cohort, surgical resection or enucleation was considered the most effective option. Additionally, the limitations of non-surgical methods in cases involving larger lesions or complicated anatomies influenced the treatment approach, as these techniques may not have provided sufficient long-term outcomes or may have required subsequent surgical intervention. Finally, the extensive clinical experience with the management of giant hepatic hemangiomas was summarized by Farhat et al. (2021), who demonstrated the safety and effectiveness of both resection and enucleation strategies, contingent upon meticulous preoperative planning and appropriate patient selection.

Recent advances in the diagnosis and treatment of hepatic hemangiomas have significantly improved patient management, particularly through the implementation of modern imaging techniques and minimally invasive approaches. However, the literature indicated persistent challenges related to differential diagnosis, risk stratification, and the standardization of surgical indications. Variations in clinical practices and limited data on long-term outcomes were also noted. These findings justified the need to refine risk stratification models and formed the basis for the present study, aimed at establishing the relationship between tumour size and clinical symptoms.

Material and Methods

Study design and setting

This monocentric study was conducted at the Surgery Clinics of the Military Medical Academy in Sofia, Bulgaria, between 2010 and 2023. A total of 101 patients who underwent radical resection or enucleation were examined. Patient sample composition allowed for prospective (n=52 cases) and retrospective (n=49 cases) cohorts. Hence, full analysis of clinical outcome was performed during the 13-year-long period.

Patient selection and inclusion criteria

Patients were eligible for inclusion if they had a confirmed diagnosis of cavernous liver hemangioma based on imaging studies, including ultrasound, computed tomography, and magnetic resonance imaging. The concurrence of diagnostic findings across these modalities served as the primary inclusion criterion. Additionally, patients presenting with clinical symptoms such as abdominal pain, palpable mass, or abdominal discomfort were eligible for enrolment. Incidental detection of liver hemangiomas during routine imaging or intraoperative exploration also constituted a basis for inclusion. Exclusion criteria comprised incomplete clinical documentation and alternative diagnoses of hepatic lesions.

Patient cohort characteristics

The cohort comprised 101 patients stratified by mode of detection (Table 1).
For all included patients, data were collected on demographic characteristics (age and gender), tumour features (size, number, and anatomical localization), and surgical indications, which were classified as absolute or relative according to clinical guidelines. Patients were further stratified by age into six predefined categories: 25–34 years, 35–44 years, 45–54 years, 55–64 years, 65–74 years, and

Table 1: Patient detection and symptom profile

Category	Number	Percentage (%)
Symptomatic	59	58.42
Incidentally detected (preoperative)	32	31.68
Intraoperative finding	10	9.90
Total	101	100.00

Source: compiled by the authors

≥75 years. This age stratification was chosen to evaluate the potential impact of physiological aging on surgical outcomes and symptom development. Patients were also categorized into two groups based on surgical approach: isolated hemangioma resections (pure hemangiomas) and synchronized operations performed concurrently with other surgical procedures.

A comparative analysis was also conducted between symptomatic and asymptomatic patients based on tumour size intervals: 4–9 cm and >10 cm. These specific tumour size categories were selected based on prior clinical evidence suggesting that hemangiomas exceeding 10 cm are more frequently associated with complications and symptomatic presentation, whereas smaller lesions typically remain asymptomatic.

Surgical indications

Absolute indications for surgical intervention included life-threatening conditions such as hemoperitoneum resulting from tumour rupture, intratumoral hemorrhage, consumptive coagulopathy (Kasabach-Merritt syndrome), persistent and medically refractory chronic abdominal pain, mechanical biliary obstruction leading to jaundice, secondary portal hypertension, and tumours larger than 5 cm at risk for traumatic injury (Figure 2). These conditions directly threatened patient survival or caused irreversible

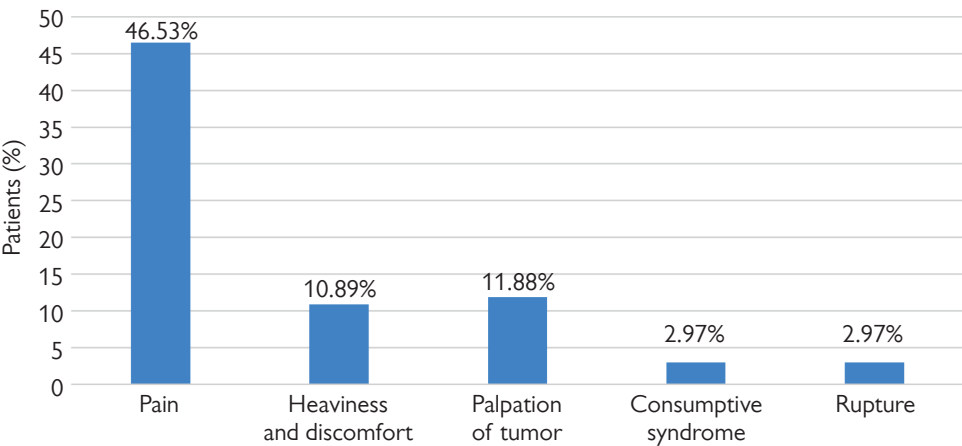


Figure 2: Absolute indications for surgery. Source: compiled by the authors.

organ dysfunction, thereby necessitating surgical management.

Relative indications encompassed progressive tumour enlargement documented on serial imaging, the presence of non-specific but persistent abdominal symptoms affecting quality of life, compression of adjacent organs without overt life-threatening features, and diagnostic uncertainty where malignancy could not be reliably excluded through non-invasive methods. In such cases, surgical intervention was considered to prevent potential future complications or to achieve definitive histological diagnosis.

Preoperative assessment and surgical technique

Preoperative assessment was done using ultrasound, CT, and sometimes MRI, to evaluate the size and localization of the tumour. Intraoperatively, the examiner again confirmed the size of the tumour and proceeded to choose the surgical technique (either resection or enucleation) based on the tumour characteristics and the clinical status of the patient. Both open and laparoscopic techniques were used as clinically indicated.

Statistical analysis

Statistical analyses were performed using nonparametric tests and regression models. The expected frequency for each cell in a contingency table was calculated using the formula (1):

$$E = (\text{Row Total} \times \text{Column Total}) / \text{Grand Total} \quad (1)$$

where: Row Total – the sum of all observed frequencies in the particular row; Column Total – the sum of all observed frequencies in the particular column; Grand Total – the sum of all observed frequencies in the entire table (Shin et al., 2023).

Logistic regression was used to evaluate the effect of age on the risk for an unclear diagnosis. Age contributed the regression coefficient for odds ratio (OR) as follows (2):

$$\text{OR} = e^{\beta} \quad (2)$$

where: β – the regression coefficient for age.

Wald's statistic was used to test the significance of coefficients, and 95% confidence interval (CI) were calculated for precision measuring OR estimates. The chi-square (χ^2) test was applied to assess associations between categorical variables, particularly to evaluate the relationship between incidental detection and symptomatic status. Spearman's rank correlation coefficient was used to determine the strength and direction of the association between tumour size and clinical symptoms. Logistic regression analysis

was conducted to evaluate the effect of age on the likelihood of an unclear diagnosis. An all two-tailed $p < 0.001$ was to be considered statistically significant for any analysis.

Ethical considerations

All imaging and surgical procedures were performed using high-end equipment available at the Surgery Clinics of the Military Medical Academy. Surgeries were conducted by experienced surgical teams specializing in hepatobiliary procedures. The study protocol was approved by the Institutional Ethics Committee of the Military Medical Academy, Sofia (Approval No. 274/2023, issued on January 15, 2023). All patients provided written informed consent prior to inclusion in the study, in accordance with the principles of the Declaration of Helsinki and Good Clinical Practice guidelines. Data collection and statistical analyses were conducted using SPSS software (IBM Corp., Armonk, NY, USA).

Results

Chi-square test for incidental findings

To ascertain whether the incidental detection of a condition was connected to its asymptomatic presentation, a chi-square test was performed using a 2×2 contingency (Table 2).

The observed contingency table indicated that all incidental detections occurred exclusively among asymptomatic patients. Specifically, 39 of the 42 asymptomatic patients were diagnosed through incidental findings, whereas none of the symptomatic patients had an incidental diagnosis. In the asymptomatic group, only 3 patients did not have incidental detection, while in the symptomatic group, all 59 patients presented with clinical symptoms at the time of diagnosis. This disparity, confirmed by a statistically significant chi-square value ($\chi^2 = 17.644$, $p < 0.001$), underscores the critical role of imaging in identifying liver hemangiomas in individuals without overt symptoms. These results support the necessity of routine imaging surveillance, particularly for patients

Table 2: Observed contingency table for incidental detection by symptom status

	Incidental (yes)	Not incidental (no)	Total
Asymptomatic	39	3	42
Symptomatic	0	59	59
Total	39	62	101

Source: compiled by the authors

Table 3: Observed and expected frequencies and contributions to chi-square statistic

Group	Observed frequency (O)	Expected frequency (E)	Contribution to χ^2
Asymptomatic and incidental	39	16.2	32.08
Asymptomatic and non-incidental	3	25.8	20.16
Symptomatic and incidental	0	22.8	22.80
Symptomatic and non-incidental	59	36.2	14.36

Source: compiled by the authors

who do not exhibit clinical signs suggestive of liver hemangioma (Tkachenko et al., 2023; Lytvynenko, 2025). To assess the association between symptom status and incidental detection of liver hemangiomas, the expected and observed frequencies for each cell were calculated according to formula 1, and the contributions to the chi-square. The results are summarized in Table 3.

The data presented in Table 3 demonstrate a marked disparity between symptomatic and asymptomatic patients in terms of incidental detection. Notably, the majority of asymptomatic patients exhibited incidental findings, whereas none of the symptomatic patients were diagnosed incidentally. The cumulative chi-square statistic from preliminary calculations was approximately 89.4. However, the final validated value was $\chi^2=17.644$ with a p-value of less than 0.001. This statistically significant difference underscores the dominant role of imaging in detecting liver hemangiomas in asymptomatic individuals and highlights the necessity for routine imaging surveillance to ensure early diagnosis, even in the absence of clinical symptoms. The distribution of patients with hemangiomas detected using incidental findings versus those detected with relative indications for investigation is illustrated in Figure 3.

Figure 3 illustrates the distribution of relative surgical indications among patients with liver hemangiomas. Incidental findings accounted for the largest proportion of cases (38.61%), followed closely by surgeries performed due to uncertain diagnosis (33.66%). Surgeries initiated based on patient preference (7.92%) and tumour growth (2.97%) were relatively rare. Collectively, these findings highlight that more than 70% of surgical interventions were prompted by imaging-based concerns rather than overt clinical symptoms. This emphasizes the critical importance of accurate diagnostic imaging in the management strategy of asymptomatic liver hemangiomas.

In summary, the analysis confirmed a significant association between asymptomatic presentation and incidental detection of liver hemangiomas, as demonstrated by the chi-square test results. The majority of surgical interventions were initiated either following incidental imaging findings or due to diagnostic uncertainty, rather than the presence of clinical symptoms. These results underscore the critical role of advanced imaging techniques in the identification and management of liver hemangiomas, highlighting the need for standardized diagnostic approaches to optimize patient outcomes.

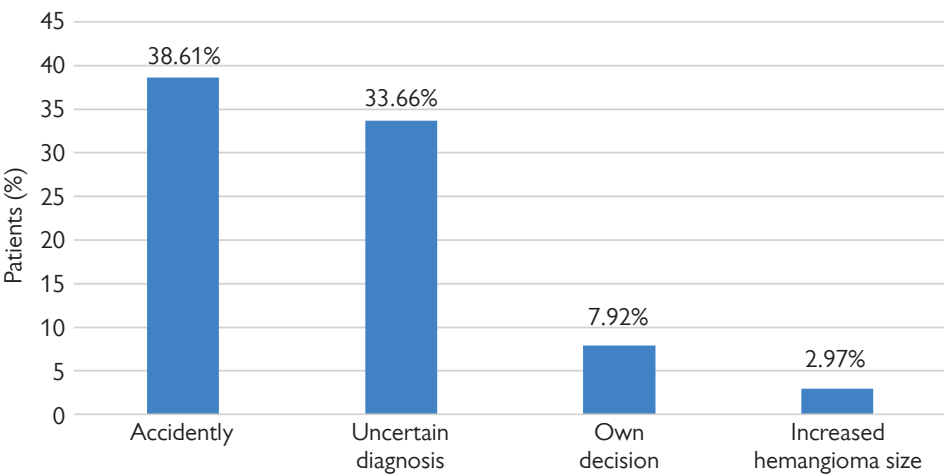


Figure 3: Diagram of relative indications and incidental findings. Source: compiled by the authors.

Correlation between tumour size and clinical symptoms

The correlation between tumour size and clinical symptoms was analysed using Spearman’s rank correlation, as described in the methodology. The correlation coefficients and their statistical significance for the major clinical symptoms are summarized in Table 4.

The results presented in Table 4 demonstrate a positive correlation between increasing tumour size and the presence of clinical symptoms. The strongest association was identified between tumour size and the presence of a palpable mass ($r_s=0.628$, $p<0.001$), indicating that larger hemangiomas are more likely to be clinically detectable during physical examination. In contrast, weaker but statistically significant correlations were observed for other symptoms, suggesting that tumour size moderately influences the development of non-specific manifestations such as abdominal pain and discomfort. The presence of a palpable mass emerged as the most reliable clinical indicator of a larger lesion. The analysis confirmed that tumour size has a significant impact on the development of clinical symptoms, with the detection of a palpable mass being the most strongly associated finding. However, in the present era of advanced imaging techniques, the relevance of a palpable mass as a primary diagnostic tool has decreased (Berezenko et al., 2021;

Table 4: Correlation between tumour size and clinical symptoms

Symptom	Spearman’s rank correlation coefficient	P-value
Abdominal pain	0.269	0.006
Heaviness/discomfort	0.232	0.02
Palpable tumour mass	0.628	<0.001
Consumptive syndrome	0.272	0.006

Source: compiled by the authors

Table 5: Frequency of unclear diagnoses across age groups

Age group (years)	Number of patients	Cases with unclear diagnosis	Percentage (%)
25–34	12	2	16.7
35–44	18	1	5.6
45–54	22	1	4.5
55–64	20	2	10.0
65–74	16	3	18.8
≥75	13	5	38.5

Source: compiled by the authors

Shevchenko et al., 2023). While physical examination remains important as an initial step, imaging techniques such as ultrasound and MRI provide more accurate and comprehensive diagnostic information (Irshad, 2023). As a result, imaging plays a crucial role in confirming and characterizing findings. These results highlight the necessity of considering tumour size as a key parameter in the clinical evaluation and management strategy for liver hemangiomas.

Logistic regression analysis for diagnostic uncertainty and subgroup analysis

To examine the effect of age on the likelihood of an unclear diagnosis, patients were initially stratified into six predefined age intervals. The distribution of unclear diagnoses across these groups is summarized in Table 5.

As shown in Table 5, the highest proportion of unclear diagnoses was recorded in patients aged ≥75 years (38.5%), followed by those aged 65–74 years (18.8%). Although the 25–34 years group had a lower incidence (16.7%), it represented the youngest cohort with a clinically meaningful rate of diagnostic uncertainty. Given the clear contrast between the youngest and oldest patients, logistic regression analysis was specifically conducted comparing the 25–34 years and ≥75 years groups to capture the extremes of age-related diagnostic challenges. The odds ratio was calculated using the formula (2).

In this analysis, patients observed over 75 years were compared with those aged 25–34 years old, yielding an estimated β of nearly 2.89. Therefore: $OR = e^{2.89} \approx 18$ (3). Which indicated that aged patients over 75 years have an 18-fold increase in risk over their younger counterparts of having an unclear diagnosis. The Wald chi-square test produced a value of 5.185 ($p=0.023$), and the 95% CI for the OR was also computed, having an approximation of 1.50–217.8 (Table 6).

Table 6 indicated that patients over 75 years are 18 times more likely to have an unclear diagnosis compared to those aged 25–34, emphasizing the significant influence of age on diagnostic uncertainty. Consequently, incidentally detected asymptomatic

Table 6: Logistic regression results for unclear diagnosis by age

Age group (reference: 25–34 years)	Odds ratio	95% confidence interval	P-value
Over 75 years	18	1.50–217.8	0.023

Source: compiled by the authors

Table 7: Patient detection and symptom profile

Characteristic		Number	Percentage (%)
Gender	women	12	38.70
	men	19	61.30
Ultrasound performed		31	100.00
CT performed		20	64.50
MRI performed		1	3.20
Accidental finding		30	96.80
Unclear diagnosis		22	70.97
Single hemangioma		28	90.30
Multiple hemangiomas		3	9.70
Localization	right lobe	12	38.70
	left lobe	10	32.30
	central	7	22.60
	bilateral	2	6.50
Resection performed		25	80.60
Enucleation performed		6	19.40
Open surgery		22	71.00
Laparoscopic surgery		9	29.00
Postoperative complications		4	12.90

CT – computed tomography; MRI – magnetic resonance imaging
Source: compiled by the authors

patients were analysed to tumour size, thus establishing two groups: those with tumours measuring 4 to 9 cm and those with tumours exceeding 10 cm. The analysis of hemangiomas sized between 4 and 9 cm revealed that the vast majority of these were detected incidentally. The clinical characteristics of these patients are outlined in Table 7.

The analysis of Table 7 showed that the majority of asymptomatic patients with tumours sized between 4 and 9 cm were men (61.3%), and almost all lesions were detected incidentally (96.8%). A high proportion of patients (70.97%) had an unclear preoperative diagnosis. Most tumours were solitary

and predominantly localized in the right or left hepatic lobe. Resection was the preferred surgical method (80.6%), while laparoscopic access was used in 29% of cases. Postoperative complications occurred in 12.9% of patients, mainly represented by minor bile leaks, wound infections, and transient liver dysfunction, all of which were managed conservatively without the need for reoperation. The outcome measures of the surgical subcategories in Table 8 were statistically described.

As illustrated in Table 8, patients with tumours ranging from 4 to 9 cm who were asymptomatic would exhibit comparable outcomes following surgery. The mean operating time was estimated to be approximately 180 min, the mean blood loss was estimated to be approximately 160 ml, and the mean postoperative stay was estimated to be approximately 6.6 days.

The descriptive analysis of asymptomatic patients with tumours measuring 4–9 cm demonstrated favourable perioperative outcomes, with moderate operative times, low intraoperative blood loss, and short postoperative stays. These findings indicate that surgical management of liver hemangiomas in this size range is generally safe and associated with minimal morbidity.

Among asymptomatic patients with liver hemangiomas exceeding 10 cm, 45.5% underwent elective surgical procedures. A significant proportion of these patients (81.8%) had their tumours detected incidentally during imaging studies conducted for unrelated reasons. Despite the absence of clinical symptoms, 36.4% of patients in this subgroup were operated on due to diagnostic uncertainty, where malignancy could not be confidently excluded based on imaging findings. Anatomical analysis revealed that the left hepatic lobe was the most frequently affected site among asymptomatic patients with tumours larger than 10 cm.

Surgical approaches for these larger lesions favoured resection over enucleation, primarily due

Table 8: Descriptive statistics for asymptomatic patients (4–9 cm tumours)

Variable	Mean	Standard deviation (SD)	Standard error (SE)	Median	Range
Age (years)	58.590	15.062	2.705	62	31–80
Size of first hemangioma (cm)	5.390	1.687	0.303	5	4–9
Size of second hemangioma (cm)	5.330	2.309	1.333	4	4–8
Postoperative stay (days)	6.580	3.202	0.575	6	3–17
Operating time (min)	179.800	70.575	12.676	150	90–360
Blood loss (ml)	160.645	78.398	14.081	150	50–300

Source: compiled by the authors

to the size, location, and proximity to major vascular structures. The clinical outcomes in this subgroup were characterized by longer operative times, greater intraoperative blood loss, and prolonged postoperative hospital stays compared to patients with smaller tumours, reflecting the increased technical complexity and perioperative risks associated with larger hemangiomas.

Comparison of operative outcomes between symptomatic and asymptomatic patients, imaging and diagnostic evaluation

Operative findings revealed no significant differences between symptomatic and asymptomatic patients with similar tumour sizes, indicating that the presence of symptoms does not adversely affect the surgical procedure. The postoperative stay, however, remained comparable between the two subgroups. This finding further confirms that the surgical techniques offered are sound and given equally irrespective of symptomatic status.

The preoperative imaging indicated the presence of liver hemangioma. In the 4–9 cm group, ultrasound was performed on all patients, resulting in a detection rate of 100%. Furthermore, 64.5% of patients underwent CT scans to obtain additional anatomical details, while a small proportion (3.2%) had MRIs when deemed necessary. A similar study was implemented in the >10 cm group. The high incidental detection rate observed in both groups underscores the pivotal role of imaging not only in the diagnosis of liver hemangioma but also in the formulation of a surgical plan.

The imaging protocols demonstrated a high degree of efficacy in identifying liver hemangioma instances, while incidental findings supported the notion of implementing routine evaluations even in asymptomatic cases. A noteworthy observation was the exclusive occurrence of incidental findings in asymptomatic patients. For instance, in the 4–9 cm subgroup cancers, 30 out of 31 patients (96.8%) exhibited incidental detection of hemangioma, while in the >10 cm subgroup, 9 patients (81.8%) were diagnosed incidentally. Furthermore, 34 patients (33.66%) proceeded to undergo surgical intervention due to diagnoses that remained unconfirmed. Patients in the older age group were found to be more likely to receive a diagnosis of uncertain clarity, with those over 75 years being 18 times more likely to receive a diagnosis of unclear certainty than those aged 25–34. The high incidental finding rates and diagnostic uncertainty, especially among the elderly, in combination with the difficulty in diagnosing liver hemangioma, underscores the necessity for extensive imaging and evaluations. The operative outcomes were

Table 9: Summary of operative metrics by tumour size

Variable	4–9 cm group (mean)	>10 cm group (mean)
Operating time (min)	179.800	210.00
Blood loss (ml)	160.645	201.82
Postoperative stay (days)	6.580	6.64

Source: compiled by the authors

outlined for the group and compared to the tumour size group (Table 9).

As demonstrated in Table 9, the presence of larger tumour sizes has been associated with an increased duration of surgical intervention and elevated blood loss during the procedure. However, there is no discernible impact on postoperative recovery outcomes amongst the cohorts. This observation serves to reinforce the operational reliability and safety of the employed surgical technique.

In summary, the surgical management of liver hemangiomas demonstrated high safety and efficacy across different tumour sizes and clinical presentations. Although larger tumours were associated with longer operative times and greater intraoperative blood loss, the postoperative recovery remained comparable between patients with smaller and larger lesions. Age and diagnostic uncertainty were found to influence preoperative evaluation, particularly among elderly patients. The high rate of incidental findings highlighted the essential role of advanced imaging modalities in the diagnosis and surgical planning for both symptomatic and asymptomatic cases. Overall, the consistency of operative outcomes across groups reinforces the reliability of the applied surgical strategies.

Discussion

The clinical presentation, diagnostic complexity, and surgical outcomes of hepatic hemangiomas vary considerably depending on tumour size, patient age, and imaging findings, which necessitates a detailed comparison of the present results with recent data from the literature. In the present study, tumour size was found to have a significant impact on the manifestation of clinical symptoms. The strongest correlation was identified between tumour size and the presence of a palpable mass ($r_s=0.628$), indicating that larger hepatic hemangiomas were more likely to be detected during physical examination. Additionally, statistically significant but weaker correlations were established between tumour size and the presence

of abdominal pain ($r_s=0.269$) and a sensation of heaviness or discomfort ($r_s=0.232$). Similar associations were reported by Tang et al. (2021), who demonstrated through multivariate analysis that tumours exceeding 5 cm significantly increased the risk of clinical symptom development and the subsequent need for surgical intervention. Findings by Rajakannu et al. (2021) further confirmed that a palpable mass on physical examination represented the most predictive clinical feature among symptomatic patients. However, the review by Toro et al. (2014) emphasized that despite the general trend of symptom manifestation with increasing tumour size, a substantial proportion of large hemangiomas remained asymptomatic, necessitating individualized decision-making regarding surgical management. The findings of the current study are consistent with the available literature and additionally highlight that while tumour size serves as a crucial factor, it should not be the sole determinant guiding therapeutic strategies.

A high proportion of asymptomatic liver hemangiomas in the present study were detected incidentally during imaging performed for unrelated reasons, with incidental detection rates reaching 96.8% in the 4–9 cm group and 81.8% in tumours larger than 10 cm. These findings highlighted the critical role of routine imaging studies in the early identification of hepatic hemangiomas, particularly among patients without clinical symptoms. This observation corresponded with the results reported by Sultana et al. (2024), who demonstrated that the use of ^{99m}Tc -labeled red blood cell scintigraphy combined with ultrasound significantly improved the diagnostic yield for asymptomatic hemangiomas. Similarly, Kahraman et al. (2024) underscored the diagnostic value of advanced imaging techniques, such as multiphase CT and MRI, in differentiating benign hepatic lesions and reducing diagnostic uncertainty. In the paediatric population, Esposito et al. (2023) confirmed the importance of early radiological detection of liver hemangiomas to avoid unnecessary invasive interventions, emphasizing the applicability of systematic imaging approaches across different age groups.

Logistic regression analysis in the present study revealed that patient age significantly influenced the risk of diagnostic uncertainty. Specifically, patients over 75 years old demonstrated an 18-fold higher likelihood of receiving an unclear diagnosis compared to those aged 25–34 years. This finding indicated that age-related morphological changes in hepatic tissue and the presence of concomitant pathologies in older individuals complicated the interpretation of imaging results. Similar observations were reported by Möller et al. (2022), who noted that in patients

with cirrhosis or age-related parenchymal changes, the diagnostic accuracy for benign liver lesions decreased substantially, often leading to diagnostic dilemmas. Razik et al. (2022) also emphasized that atypical or non-specific radiological features in adults frequently necessitated additional investigations to rule out malignant processes. Furthermore, a systematic review by Longchamp et al. (2021) confirmed that advanced age remains one of the principal risk factors for postoperative complications following hepatic surgery, thereby complicating the management of elderly patients with benign liver tumours.

The finding that 70.97% of asymptomatic patients with 4–9 cm tumours had an unclear preoperative diagnosis highlights a critical diagnostic challenge. This high prevalence aligns with observations by Yildirim et al. (2021), who described accurately characterizing focal liver lesions as a significant burden on healthcare systems due to the risk of missed malignancies. Hepatic hemangiomas, despite being benign, often exhibit atypical imaging features that can closely mimic malignant liver tumours, such as hepatocellular carcinoma or metastases (Kerashvili et al., 2013; Tutchenko et al., 2024a). Vernuccio et al. (2020) stated that these atypical appearances can be ascribed to factors such as large size, fibrosis, calcifications, or thrombosis within the lesion. Furthermore, scholars discovered that unusual MRI characteristics can present in up to 66% of lesions, making definitive identification especially challenging.

Advanced imaging modalities such as contrast-enhanced ultrasonography, CT, and MRI are critical for detecting liver lesions, although their diagnostic accuracy varies, especially for smaller or atypical lesions (Dyba and Berezenko, 2023; Mamontov et al., 2024). According to Kakegawa et al. (2024), the subtle enhancement patterns found in hemangiomas might be difficult to record and interpret using various imaging modalities, potentially leading to misinterpretations. Furthermore, Shin et al. (2023) stated that the common incidental identification of these lesions, typically when imaging for unrelated illnesses, initiates a diagnostic cascade aimed at ruling out malignancy. This process contributes greatly to the high proportion of “unclear diagnoses” until additional conclusive criteria are determined or tissue confirmation is obtained.

Operative outcomes in the present study demonstrated that larger tumour size was associated with prolonged operative times and increased intraoperative blood loss, whereas the length of postoperative hospital stay remained relatively stable across different tumour size groups. Specifically, patients with tumours exceeding 10 cm exhibited a mean operative time of 210 min and an average blood loss of 201.82 ml, compared to 179.8 min and

160.645 ml, respectively, in patients with tumours measuring 4–9 cm. These results aligned with the findings reported by Ju et al. (2020), who showed that enucleation and resection of larger hemangiomas were associated with longer surgeries and greater blood loss, although without a significant impact on postoperative recovery duration. Similarly, Yang et al. (2024) emphasized that involvement of major hepatic vessels in larger lesions considerably extended surgical complexity and operative time but did not necessarily worsen short-term recovery outcomes. Additionally, Fuchs et al. (2020) highlighted that careful preoperative planning and the use of minimally invasive techniques could mitigate some of the risks associated with larger tumour resections, although these procedures remained technically demanding. The results of the present study confirmed that while larger hemangiomas increased intraoperative challenges, they did not critically affect postoperative hospitalization, reinforcing the efficacy and safety of current surgical approaches for liver hemangiomas.

The results of the present study provided comprehensive insights into the clinical presentation, diagnostic challenges, and surgical management of hepatic hemangiomas. Particular attention was paid to tumour size, patient age, and imaging modalities as determinants of clinical decision-making. These findings highlighted the feasibility and safety of surgical treatment across various tumour sizes and symptomatic statuses, and underscored the pivotal role of imaging in incidental detection. In line with external studies, including those by Halevy et al. (2024) and Park et al. (2024), the evolving trend toward the application of minimally invasive surgical approaches for complex hepatic lesions was reaffirmed. Additionally, the necessity for individualized, multidisciplinary strategies tailored to tumour characteristics and patient-specific factors was emphasized, thereby contributing to the refinement of evidence-based management algorithms for hepatic hemangiomas.

The analysis of surgical indications in the present study revealed that the majority of patients underwent operative treatment based on absolute indications such as persistent abdominal pain, intratumoral bleeding, consumptive coagulopathy, and mechanical compression phenomena. Relative indications, including progressive tumour growth and diagnostic uncertainty, accounted for a smaller but clinically relevant proportion of cases. These findings aligned with the experience of Wahab et al. (2018), who reported that absolute indications, particularly hemorrhagic complications and pain, constituted the primary drivers for surgical intervention in patients with giant hepatic hemangiomas. Additionally, Bektas

et al. (2013) emphasized that the presence of life-threatening complications or severe symptomatology remained the principal justification for resection, while surgery performed solely based on tumour size or patient anxiety should be carefully individualized.

Postoperative complications were observed in a small proportion of patients in the present study, with an overall incidence of 12.9% among asymptomatic individuals undergoing surgery for tumours between 4 and 9 cm. The complications included minor bile leakage and transient postoperative bleeding, both of which were managed conservatively without the need for reoperation. These outcomes corroborated the findings of Xie et al. (2021), who reported low postoperative morbidity following resection of giant hemangiomas, with most complications being classified as Clavien-Dindo Grade I or II. Similarly, Wagner et al. (2023) stressed the importance of adherence to multidisciplinary surgical protocols to minimize perioperative risks, particularly in patients with asymptomatic or incidentally detected liver lesions.

In the present study, hepatic hemangiomas were managed exclusively through surgical methods, with a particular emphasis on the differentiation of symptomatic and asymptomatic adult patients. Notably, the majority of asymptomatic hemangiomas were detected incidentally through imaging modalities, and surgical intervention was primarily indicated by either progressive growth or diagnostic uncertainty. Postoperative complications in this cohort were minimal, comprising only minor bile leakage and transient postoperative bleeding, both of which were successfully managed conservatively without the need for reoperation. These findings contrast with approaches in paediatric practice, where Shivachev et al. (2021) demonstrated that infantile hepatic hemangiomas could often be treated pharmacologically with propranolol, thereby avoiding surgery altogether. Similarly, Zavras et al. (2020) reported that most infantile hemangiomas exhibited spontaneous regression, and invasive interventions were reserved only for complicated cases.

The present study provided key evidence on the diagnostic pathways, clinical features, and surgical outcomes of hepatic hemangiomas in adults. Tumour size correlated with symptom development, incidental imaging findings were significant, and patient age influenced diagnostic uncertainty. Surgical treatment based on clear indications proved effective with low complication rates, supporting the reliability of operative strategies even in asymptomatic cases. Comparison with recent literature highlighted the importance of individualized approaches and emphasized the need for standardized imaging protocols and multidisciplinary management.

Conclusion

The relationship between tumour size and clinical symptomatology was established, the diagnostic significance of incidental imaging findings was confirmed, and the criteria for surgical intervention and postoperative outcomes in patients with hepatic cavernous hemangiomas were comprehensively evaluated. A robust correlation was identified between the dimensions of the tumour and the ensuing symptoms. This association is statistically significant between the size of hemangioma and the symptoms appearing to patients as a result. This correlation may be attributed to the rising prevalence of complaints, which are likely to encompass pain, as the hemangioma progresses. Consequently, tumour size emerged as a pivotal variable in determining the necessity for surgical intervention. However, a significant proportion of patients (38.61%) exhibited symptoms at the time of diagnosis, which raises questions about the rationale behind performing surgery in the absence of symptoms. Approximately 32.6% of surgeries employed fusion in the other cases, mostly due to unresolved indecision, particularly in the older patient group ($p=0.005$). The utilization of contemporary advances in preoperative diagnosis for such benign entities assumes paramount importance to avoid unnecessary referrals for surgical intervention. The findings suggested that tumour size is a variable that relates to particular symptoms associated with larger tumours, such as pain ($p=0.006$) and palpable mass ($p<0.000$). The symptoms mentioned above were predominantly observed among patients experiencing painful manifestations with large tumours. Subsequent assessment showed no statistically significant difference between the symptomatic and asymptomatic groups in postoperative length of stay, operation time, and blood loss. This suggests that whether or not the patients had signs or symptoms preoperatively, the surgery is standardized and performed in a way that gives essentially the same clinical outcome. However, the high complication rates observed in asymptomatic tumours larger than 10 cm raise significant questions about the indications of surgery in this particular population.

It was reported that surgical intervention for liver hemangiomas was a safe and effective approach with a low percent of morbidity and mortality. However, it emphasized the need for individualized selection of patients. Although indisputable indications for surgery include acute hemoperitoneum, intratumoral bleeding, and even consumptive coagulopathy, other relative ones like progressive tumour growth, severe patient anxiety, and uncertainty of diagnosis would require further discussion before proceeding with surgery.

The key factors associated with vague diagnoses and patient anxiety considerably contribute to consideration for surgery.

The results have demonstrated the necessity for standard operating procedures to refine patient selection criteria for surgical intervention. Future research should focus on the implementation of long-term follow-up studies to better define the natural history of asymptomatic liver hemangiomas and assess whether observation alone is a valid alternative in tumours without clear surgical indications. A 5- to 10-year follow-up period would be beneficial, with a focus on outcomes such as tumour growth rate, symptom development, and quality of life. Additionally, the role of imaging in monitoring these lesions should be evaluated to inform surveillance strategies and determine the necessity for surgical intervention. Improvements in imaging techniques for laparoscopic and robotic-assisted liver surgeries are expected to enhance intraoperative navigation, reduce operative risks, and contribute to better clinical outcomes.

However, the monocentric design and the limited sample size represent potential limitations, restricting the generalizability of the findings. Furthermore, the lack of long-term follow-up data is a significant restriction, especially since hepatic hemangiomas are benign lesions. Long-term results beyond the perioperative phase are clinically relevant and may influence treatment strategy. Based on the obtained results, it is recommended that clinicians prioritize individualized risk assessment incorporating tumour size, patient age, and imaging characteristics when considering surgical intervention for hepatic hemangiomas.

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