

# Research Paper: Investigating Effective Factors on Estimated Hemorrhage Intraoperative in Brain Meningioma Surgery



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## ABSTRACT

**Introduction:** The primary and definitive diagnosis of meningioma is based on histological assessment; however, employing imaging methods, like Magnetic Resonance Imaging (MRI) is very helpful to describe lesion's characteristics. Accordingly, we decided to study the effect of imaging factors, like MRI data on the volume of hemorrhage (estimated blood loss) during meningioma surgery.

**Methods:** This was a cross-sectional, retrospective, and analytical study. The eligible patients were those with meningioma who were candidates for surgery. A total of 40 patients with meningioma were selected and assessed. The preoperative imaging findings were recorded, then estimated blood loss during the surgery was determined

**Results:** A reverse association was revealed between the degree of proximity to the nearest sinus and the rate of bleeding. Furthermore, the size of the mass was positively associated with the rate of bleeding; however, there was no significant correlation between the volume of bleeding and other parameters, including the degree of edema, the volume of mass, the site of the tumor in the brain, and the histological subtype of the tumor. The mean time of operation was strongly correlated with blood loss. The rate of bleeding was more expected in hypertensive versus normotensive patients.

**Conclusion:** Bleeding in various volumes could be a frequent finding in intracranial meningioma surgery. Overall, tumor size, the duration of surgery, a history of hypertension, and distance to the nearest sinuses were the main determinants for the severity of hemorrhage in patients undergoing meningioma surgery.

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## Highlights

- The size of the mass was positively associated with estimated blood loss volume in meningioma surgery.
- The mean time of operation was strongly correlated with the rate of bleeding in meningioma surgery.
- The closer a tumor to the sinuses, the more loss of blood volume will occur during operation in meningioma surgery.
- The rate of bleeding was expected to be higher in hypertensive patients under meningioma surgery.

## Plain Language Summary

Meningioma is the most common tumor in the central nervous system. The primary and definitive diagnosis of meningitis is based on histological evaluation. Using imaging techniques, like Magnetic Resonance Imaging (MRI) can be helpful in preoperative diagnostic evaluations in patients undergoing the surgical management of meningioma. These modalities can provide good diagnostic performance to predict the operational risk as well as the likelihood of procedural complications, like brain hemorrhage. In this study, eligible patients were those with meningioma, who completely eliminated the lesion. The employed preoperative diagnostic method was MRI. The studied patients' demographic characteristics, including age, gender, preoperative laboratory examinations, history of cardiovascular disease, diabetes, and antiplatelet use, operation time, and total intraoperative blood loss were recorded. The tumor volume was measured in coronal, axial, and sagittal cuts in MRIs; we also evaluated parameters, such as maximum connection to the dura, tumor size, and distance to the nearest sinuses. Brain edema was determined as mild, moderate, and severe, according to its volume concerning tumor volume (less, equal, & more in size, respectively). The results suggested no association between the rate of hemorrhage, and gender, age, history of diabetes, history of coronary disease, and history of anti-thrombocyte tumor size; however, the duration of surgery, history of hypertension, and distance to the nearest sinuses were the main determinants for the severity of hemorrhage in meningioma surgery.

### 1. Introduction

**M**eningioma is the most prevalent tumor in the central nervous system; it accounts for between 16% and 20% of the total intracranial tumors (Toh et al., 2008). The Magnetic Resonance Imaging (MRI) technique is a selective modality for assessing meningioma. MRI not only presents the tumor's position with high contrast and can evaluate intra- and extra-axial lesions (Whittle, Smith, Navoo & Collie, 2004; O'Leary, Adams, Parrish & Mukonoweshuro, 2007; Nagar et al., 2008; Buetow, Buetow & Smirniotopoulos, 1991). In addition to MRI, Computed Tomography (CT) scan also plays an essential role in detecting calcification, as well as lesions associated with calvarium changes (Tokgoz et al., 2005). However, typical meningioma has well-known visual characteristics; there are also various atypical and unusual types that in addition to creating a diagnostic challenge for meningioma, have questioned the diagnostic accuracy of imaging techniques (Paek et al., 2005; Hakyemez et al., 2006). A radiologist must achieve a complete understanding of the atypical features of the disease in the images pro-

vided to present the correct diagnosis (Elder, Atkinson, Zee & Chen, 2007; Komotar, Keswani, Wityk, 2003).

In MRI, meningioma appears in the form of signal strength characteristics, including isointensity to mild hyperintensity, relative to gray matter, on the T2 sequence (Heye, Maleux, Van Loon & Wilms, 2006). After applying contrast, meningioma appeared in the form of homogenous enhancement (Yue et al., 2008). However, the lesions occasionally exhibited necrosis or calcification, which in this case lacked enhancement. Calcification is visualized better in the CT scan view (Chen et al., 2004). On MRI view, especially on T2 sequences, calcification can be detected in the form of low-intensity signals (Bitzer et al., 1998). Contrast is also well-suited for detecting plaque-shaped meningioma, i.e. appeared as asymmetrical thickness on dura (Nakano, Nakano, Miura, Itoh & Suzuki, 2002).

The primary and definitive diagnosis of meningioma is based on histological assessment. However, implementing imaging methods, like MRI has a special place in this field. Such approaches not only detect the nature of the tumor but also help detect local invasion, especially on

T2-weighted images. Therefore, concerning non-invasive nature, imaging techniques could be beneficial in preoperative diagnostic evaluations in patients undergoing surgical management of meningioma. These modalities could provide desirable diagnostic performance to predict the operation risk, as well as the odds of procedural complications, like brain hemorrhage. Accordingly, we investigated the effect of imaging techniques, like MRI on the rate of hemorrhage during meningioma surgery.

## 2. Materials and Methods

This was an observational study, i.e. performed as a cross-sectional retrospective analytical study. Besides, the eligible patients were those with meningioma and totally removed lesion. The study exclusion criteria were contraindications for imaging with different methods, like MRI, and significant bony involvement by tumor. A total of 40 patients with meningioma admitted to Rasoul-e-Akram Hospital in Tehran City, Iran from 2015 to 2016 were selected and assessed in this research.

The demographic characteristics of the patients, including age, gender, preoperative laboratory examinations, a history of cardiovascular disease, diabetes, and anti-platelets use were collected from the patients' medical records. The operation time and total intraoperative blood loss were recorded from the patients' anesthesia file. The most frequent manifestation in the outcome analysis was a headache, followed by blurred vision, and limb weakness.

The preoperative data of the brain were received from MRI data. MRI examinations were obtained on a 1.5 T scanner (Philips Medical Systems, Ingenia). Imaging protocols in the T1 sequence were performed with contrast (slice thickness: 2 mm). The location of the tumors was classified as parasagittal, parallax, convexity, and skull base (anterior, posterior, & middle).

The tumor volume was measured and calculated using the ellipsoid formula, where A. The largest diameter of the tumor in the axial view; b. The tumor diameter in the same cut of the axial view perpendicular to A; and C. The tumor height using the number of cut counts that the tumor is observed in. Additionally, parameters, such as maximum connection to the dura, tumor size, and distance to nearest sinuses were measured.

The tumor size represents its diameter. The axial, coronal, and sagittal views were examined; the largest diameter of the tumor was specified in each.

Brain edema was determined as mild, moderate, and severe according to its volume respecting tumor volume (less, equal, and more in size, respectively). The preoperative imaging findings were recorded, then volume blood loss was evaluated during surgery. The frequency of hemorrhage cases was finally determined based on the imaging data.

The collected results were presented as Mean±Standard Deviation (SD) for quantitative variables. The study findings were summarized by absolute frequencies and percentages for categorical variables. The normality of the data was analyzed using the Kolmogorov-Smirnov test. Categorical variables were compared using the Chi-squared test or Fisher's Exact test when >20% of the cells with an expected count of <5 were observed. The quantitative variables were also compared with the t-test or Mann-Whitney U test. The correlation between the quantitative parameters was examined by Pearson's correlation test. For the statistical analysis, SPSS was used.  $P \leq 0.05$  was considered as statistically significant.

## 3. Results

Totally, 40 patients with meningioma who underwent total surgical removal were assessed. Besides, the mean±SD age of patients was  $54.90 \pm 12.66$  years, with a range of 28 to 77 years. In total, 72.5% of the study participants were female. Regarding cardiovascular risk factors, 30.0% were hypertensive, 12.5% were diabetic, 7.5% reported a history of coronary disease, and 7.5% had a history of anti-platelets use. The most prevalent manifestation was headache (67.5%), followed by blurred vision (30.0%), and limb weakness (25.0%). In imaging assessment, mild, moderate, and severe brain edema were revealed in 45.0%, 37.5%, and 17.5% of the cases, respectively. Regarding the site of tumor, 25.0% was located in convexity, 45.0% in skull base (72.2% in anterior & 27.7% in posterior sites), and 30.0% in parasagittal regions. The Mean±SD size of meningioma was  $41.72 \pm 19.42$  mm with the Mean±SD volume of  $49.36 \pm 61.90 \text{ mm}^3$  (Table 1). Concerning the subtypes of meningioma, meningothelial type was detected in 35.0%, transitional in 30.0%, atypical in 10.0%, cystic meningioma in 5.0%, non-specified grade 1 in 5.0%, angiomatosis in 5.0%, psammomatous in 2.5%, and microcystic in 5.0%. The Mean±SD volume of hemorrhage was  $925.64 \pm 756.19 \text{ mL}$ , and the Mean±SD operation time equaled  $7.15 \pm 2.03 \text{ h}$ . With regard to tumor distance to the nearest sinus, the proximity was found as 50.0%, 15%, and 35% for superior sagittal, transverse, and cavernous sinuses, respectively.

**Table 1.** Meningioma characteristics observed in MRI findings

	Variabels	No. (%)	
Edema	Mild	18 (45.0)	
	Moderate	15 (37.5)	
	Severe	7 (17.5)	
The location of the tumor	Convexity	10 (25.0)	
	Skull base	18 (45.0)	
	Ant Skull base	13 (72.2)	
	Pos Skull base	5 (27.7)	
	Parasagittal	12 (30.0)	
	Size of the tumor (Mean±SD)	41.72±19.42	
	The volume of the tumor (Mean±SD)	49.36±61.90	
	Maximum connection to the dura (Mean±SD)	39.44±21.14	
	Subtypes	Meningothelial	14 (35.0)
		Transitional	12 (30.0)
Atypical		4 (10.0)	
Cystic meningioma		2 (5.0)	
Nonspecific grade 1		2 (5.0)	
Angiomatosis		2 (5.0)	
Psammomatous		1 (2.5)	
Microcystic		2 (5.0)	
Distance from the superior sagittal sinus		20 (50)	
Distance from the transverse sinus		6 (15)	
Distance to cavernous sinus	14 (35)		

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A reverse association was observed between the degree of proximity and the volume of bleeding ( $P=0.06$ ).

Furthermore, the mass size was positively correlated with estimated blood loss volume ( $P=0.003$ ); however, there was no significant correlation between the volume of bleeding and other parameters, including the degree of edema, the volume of mass, the site of the tumor in the brain, the type of tumor, and maximum connection to the dura (Table 2). The mean time of operation was strongly correlated with the rate of bleeding. ( $P=0.001$ ). We detected no relationship between the rate of hemorrhage, and gender, age, a history of diabetes, a history of coronary

disease, a history of antiplatelet use, as well as the mean level of serum hemoglobin, WBC, and platelet counts. However, the rate of bleeding was more expected in hypertensive, compared to normotensive patients (Table 3).

#### 4. Discussion

Hemorrhage following brain tumor surgery adversely affects the treatment outcome of such tumors. Accordingly, the volume of massive hemorrhage and the high need for transfusion during and after surgery is essential predictors of adverse outcomes in the treatment of these patients. Therefore, predicting this volume of surgical

**Table 2.** The relationship between bleeding volume and imaging indices

Index	Mean±SD or R Coefficient	P
Edema	Mild	861.11±688.25
	Moderate	893.33±797.95
	Severe	1340.00±952.89
Tumor site	Convexity	1080.00±868.65
	Skull base	1025.00±872.83
	Parasagittal	585.00±212.20
Mean size	0.463	0.003
Mean volume	0.223	0.171
Maximum connection to dura	0.279	0.085
Subtypes	Meningothelial	1037.50±1154.11
	Transitional	1087.50±972.37
	Atypical	737.50±325.00
	Cystic	850.00±212.13
	Nonspecific G1	750.00±212.13
	Aniomathosis	725.00±106.07
	Psammomas	0.350
	Microcytic	0.800
Operation time	0.710	0.001
Distance to sinus	-0.084	0.06

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bleeding can improve the patient's treatment outcomes and affect their long-term survival. Meningioma-induced Hemorrhage as well as bleeding from the surgical site are relatively common phenomena. Therefore, given its significant impact on the treatment outcome, its prediction is vital. The non-invasive evaluation of these patients before and after surgery by imaging, especially with MRI, is essential for assessing tumor progression and the favorable advancement of treatment; pre-surgical MRI indexes can be used to predict bleeding during surgery.

The main purpose of the current project was to describe the imaging characteristics of meningioma by MRI and aided to reduce intraoperative blood loss. In addition, we found that three of the indexes were related to the primary indicators of patients (history of hypertension), surgery (operation time), and the lesion's characteristics (tumor size); i.e. closely related to the volume of bleed-

ing during the operation. In other words, in hypertensive patients or patients with large size of the meningioma, as well as a longer duration of surgery, this can increase the odds of bleeding during surgery. There was no significant correlation between the volume of bleeding and tumor volume. The reason for this finding cannot be easily evaluated. Perhaps, the largest tumor diameters are a better benchmark for presenting the depth of its penetration into the brain. For example, in two tumors of equal volume, in elliptical and spherical form, in the elliptical tumor, the shape of the penetration of the lesion is larger in the brain; thus, it takes more time to rescue such patients. Of course, this argument cannot be presented without a closer examination, and further studies are recommended in this area.

**Table 3.** The relationship between bleeding volume and the baseline indices of patients

Index		Mean±SD or R Coefficient	P
Gender	Male	934.48±752.51	0.903
	Female	900.00±807.26	
Age, y		0.217	0.186
Hypertension	Yes	1283.33±930.38	0.044
	No	750.00±625.93	
Diabetes	Yes	730.00±723.36	0.543
	No	954.42±767.06	
Coronary disease	Yes	1600.00±1352.77	0.109
	No	869.44±688.51	
Anti-platelet use	Yes	1333.33±1457.17	0.338
	No	891.67±695.75	
Hemoglobin level		0.170	0.307
WBC count		0.124	0.458
Platelet count		0.009	0.958

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Therefore, all measures should be taken to prevent bleeding and transfusion during surgery in hypertensive patients, as well as those with large meningioma.

It can be concluded that the closer tumor to the sinuses, the more blood volume will be lost during operation.

Data on the relationship between underlying characteristics and MRI and the prediction of bleeding during surgery are scarce. In a study (Lü, 2013), the related factors influencing bleeding severity were the origin of the tumor, tumor volume, bleeding vessel or venous sinus involvement, and the tumor size; these data were consistent with our study findings. They also argued that calcification, invasive behavior, dural tail symptoms, peripheral edema, and adjacent bone involvement did not affect hemorrhage. However, they disregarded evaluating the relationship between bleeding and baseline indices, like a history of hypertension. Moreover, Murph et al. (2013) found that preoperative MR-elastography can help determine the tumor's stiffness and bleeding during meningioma surgery. Hoover et al. mentioned that preoperative MRI could predict the tumor's stiffness and its bleeding probability in 90% of cases (Hoover, Morris & Meyer, 2011). As previously mentioned, the cause of bleeding in meningeal tumors, either prematurely due to the nature

of the tumor or during its therapeutic operation, can be attributed to the weakening of the nerve and ductile vessels, intratumoral angiogenesis, vascular wall invasion, blood dyscrasia, and simultaneous anticoagulation. However, the surgeon's experience should also be considered as the main cause of bleeding or its control (Lü, 2013).

Other studies investigated the association between tumor volume and hemorrhage during surgery, especially in the T2 sequence. In this study, we attempted to apply other imaging factors, i.e. less studied on them. However, the limitations of this study consisted of the lack of considering further factors in imaging in assessing the volume of bleeding. The other research limitation was the small sample size. We hope that in the future, these deficits will be compensated for achieving better results.

## 5. Conclusion

Bleeding in various volumes could be a common finding in intracranial meningioma surgery. In total, tumor size, the duration of surgery, a history of hypertension, and distance to the nearest sinuses were the main determinants for the severity of hemorrhage in patients undergoing meningioma surgery.

## Ethical Considerations

### Compliance with ethical guidelines

All ethical principles were considered in this article. The participants were informed about the purpose of the research and its implementation stages; they were also assured about the confidentiality of their information; Moreover, They were allowed to leave the study whenever they wish, and if desired, the results of the research would be available to them; also this study was approved by the Ethics Committee of Iran University of Medical Sciences, Tehran, Iran (Code: 1396.9211255005).

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### Authors' contributions

All authors were equally contributed in preparing this article.

### Conflict of interest

The authors declared no conflicts of interest.

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