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Original Research Article

Juvenile Nasopharyngeal Angiofibroma- Analysis of Intraoperative Bleeding in Patients Undergoing Preoperative Embolization vs. Carotid Artery Ligation

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Abstract: *A rare vascular tumor called Juvenile Nasopharyngeal Angiofibroma causes severe bleeding during its surgical removal. To determine whether the procedure significantly reduces intraoperative blood loss, this study compares carotid artery ligation with preoperative embolization.* ***Objectives:*** *To compare the efficacy of preoperative embolization versus external carotid artery ligation in reducing intraoperative blood loss in patients undergoing surgical resection for Juvenile Nasopharyngeal Angiofibroma (JNA).* ***Methodology:*** *This prospective, randomized, controlled trial was conducted over a 6-month period, from March 1, 2024, to August 31, 2024, at the Department of ENT, Sir Ganga Ram Hospital, Lahore. After ethical approval, forty male JNA patients (Radkowski Stage II & III) were randomly assigned to two groups. Twenty Group A patients had super-selective embolisation of the tumor-feeding arteries 24–72 hours before surgery. Twenty patients in Group B had the ipsilateral external carotid artery (ECA) surgically ligated at least 24 hours before final excision. The same ENT doctor performed all tumour resections endoscopically. Millilitres of intraoperative blood loss were the primary outcome measure. Secondary outcomes included blood transfusions, surgery duration, and complications.* ***Results:*** *The mean intraoperative blood loss was significantly lower in Group A (Preoperative Embolization) (645 ± 215 mL) compared to Group B (Carotid Ligation) (1185 ± 430 mL) ($p < 0.001$). Consequently, the intraoperative blood transfusion requirement was also significantly lower in Group A (1.1 ± 0.7 units) than in Group B (2.8 ± 1.2 units) ($p < 0.001$). The mean duration of surgery was shorter in Group A (145 ± 35 minutes) than in Group B (195 ± 45 minutes) ($p = 0.002$). No significant complications related to the embolization procedure were noted.* ***Conclusion:*** *Preoperative super-selective embolization is a significantly more effective adjunctive procedure than external carotid artery ligation in reducing intraoperative blood loss and transfusion requirements during surgical resection of JNA. It should be considered the gold standard preoperative preparation for JNA where interventional radiology expertise is available.*

Keywords: Juvenile Nasopharyngeal Angiofibroma; Preoperative Embolization; Carotid Artery Ligation; Intraoperative Bleeding; Endoscopic Surgery

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Introduction

Juvenile Nasopharyngeal Angiofibroma (JNA) is a benign but locally invasive neoplasm that primarily occurs in adolescent males. Given its propensity for significant intraoperative bleeding due to its abundant vascular supply, surgical management poses challenges for surgeons. Various techniques have been implemented to mitigate intraoperative hemorrhage, including preoperative embolization and carotid artery ligation. Recent studies suggest that preoperative embolization can reduce intraoperative bleeding and enhance surgical outcomes by occluding the tumor's feeding vessels (1, 2). In contrast, carotid artery ligation is often used in cases where embolization is not feasible; however, it carries its own set of risks, including the potential for ischemic complications (3).

The role of intraoperative bleeding in determining surgical success is critical. Excessive bleeding can lead to increased surgical time, higher rates of blood transfusion, and a greater risk of postoperative complications, including hematomas and infections (4, 5). Various strategies, such as the administration of tranexamic acid (TXA), have demonstrated effectiveness in reducing perioperative blood loss (6). Furthermore, the use of advanced hemostatic agents and intraoperative monitoring techniques continues to be explored (7).

Understanding the specific vascular architecture of JNA is vital, as it influences the choice of surgical approach and bleeding management strategies (1). Given the potential complications associated with excessive intraoperative bleeding, evolving interventions, including targeted embolization, are critical for enhancing patient safety and surgical effectiveness (2). A recent study highlighted that preoperative embolization significantly reduces intraoperative blood loss compared to conventional approaches, reinforcing its utility in managing JNA cases (2).

In the context of the Pakistani population, where healthcare resources may be limited, understanding the dynamics of intraoperative bleeding in JNA surgeries is paramount. The prevalence of JNA and associated morbidities underscores the need for optimized surgical techniques that reflect the unique demographic and clinical settings of the region. Consequently, this study seeks to meticulously evaluate and compare the efficacy of preoperative embolization versus carotid artery ligation in minimizing intraoperative bleeding, potentially informing clinical practices and improving outcomes in patients undergoing surgical resection of juvenile nasopharyngeal angiofibromas in Pakistan. The primary objective of this randomized study is to directly and prospectively compare the two techniques—preoperative super-selective embolization versus external carotid artery ligation—in terms of their efficacy in reducing intraoperative blood loss during the endoscopic resection of JNA. By utilizing a single surgeon to perform all resections, we aim to eliminate inter-surgeon variability and provide a clear, unbiased comparison of the two preoperative strategies. The results aim to provide Level 1 evidence to guide clinical decision-making and establish a standard of care for the preoperative preparation of patients with JNA.

Methodology

This was a prospective, randomized, single-blind, single-surgeon study conducted at the Departments of ENT, Sir Ganga Ram Hospital, Lahore, from March 1, 2024, to August 31, 2024. The study protocol was approved by the hospital's Institutional Review Board (IRB) and Ethical Committee.

A total of 48 male patients with a clinical and radiological diagnosis of JNA (contrast-enhanced CT and/or MRI) were assessed for eligibility. Inclusion criteria were: male patients aged 10-25 years; newly diagnosed, biopsy-proven JNA; Radkowski stage II or III disease (17); and fit for general anesthesia and major surgery. Exclusion criteria included: recurrent JNA; Radkowski stage I (limited to nasopharynx/nose) or massive Stage IV/V with significant intracranial extension requiring a combined approach; renal impairment contraindicating contrast use; and known allergy to embolic materials.

After obtaining informed consent from parents/guardians, 40 eligible patients were randomly allocated into two groups using computer-generated random numbers. Group A (Preoperative Embolization, n=20): Underwent super-selective angiographic embolization of tumor-feeding vessels 24-72 hours prior to surgery. Performed by an experienced interventional radiologist under local anesthesia. Via a transfemoral approach, selective angiography of the internal and external carotid arteries was performed to map the tumor's vascular supply. Using microcatheters, the dominant feeding vessels (primarily internal maxillary artery branches) were super-selectively catheterized, and polyvinyl alcohol (PVA) particles (300-500 μm) were injected until stasis of flow was achieved(4).Group B (Carotid Ligation, n=20): Underwent surgical ligation of the ipsilateral external carotid artery 24 hours prior to definitive tumor resection. Performed by the same ENT surgeon under general anesthesia. A standard incision along the anterior border of the sternocleidomastoid muscle was made to identify the carotid sheath. The external carotid artery was identified, isolated, and doubly ligated with non-absorbable sutures proximal to the origin of its lingual and facial branches.

All definitive tumor resections were performed by the same ENT surgeon with extensive experience in endoscopic skull base surgery, who was blinded to the preoperative group allocation until the time of surgery. The procedures were performed under general anesthesia with controlled hypotension (19). A standard four-hand, binocular endoscopic technique was used (15). The tumor was dissected in a subperiosteal plane using electrocautery and microdebriders. Intraoperative blood loss was meticulously measured by subtracting the volume of irrigation used from the total volume of suction fluid and weighing saturated gauzes.

Patient demographics, tumor stage (according to the Radkowski classification), and preoperative hemoglobin level were recorded. The primary outcome measure was the amount of intraoperative blood loss (in milliliters). Secondary outcome measures included:

1. Blood transfusion requirements: Number of units of packed red blood cells (PRBC) transfused intraoperatively and in the first 24 hours post-op.
2. Duration of surgery: Time from first incision to application of the last nasal pack (minutes).
3. Perioperative complications: Related to either the preoperative procedure (e.g., stroke, neuropathy from embolization; nerve injury from ligation) or the surgery itself (e.g., cerebrospinal fluid leak, significant postoperative hemorrhage).

Data were analyzed using SPSS software version 26.0. Continuous variables (blood loss, transfusion units, surgery time) were expressed as mean ± standard deviation (SD) and compared using the independent samples t-test. Categorical variables (complications) were expressed as numbers and percentages and compared using the Chi-square test or Fisher's exact test, as appropriate. A p-value of < 0.05 was considered statistically significant.

Results

All 40 patients successfully underwent their allocated preoperative procedure and subsequent surgical resection. The two groups were comparable in terms of baseline demographics and tumor stage, ensuring an equitable comparison (Table 1).

Table 1: Baseline Characteristics of the Study Groups

Characteristic	Group A (Embolization) (n=20)	Group B (Ligation) (n=20)	p-value
Age (years), Mean ± SD	15.4 ± 2.8	16.1 ± 3.2	0.452
Preoperative Hemoglobin (g/dL), Mean ± SD	12.5 ± 1.4	12.2 ± 1.6	0.527
Tumor Stage (Radkowski), n (%)			0.765
Stage II	12 (60%)	11 (55%)	
Stage III	8 (40%)	9 (45%)	

The outcomes for the primary and secondary endpoints are detailed in Tables 2 and 3. The intraoperative blood loss was nearly halved in the embolization group compared to the ligation group (645 mL vs. 1185 mL, $p < 0.001$).

Table 2: Primary Surgical Outcomes

Outcome	Group A (Embolization) (n=20)	Group B (Ligation) (n=20)	p-value
Intraoperative Blood Loss (mL), Mean ± SD	645 ± 215	1185 ± 430	< 0.001
Surgery Duration (min), Mean ± SD	145 ± 35	195 ± 45	0.002

Table 3: Transfusion Requirements and Complications

Outcome	Group A (Embolization) (n=20)	Group B (Ligation) (n=20)	p-value
PRBC Transfused (units), Mean ± SD	1.1 ± 0.7	2.8 ± 1.2	< 0.001
Patients Requiring Transfusion, n (%)	9 (45%)	18 (90%)	0.003
Major Complications, n (%)	0 (0%)	1 (5%)*	0.311
*One patient in Group B had a temporary marginal mandibular nerve weakness post-ligation, which resolved by 3 months.			

This significant reduction in blood loss directly translated to clinical benefits, with the embolization group requiring significantly fewer blood transfusions (Table 3) The Fromme-Boezaart scale ratings show that surgical field quality was significantly better in the embolization group (Group A) than in the ligation group (Group B) ($p < 0.001$). Group A had no cases of “extremely bleedy” fields compared to 4 in Group B, fewer “bleedy” cases (15% vs. 45%), and more patients with “minor bleeding” (40% vs. 10%) or “nearly bloodless” fields (20% vs. 0%), indicating superior intraoperative visibility and reduced blood loss with embolization.(Table 4)

Table 4: Surgeon Qualitative Assessment of Surgical Field

Rating (From 1-5 Scale)	Group A (Embolization) (n=20)	Group B (Ligation) (n=20)
1 Extremely Bleedy	0	4
2 Bleedy	3	9
3 Acceptable	5	5
4 Minor Bleeding	8	2
5 Nearly Bloodless	4	0
(Based on the Fromme-Boezaart scale, data presented as number of patients. Field quality was significantly better in Group A, $p < 0.001$).		

Discussion

The discussion of our study focused on the comparison of preoperative embolization versus carotid artery ligation in patients undergoing surgical resection for Juvenile Nasopharyngeal Angiofibroma (JNA). The results indicate that the embolization group (Group A) experienced significantly less intraoperative blood loss than the ligation group (Group B), with a mean blood loss of 645 mL and 1185 mL, respectively ($p < 0.001$). This reduction aligns with findings from recent literature emphasizing the effectiveness of preoperative embolization in reducing intraoperative hemorrhage during JNA surgery (8, 9).

In Table 1, our patient demographics revealed no significant differences between the two groups in terms of age, preoperative hemoglobin levels, and tumor stage, confirming that the groups were comparable and that the outcomes could be reliably interpreted. The consistency of our cohort with that in the existing literature is noteworthy, as both age and tumor stage have been established as influential factors in the likelihood of increased blood loss and consequent surgical complications (10, 11). Bahar et al. support this notion, highlighting that effective preoperative planning and risk stratification are essential as advanced tumor stages correlate with elevated risks of intraoperative bleeding and other complications (10).

The observation that surgical duration was significantly shorter in the embolization group, at 145 ± 35 minutes, compared to 195 ± 45 minutes in the ligation group ($p = 0.002$), suggests that preoperative embolization not only reduces intraoperative bleeding but may also facilitate expedited surgical procedures. This finding aligns with the literature, which posits that reduced bleeding leads to shorter surgical times, thereby enhancing overall patient management during JNA surgeries (9, 12). A systematic review by Diaz et al. reaffirms that embolization contributes significantly to decreased surgery duration by limiting blood loss (9).

Moreover, our results from Table 3 demonstrated that the embolization group required substantially fewer blood transfusions (a mean of 1.1 units) and had a lower percentage of patients needing transfusions (45% vs. 90%, $p = 0.003$). These findings are in agreement with recent studies that highlight the role of preoperative embolization in reducing transfusion needs, which is critically beneficial in minimizing the risks associated with massive transfusion procedures (13, 14). Furthermore, the experience of being transfusion-free amidst surgical procedures represents a considerable safety advantage, as excessive transfusions can lead to immunological complications and adverse patient outcomes (14).

In evaluating the qualitative surgical field assessment presented in Table 4, the scores reflected superior surgical visualization in the embolization group, aligning with existing literature that underscores the importance of managing intraoperative bleeding to ensure optimal surgical conditions. Our results (4 patients rated 'Nearly Bloodless') contrast sharply with the ligation group, emphasizing the efficacy of preoperative embolization in achieving a bloodless surgical field (15). This planning not only enhances surgical success rates but also potentially reduces postoperative complications stemming from excessive bleeding, corroborating findings in similar studies (9, 16).

In summary, our study's results extend the existing body of evidence supporting preoperative embolization as a safe and effective method to mitigate intraoperative bleeding risks associated with JNA surgeries. While carotid artery ligation remains a viable alternative, its higher risks and drawbacks, including transfusion rates and surgical duration, present compelling reasons for favoring embolization. The success of 40 patients underscores the need for ongoing research to identify best practices for managing JNA in clinical settings, particularly in our local context, where resources may differ.

Conclusion

Preoperative super-selective embolization of feeding vessels is a significantly more effective strategy than external carotid artery ligation for reducing intraoperative blood loss, transfusion requirements, and operative time during the endoscopic resection of juvenile nasopharyngeal angiofibroma. The targeted nature of embolization results in a superior surgical field, thereby enhancing both the safety and efficacy of tumor removal. Based on these results, preoperative embolization must be considered the gold standard of care, while carotid ligation should be abandoned as a primary preoperative devascularization technique for JNA.

Declarations

Data Availability statement

All data generated or analysed during the study are included in the manuscript.

Ethics approval and consent to participate

Approved by the department concerned. (IRBEC-24)

Consent for publication

Approved

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Conflict of interest

The authors declared the absence of a conflict of interest.

Author Contribution

MB (Post Graduate Trainee/Resident)
Substantial contributions to study design, acquisition of data
Analysis & Interpretation of Data, Manuscript writing
Has given final approval of the version to be published

WJ (Associate Professor ENT)
Substantial contributions to concept, study design
Data Analysis, Manuscript writing, Critical Review
Has given final approval of the version to be published

All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

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