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Original Article

Exploring the Association between Allogenic Blood Transfusion and Postoperative Infection Risk Following Intracranial Surgery: A Retrospective Cross-Sectional Analysis

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Abstract

Background Neurosurgical procedures pose a heightened risk of bleeding, often necessitating blood or blood product transfusions. However, allogenic blood transfusion has various adverse consequences, including the transmission of blood-borne infection and immune consequences. While multiple studies have indicated an increased incidence of postoperative infections among patients receiving allogenic blood transfusions, these investigations have primarily focused on non-neurosurgical populations. Therefore, this retrospective study aimed to explore the relationship between blood transfusions and the occurrence of postoperative infections in patients undergoing intracranial surgery for tumors and cerebral aneurysms.

Methods All American Society of Anesthesiologists (ASA) class I to III patients who underwent intracranial surgery (tumors—supratentorial and infratentorial, aneurysm—anterior and posterior circulation) during 3 years (January 2017–December 2020) were included in the study.

Results A total of 240 patients met the inclusion criteria. Perioperative blood transfusion was observed in 103 patients (42.9%). Postoperative infections were observed in 34 patients (14.16%). It was observed that the odds of developing a postoperative infection were 3.37 ($p < 0.001$) times higher if the patient received a blood transfusion.

Conclusion There exists a robust correlation between perioperative blood transfusion and the subsequent postoperative infection following craniotomy.

Keywords
- neurosurgery
- blood loss
- craniotomy
- postoperative infection
- allogenic
- blood transfusion

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Introduction

The brain is a highly vascular organ. Thus, neurosurgical interventions, involving intricate brain tissue and vessel manipulation, present unique challenges due to the inherent risk of bleeding. To maintain optimal cerebral perfusion and oxygenation, these patients often end up with blood transfusions during or after surgery.[1] However, while allogenic blood transfusion is a common practice, it carries inherent disadvantages, including the potential transmission of infections and immune consequences, aggravation of surgical bleeding by preventing hypercoagulative response, and postoperative infection.[2] Notably, emerging evidence suggests a correlation between allogenic blood transfusion and an increased risk of postoperative infections in various surgical settings.[3–5] Nevertheless, the majority of these investigations have primarily focused on non-neurosurgical populations, leaving a gap in our understanding of this relationship specifically within neurosurgery. Therefore, this retrospective study aims to elucidate the association between blood transfusions and the occurrence of postoperative infections in neurosurgical patients undergoing intracranial surgery for tumors and aneurysms. By addressing this knowledge gap, we seek to provide valuable insights that could guide clinical practice and enhance patient outcomes in neurosurgical care.

Methods

This study was conducted at a tertiary-level hospital in India as a retrospective cross-sectional study. The study protocol was approved by the institutional ethics committee, and retrieval of data from previous medical records was done. American Society of Anesthesiologists (ASA) class I to III patients who underwent intracranial surgery (tumors—supratentorial and infratentorial, aneurysm—anterior and posterior circulation), both emergency and elective during last four years (January 2017–December 2020), were included in the study. Patients who underwent intracranial surgery other than the above-described traumatic brain injuries or spine surgeries, preexisting infections, preexisting diabetes, immunocompromised status, significant respiratory or cardiac diseases, and pregnant females were excluded from the study. Patients with preexisting anemia (hemoglobin [Hb] <10 g/dL for adults and <11 g/dL for the pediatric age group) or with a high risk of bleeding (patients on antiplatelet drugs or heparin) were also excluded from the study. Perioperative blood transfusion was defined as the administration of blood products within 7 days preceding and following the surgery.

As an institutional protocol, intraoperative trigger of blood transfusion was Hb <8 g% or presence of hemodynamic instability and ongoing blood loss. Postoperative infection was defined as the development of infection within 90 days of surgery at the surgical site (SSI), chest (pneumonia), catheter site (central line and arterial line sites), urinary tract (UTI), and generalized septicemia as well as bacteremia. A positive culture report obtained from any of the above-described sites was considered as infection. Data were tabulated using Microsoft Excel (Version 16.61.1). The primary objective of the study was to elucidate the relationship between blood transfusion and postoperative infections in neurosurgical patients. Secondary objectives encompassed determining the percentage of neurosurgical patients necessitating perioperative blood transfusions and the incidence rates of various types of postoperative infections among this cohort.

Statistical Analysis

The tabulated data were analyzed using version 20.0 of the SPSS software package (SPSS, Chicago, Illinois, United States). Categorical variables were presented as absolute numbers and corresponding percentages, while quantitative variables were presented as means and standard deviation (SD). The chi-squared test was used for categorical variables to detect significant differences between groups. Three-way contingency analysis was done to detect correlation among dependent and independent variables. Statistical significance was established at $\alpha = 0.05$; all reported p-values were two-tailed. A p-value less than 0.05 was considered significant.

Results

A total of 240 patients were analyzed for this study whose baseline characteristics are with primary diagnosis outlined in ►**Table 1**. The majority of patients were of ASA class I ($n = 163$). Those classified under ASA II ($n = 73$) were majorly suffering with smoking and relating ailment such as chronic obstructive pulmonary disease (COPD) and controlled hypertension on medications. ASA III ($n = 4$) patients had a history of uncontrolled hypertension and one patient had unstable angina. The mean baseline preoperative Hb was

Table 1 Baseline patient characteristics

Patient characteristics		No. of patients ($n = 240$)
Age	5–18 y	25
	19–59 y	183
	60–70 y	32
Gender	Male	129
	Female	111
American Society of Anesthesiologists (ASA) status class	I	163
	II	73
	III	4
Indication for surgery	Supratentorial tumors	133
	Infratentorial tumors	60
	Aneurysms	47
Type of surgery	Elective	174
	Emergency	66

Table 2 Distribution of blood transfusion and postoperative infection according to primary diagnosis

Blood transfusion		Diagnosis	Blood transfusion	
Yes	No		Infected	Noninfected
24 (23.3%)	23 (16.8%)	Aneurysm	7 (30.4%)	17 (21.3%)
33 (32%)	36 (26.3%)	Infratentorial tumors	11 (47.8%)	22 (27.5%)
46 (44.7%)	78 (56.9%)	Supratentorial tumors	5 (21.7%)	41 (51.3%)
103 (57.1%)	137 (42.9%)	Total	23 (100%)	80 (100%)
0.160		*p* value	0.040	

Table 3 Distribution of various blood products transfused

Product transfused	Number of patients in which specified product was transfused
Packed red blood cells (PRBC)	101
Fresh frozen plasma (FFP)	11
Platelets concentrate (PC)	7

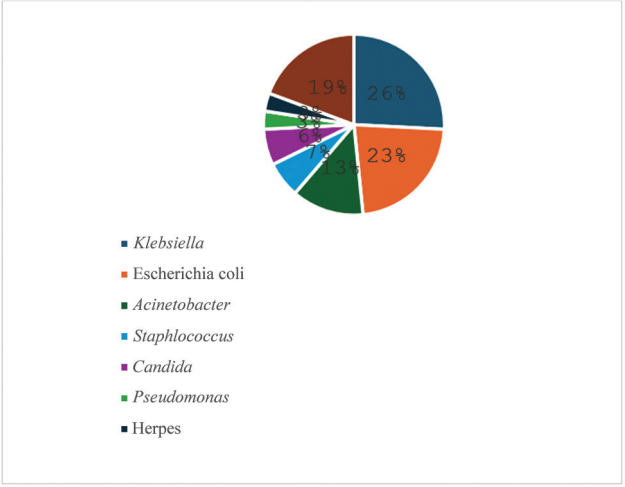

Fig. 1 Distribution of various bacterial growth present on culture.

13.14 g/dL. The mean blood loss was 653 mL; however, patients who received blood transfusion had a significantly higher blood loss (mL) than those who did not receive transfusions (1,043.69 ± 725.44 vs. 354.53 ± 132.30 mL, $p = 0.0001$). A total of 103 patients (42.9%) required transfusions during the perioperative period. Among these, 97 transfusions were intraoperative and 9 were postoperative and three patients received both intraoperative and postoperative transfusions. The total duration of surgery (minutes) was significantly higher among the patients who received blood transfusions (334.08 ± 132.50 vs. 260.58 ± 102.59 mL, $p = 0.003$). The distribution of blood transfusion according to diagnosis and the distribution of postoperative infection according to diagnosis are presented in ►**Table 2**. The distribution of various products transfused is shown in ►**Table 3**. A total of 28 patients who received transfusions had tracheostomy as compared with 14 patients who did not receive transfusions. Total duration (days) of mechanical ventilation was significantly higher in patients who received transfusions (5.53 ± 12.8 vs. 2.49 ± 8.1 mL, $p = 0.012$). The sites of infection were the urinary tract, respiratory tract, and blood stream (►**Table 4**). None of the patients developed cerebrospinal fluid (CSF) leak, meningitis, or surgical site infection. *Klebsiella pneumoniae* and *Escherichia coli* were the most frequently cultured organisms (►**Fig. 1**). Overall, 34 patients (14.6%) developed postoperative infection. Only 8% of patients who did not receive blood transfusion (11 of 137) developed postoperative infection and among 103 patients who received blood transfusion, 23 (22%, $p = 0.001$) developed postoperative infection (►**Table 5**). Patient outcome at discharge is shown in ►**Table 6**.

Table 4 Percentage of various postoperative infections

Postoperative infection	Number of patients affected, *n* (%)
Total patients infected	34 (14.16)
Urinary tract infection	10 (4.1)
Blood stream infection	6 (2.5)
Respiratory tract infection	15 (6.2)
Blood stream and urinary tract infection	1 (0.41)
Respiratory tract and urinary tract infection	1 (0.41)
Blood stream and respiratory tract infection	1 (0.41)

Table 5 Association between perioperative blood transfusion and postoperative infection

		Postoperative infection present		Total
		No	Yes	
Perioperative blood transfusion	No	126 (61.2%)	11 (32.3%)	137 (57.0%)
	Yes	80 (38.8%)	23 (67.7%)	103 (43.0%)
Total		206 (100.0%)	34 (100.0%)	240 (100.0%)

Note: Applied χ^2 test for significance. χ^2 value =11.54; df(1); $p = 0.001$; consider very significant.

Table 6 Outcome of patients at discharge

Patient outcome	Blood transfusion	
	Yes	No
Expired	19 (18.5%)	12 (8.8%)
Poor GCS (<8)	33 (32%)	32 (23.4%)
GCS ≥8	51 (49.5%)	93 (67.9%)
Total	103 (100%)	137 (100%)

Abbreviation: GCS, Glasgow coma scale.

Discussion

Neurosurgical patients have different concerns depending upon the type or site of pathology. They are likely to have stormy intraoperative course as well as prolonged postoperative course due to varied reasons. In this study, we evaluated blood transfusion and its association with all types of postoperative infections.

The incidence of postoperative infections in this study (14.16%) highlights the importance of exploring potential risk factors to mitigate such complications in this cohort of patients. Dosch et al conducted a retrospective study on 6,869 patients who underwent pancreatoduodenectomy. Among these, 1,372 patients had undergone perioperative blood transfusion. The incidence of postoperative infection was significantly higher in patients who received transfusion (34.7 vs. 26.5%, $p < 0.001$). They concluded that perioperative blood transfusion was independently associated with the risk of postoperative infection with an adjusted odds ratio of 1.41 (1.23–1.62).[6]

However, in contrast, Abukhodair et al conducted a prospective cohort study of 197 patients aged 18 to 84 years posted for elective cardiac surgery.[7] They observed that the majority of patients (93.4%) received transfusion perioperatively, whereas only 31.82% of patients among them had postoperative infection at 6 weeks. Since most of the patients received transfusions, they compared the patients by dividing them into two groups, patients who received greater than 2 units of packed red blood cells (pRBC) or ≤2 units of pRBC. On analysis, the risk of postoperative infection was comparable between the two groups ($p = 0.902$). This study was done prospectively; however, the groups were compared with respect to more transfusion versus less transfusions. Almost all the patients received transfusions. Recently, Ryvlin et al conducted a retrospective study on 153 patients who underwent surgery for spinal metastases.[8] A total of 43% patients had received perioperative RBC transfusion and the overall incidence of postoperative infection was 22%. The rate of development of postoperative infection was three times more in patients who received perioperative blood transfusion (odds ratio [OR]: 3.02; 95% confidence interval [CI]: 1.36–6.73; $p = 0.007$). However, on adjusting confounders, they found out that also to be statistically insignificant. However, this cohort had the highest numbers of patients suffering from hematological malignancy and these patients already had metastatic disease and most likely on chemotherapy or irradiation. This makes this cohort anyways more vulnerable for development of postoperative infection. The cohort in our study was different since most of the intracranial tumors are confined intracranially and only locally invasive. Most patients suffering from intracranial tumors received alternate therapy such as irradiation only after surgical decompression of masses.

It may be intuitive to transfuse blood in a bleeding patient to correct anemia and coagulopathy; however, transfusion is not risk free.[9,10] Transfusion-associated immunomodulation (TRIM) represents a possible mechanism wherein blood transfusions can suppress immune function, predisposing recipients to infectious complications. The TRIM effect may be mediated by allogenic white blood cells (WBC) present in blood products or due to the presence of soluble products such as human leukocyte antigen (HLA) class I peptide in transfused allogenic plasma.[11]

In our cohort, surgical time—an important factor contributing to postoperative infections—was significantly longer in patients who received blood transfusions. This could be due to the extended time required to complete surgery because of bleeding, or because longer surgeries result in more bleeding and thus more transfusions. Additionally, patients who received transfusions also had prolonged durations of

mechanical ventilation. Those with extended surgical times and greater intraoperative blood loss are more likely to remain intubated postoperatively, leading to an increased period of mechanical ventilation.

In our study, 8% of the patients who did not receive any transfusion also developed postoperative infection. There can be numerous reasons for postoperative infections, especially in neurosurgical patients who remain on mechanical ventilation for prolonged periods, predisposing them to ventilator-associated pneumonias and the presence of indwelling urinary catheters can predispose to catheter-related infections.

While this study provides valuable insights into the association between perioperative transfusion and postoperative infections, certain limitations warrant consideration. The retrospective nature of the study introduces inherent biases and confounders and thus limits the ability to establish causality. Furthermore, the single-center design may restrict the generalizability of the findings to broader patient populations. Prospective multicenter studies are warranted to validate these findings and elucidate the underlying mechanisms driving this association. Perioperative steroid use is integral to neurosurgical management and cannot be feasibly avoided, which in turn might also altered the incidence of infection due to immunomodulation.

Conclusion

In conclusion, our study suggests an association between blood transfusion and development of postoperative infections among neurosurgical patients. The findings underscore the importance of judicious transfusion practices to minimize infectious complications in this vulnerable population, although implementing such practices poses challenges in neurosurgical patients due to their specific surgical requirements.

Conflict of Interest
None declared.

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