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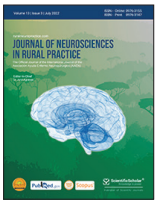

Original Article

Post-operative anemia in children undergoing elective neurosurgery: An analysis of incidence, risk factors, and outcomes

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ABSTRACT

Objectives: Pediatric neurosurgeries carry a considerable risk of intraoperative bleeding and, subsequently, anemia in the post-operative period. Post-operative anemia is often multifactorial with several factors contributing to its occurrence. The present study aims to quantify the incidence of post-operative anemia, identify potential risk factors, and assess the impact of post-operative anemia on clinical outcomes in the pediatric neurosurgery population.

Materials and Methods: This was a single-center and retrospective cohort study which included children <18 years of age undergoing elective neurosurgery. The data were extracted from the electronic and physical patient health records. Post-operative anemia was defined for this study as a hemoglobin value below 10 g/dL at any time up to 3 days after surgery.

Results: A total of 300 children were recruited during the study period. The incidence of post-operative anemia after elective pediatric neurosurgery was 21.33%. Children in the post-operative anemia group were younger ($P = 0.004$), had lower pre-operative hemoglobin values ($P < 0.001$), belonged to higher American Society of Anesthesiologists (ASA) physical status ($P = 0.023$), underwent predominantly supratentorial ($P = 0.041$) and non-tumor surgeries (0.004), and received lesser intraoperative blood transfusion ($P = 0.010$) compared to no post-operative anemia group. The factors that remained predictive of post-operative anemia on multivariate analysis were ASA physical status ($P = 0.018$, odds ratio [OR] = 1.94, 95% confidence interval [CI] of 1.12–3.36), pre-operative hemoglobin ($P < 0.001$, OR = 0.64, 95% CI of 0.50–0.82), and intraoperative transfusion ($P = 0.028$, OR = 0.45, 95% CI of 0.22–0.92).

Conclusion: Optimization of modifiable risk factors is essential to reduce the occurrence of post-operative anemia and improve outcomes in pediatric neurosurgical patients

Keywords: Pediatric neurosurgery, Post-operative, Anemia, Outcome

INTRODUCTION

Pediatric neurosurgeries carry a considerable risk of intraoperative bleeding and, subsequently, anemia in the post-operative period.[1] This risk is often attributable to factors such as the nature of the surgery, body weight, pre-operative hemoglobin level, and blood loss and transfusion during surgery. Intraoperative bleeding can result in hemodynamic instability, reduced oxygen-carrying capacity, increased transfusion of intravenous fluids and blood products during and after the surgery, and consequently, increased perioperative morbidity and mortality. Post-operative anemia can be minimized to a great extent by optimizing pre-operative hemoglobin levels in elective surgeries, adopting meticulous surgical technique, careful assessment of intraoperative blood loss, hematocrit measurements at regular intervals, and appropriate transfusion of blood products.[1] The margin of tolerance of perioperative anemia in children undergoing neurosurgeries may be lower than that of adults requiring close assessment and appropriate blood management strategies.

Both anemia and blood transfusion negatively impact the clinical outcomes in the neurosurgical population.[2] Anemia results in impaired cerebral oxygen delivery. On the other hand, blood transfusion is associated with transfusion reactions, thrombotic events, and circulatory overload, all of which could result in secondary brain injury.[2,3] Both anemia and transfusion result in increased length of stay in the intensive care unit (ICU) and the hospital, increased rate of a second surgery, and increased hospital costs.[4,5]

There are limited data about the burden of anemia after elective neurosurgery in children. Post-operative anemia is

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often multifactorial with several factors contributing to its occurrence. It is prudent to identify correctable causes to improve outcomes. The present study aims to quantify the incidence of post-operative anemia, identify potential risk factors, and assess the impact of post-operative anemia on clinical outcomes in the pediatric neurosurgery population.

MATERIALS AND METHODS

This was a single-center and retrospective cohort study conducted at a tertiary neurosciences academic hospital. Approval of the Institute Ethics Committee was obtained (NIMH/40th IEC/BS and NS DIV/2023), and the requirement for written informed consent was waived due to the retrospective nature of the study. All the procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional or regional) and with the Helsinki Declaration of 1975, as revised in 2000.

All consecutive children aged below 18 years and undergoing elective neurosurgery with general anesthesia for 10 months from February 2022 to November 2022 were included in this study. The data were extracted from the electronic and physical patient health records. We collected data regarding age, gender, body mass index (BMI), American Society of Anesthesiologists (ASA) physical status, diagnosis, surgery, pre-operative hemoglobin, surgery duration, intraoperative blood loss and red blood cell (RBC) transfusion, and intraoperative fluid balance. Post-operative data collection with regard to patient outcomes included post-operative hemoglobin and RBC transfusion up to 72 h after surgery, non-extubation after surgery in the operating room, ICU and hospital stay, and mortality. Post-operative anemia was defined for this study as a hemoglobin value below 10 g/dL at any time up to 3 days after surgery.

The primary outcome of this study was the incidence of anemia in the post-operative period in a cohort of pediatric patients undergoing neurosurgery. Secondary outcomes were predictors of post-operative anemia and impact of post-operative anemia on patient-important clinical outcomes.

A previous study in children undergoing cardiac surgeries documented an incidence of post-operative anemia of 27.7% among 119 patients.[4] Considering a 95% confidence level and a 5% margin of error, a minimum sample size of 87 was deemed necessary. As we also planned to explore an association between post-operative anemia and 11 potential risk factors, we inflated the sample size to 220 considering about 20 patients for each predictor variable. We studied a total of 300 patients to overcome limitations posed by loss from attrition or non-availability of hemoglobin values for any reason.

The statistical analysis was performed using IBM SPSS Statistics 26. The categorical data are presented as frequencies and percentages. Continuous data are presented as mean ± standard deviation or as median with interquartile range (IQR), based on the normality of data distribution. The study population was divided into anemia and no anemia groups based on post-operative hemoglobin cutoff of 10 g%. Univariate analysis was first performed to study the association between post-operative anemia and possible risk factors (age, gender, BMI, ASA physical status, diagnosis, surgery, pre-operative hemoglobin, surgery duration, intraoperative blood loss, and RBC transfusion). Factors significant ($P < 0.05$) on univariate analysis were then entered into a multivariate regression model to identify predictors of post-operative anemia. The odds ratio (OR) and the 95% confidence interval (CI) are reported as significant factors. The association between post-operative anemia and clinical outcomes was also studied. $P < 0.05$ was taken as statistically significant for the final model.

RESULTS

A total of 300 children were recruited during the study period and there was no loss of outcome data. The incidence of post-operative anemia after elective pediatric neurosurgery was 21.33% (64/300). The median (IQR) hemoglobin value after surgery in the anemia group was 9.3 (8.5–9.7) g% and 11.5 (10.7–12.9) g% in the no anemia group. The median (IQR) pre-operative hemoglobin values in the anemia and no anemia groups were 11.15 (10.3–12.2) g% and 12.2 (11.43–13.1) g%, respectively. Children in the post-operative anemia group were younger ($P = 0.004$), had lower pre-operative hemoglobin values ($P < 0.001$), belonged to higher ASA physical status ($P = 0.023$), underwent predominantly supratentorial ($P = 0.041$) and non-tumor surgeries (0.004), and received lesser intraoperative blood transfusion ($P = 0.010$) compared to no post-operative anemia group [Table 1]. The factors that remained predictive of post-operative anemia on multivariate analysis were ASA physical status ($P = 0.018$, OR = 1.94, 95% CI of 1.12–3.36), pre-operative hemoglobin ($P < 0.001$, OR = 0.64, 95% CI of 0.50–0.82), and intraoperative transfusion ($P = 0.028$, OR = 0.45, 95% CI of 0.22–0.92) [Table 2].

The non-extubation rate in the operating room after surgery ($P = 0.045$) and post-operative RBC transfusion up to 3 days after surgery ($P < 0.001$) were significantly higher in patients demonstrating post-operative anemia. The post-operative ICU admission, hospital stay, and mortality though higher in children with post-operative anemia were however not statistically different when compared to those without post-operative anemia [Table 1]. Four out of 300 children, two in each group, died after surgery during the hospital stay. The cause of death in both groups was not related to anemia and was due to severe electrolyte disturbance, post-operative meningitis, and neurogenic pulmonary edema ($n = 2$).

Table 1: Factors associated with postoperative anemia on univariate analysis; values are presented as median (interquartle range) or as numbers (percentages).

Variable	Anemia (*n*=64)	No anemia (*n*=236)	*P*-value
Age (months)	63.5 (21.5–135.25)	108 (48.5–156)	**0.004***
BMI (kg/m^2)	16.9 (14.5–19.3)	16.5 (14.1–20.4)	0.628
Pre-operative hemoglobin (g %)	11.2 (10.3–12.2)	12.2 (11.4–13.1)	**<0.001***
Surgery duration (min)	200 (91.5–270)	197.5 (120–283.75)	0.482
Intraoperative blood loss (mL/kg/h)	2.8 (1.4–4.8)	2.3 (1.1–4.7)	0.139
Intraoperative fluid balance (mL)	18.26 (12.26–27.70)	21.30 (12.96–35.85)	0.221
Male gender (*n*)	33/64 (51.5%)	126/236 (53.4%)	0.888
ASA grade (*n*)	2 (2–2)	2 (1–2)	**0.023***
Surgery site			
Supratentorial surgery (*n*)	50/64 (78%)	161/236 (68%)	**0.041***
Infratentorial surgery (*n*)	2/64 (3%)	35/236 (15%)	
Spine surgery (*n*)	12/64 (19%)	40/236 (17%)	
Surgical pathology (*n*)			
Tumor	16/64 (25%)	106/236 (45%)	**0.004***
Non-tumor	48/64 (75%)	130/236 (55%)	
Intraoperative RBC transfusion (*n*)	16/64 (25%)	101/236 (43%)	**0.010***
Non-extubation in the operating room (*n*)	12/64 (18.8%)	22/236 (9.3%)	**0.045***
Postoperative transfusion upto 3 days (*n*)	21/64 (32.8%)	5/236 (2.1%)	**<0.001***
Postoperative intensive care unit admission (*n*)	15/64 (23.4%)	33/236 (13.9%)	0.083
Postoperative hospital stay (days)	6 (5–10.75)	6 (4–9)	0.066
Postoperative mortality (*n*)	2/64 (3%)	2/236 (0.9%)	0.201

BMI: Body mass index, ASA: American society of anesthesiologists, RBC: Red blood cells, *P<0.05

Table 2: Predictors of postoperative anemia on multivariate analysis.

Variables	B	S.E.	Wald	df	Sig.	Exp (B)	95% CI for EXP (B)	
							Lower	Upper
Age (months)	−0.004	0.003	2.125	1	0.145	0.996	0.991	1.001
ASA grade	0.661	0.280	5.565	1	**0.018***	1.937	1.118	3.355
Pre-operative hemoglobin	−0.447	0.124	12.981	1	**<0.001***	0.639	0.501	0.815
Site of surgery			2.397	2	0.302			
Spine surgery	−0.034	0.407	0.007	1	0.934	0.967	0.436	2.146
Supratentorial	−1.277	0.880	2.104	1	0.147	0.279	0.050	1.566
Tumor pathology	−0.106	0.378	0.078	1	0.780	0.900	0.429	1.887
Intraoperative RBC transfusion	−0.790	0.360	4.823	1	**0.028***	0.454	0.224	0.919
Constant	3.553	1.48	5.796	1	0.016	34.93		

ASA: American Society of Anesthesiologists, RBC: Red blood cells, S.E.: Standard error, CI: Confidence interval, *P<0.05

DISCUSSION

Children undergoing major neurosurgery are likely to suffer intraoperative blood loss, requiring blood transfusion, and are also prone to develop post-operative anemia. The incidence of post-operative anemia in children undergoing neurosurgery is not known. Similarly, the threshold for blood transfusion in pediatric neurosurgical patients is not well established.[6] In our study, we noted the incidence of post-operative anemia after elective pediatric neurosurgery to be 21.3%. The predictors for post-operative anemia were higher ASA grade, lower pre-operative hemoglobin, and not receiving intraoperative blood transfusion. The latter two are modifiable risk factors and should be aggressively pursued to reduce the occurrence of post-operative anemia in children undergoing neurosurgery.

Pre-operative anemia has been shown to be an important risk factor for in-hospital mortality and neurodevelopment disorders.[7] The previous studies in pediatric surgical patients undergoing non-cardiac surgeries in low-middle-income countries have shown a prevalence of pre-operative anemia of 30–45%.[7,8] In our study cohort, only 7% (21/300) of the children had pre-operative hemoglobin values below 10 g% (pre-operative anemia). The lower incidence of pre-operative anemia in our study could be due to the 10 g% cutoff used and including only the elective neurosurgical patients.

In our study population, 39% of the children received RBC transfusion in the intraoperative period and 8.7% of the children received transfusion in the first 72 h of surgery. No patient in our study received transfusion if their hemoglobin was >10 g%. The British Committee for Standards in Hematology guideline[9] and the Association of Anesthetists of Great Britain and Ireland guidelines[10] recommend 7–8 g% as the RBC transfusion trigger. However, it is unclear if these recommendations are applicable to children and especially those undergoing neurosurgeries. There are no high-quality randomized controlled trials or systematic reviews informing the transfusion trigger in children undergoing neurosurgery. Thus, clinical experience, extrapolation from the non-neurosurgical population, and expert opinions guide transfusion practice in pediatric neurosurgery. The World Health Organization definition of anemia (hemoglobin values in men <13 g% and women <12 g%) is usually not used to decide perioperative anemia management.

The blood transfusion practices in the perioperative period vary among clinicians, institutes, and type of surgeries.[11] The appropriateness of intraoperative patient blood management should reflect in acceptable post-operative hemoglobin values without leading to anemia or polycythemia. A higher percentage (39%) of intraoperative RBC transfusion in our study population might have contributed to a lower incidence of post-operative anemia. Intraoperative transfusion in children undergoing neurosurgeries is largely guided by hemoglobin levels done using point-of-care devices, hemodynamic fluctuations, stage of surgery, rapidity of blood loss, and clinical judgment of the anesthesiologist.[12] Although the previous studies have demonstrated the safety of restrictive transfusion (7 or 8 g/dL) in pediatric patients, the sensitivity of the pathological brain to the reduced oxygen delivery, effects of anemia, and the vulnerable age group have to be given due consideration.[6,13]

A previous study in pediatric surgical patients noted that pre-operative anemia was associated with a 2.17 higher odds of in-hospital mortality.[14] In our study, we observed that for every 1 unit increase in pre-operative hemoglobin value, the occurrence of post-operative anemia was reduced by 36%. We also observed that post-operative anemia was significantly associated with non-extubation in the operation room and increased RBC transfusion up to 3 post-operative days. However, no association was observed with regard to ICU and hospital stay or mortality. The previous studies have shown pre-operative and intraoperative anemia are associated with increased length of ICU and hospital stay after pediatric surgeries.[8] Anemia can be corrected by blood transfusion; however, transfusion to treat anemia itself can increase morbidity and mortality. Studies have shown that elevated hematocrit after transfusion increases the risk of venous thrombosis.[15] In patients undergoing cranial surgeries, blood transfusion was associated with increased post-operative complications, re-operations, prolonged length of stay, and mortality.[16] Studies have shown increased 30-day morbidity and mortality in adult patients undergoing neurosurgery if they had pre-operative anemia or received a blood transfusion.[3,17-19]

In pediatric neurosurgery, multiple factors such as hemoglobin levels, ASA status, type of surgery, and risk of transfusion should be considered before taking the decision to transfuse. The hemoglobin level alone may not be useful in predicting outcomes.[14,16] As the incidence of post-operative anemia in children undergoing neurosurgery is high, careful monitoring and optimizing perioperative patient blood management strategies should be considered to improve outcomes.

To the best of our knowledge, this is probably the first study to assess the incidence, risk factors, and impact of post-operative anemia in children undergoing neurosurgery. However, our study has certain limitations that need to be considered when interpreting the results. First, the study was conducted in a single center, and the data were collected retrospectively. Second, intraoperative transfusion was not always guided by point-of-care hemoglobin assessment, which might have influenced the occurrence of post-operative anemia. The decision to transfuse was multifactorial not based solely on hemoglobin values but took into consideration factors such as rapidity and extent of blood loss, stage of surgery, and hemodynamic status. Third, our definition of anemia may be different from that of other centers. Finally, we did not assess the long-term outcomes beyond the hospital stay.

CONCLUSION

About one in five children undergoing elective neurosurgery develop post-operative anemia in the first 3 days after surgery. Optimization of modifiable risk factors – pre-operative hemoglobin level and intraoperative RBC transfusion, is essential to reduce the occurrence of post-operative anemia and improve outcomes in pediatric neurosurgical patients. A larger prospective study using different transfusion triggers will help determine the appropriate perioperative transfusion threshold to optimize clinical outcomes in the pediatric neurosurgical population.

Ethical approval

Approval of the Institute Ethics Committee was obtained (NIMH/40th IEC/BS and NS DIV/2023).

Declaration of patient consent

The Institutional Review Board (IRB) permission was obtained for the study.

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Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The author(s) confirms that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using the AI.

REFERENCES

1. Alsatli RA. Pediatric neurosurgery, special attention is required! Anesth Essays Res 2011;5:127.
2. Gruenbaum SE, Ruskin KJ. Red blood cell transfusion in neurosurgical patients. Curr Opin Anaesthesiol 2014;27:470-3.
3. Kisilevsky A, Gelb AW, Bustillo M, Flexman AM. Anaemia and red blood cell transfusion in intracranial neurosurgery: A comprehensive review. Br J Anaesth 2018;120:988-98.
4. Liu J, Lin J, Guan X, Liu L, Pan X, Zhou L, *et al*. Risks associated with perioperative anaemia and perioperative blood transfusion in patients undergoing neurosurgical operation. Transfus Med 2020;30:343-51.
5. Jutras C, La KA, Gerardis G, Richard R, Pont-Thibodeau GD. Anemia after pediatric congenital heart surgery. J Pediatr Intensive Care 2022;11:308-15.
6. Feng H, Charchaflieh JG, Wang T, Meng L. Transfusion in adults and children undergoing neurosurgery: The outcome evidence. Curr Opin Anaesthesiol 2019;32:574-9.
7. Meyer HM, Torborg A, Cronje L, Thomas J, Bhettay A, Diedericks J, *et al*. The association between preoperative anemia and postoperative morbidity in pediatric surgical patients: A secondary analysis of a prospective observational cohort study. Paediatr Anaesth 2020;30:759-65.
8. Charuvila S, Davidson SE, Thachil J, Lakhoo K. Surgical decision making around paediatric preoperative anaemia in low-income and middle-income countries. Lancet Child Adolesc Health 2019;3:814-21.
9. Robinson S, Harris A, Atkinson S, Atterbury C, Bolton-Maggs P, Elliott C, *et al*. The administration of blood components: A British Society for Haematology Guideline. Transfus Med 2018;28:3-21.
10. Klein AA, Arnold P, Bingham RM, Brohi K, Clark R, Collis R, *et al*. AAGBI guidelines: The use of blood components and their alternatives 2016. Anaesthesia 2016;71:829-42.
11. Shander A, Corwin HL, Meier J, Auerbach M, Bisbe E, Blitz J, *et al*. Recommendations from the international consensus conference on anemia management in surgical patients (ICCAMS). Ann Surg 2023;277:581-90.
12. Meier J, Filipescu D, Kozek-Langenecker S, Pitarch JL, Mallett S, Martus P, *et al*. Intraoperative transfusion practices in Europe. Br J Anaesth 2016;116:255-61.
13. Akyildiz B, Tekerek NU, Pamukcu O, Dursun A, Karakukcu M, Narin N, *et al*. Comprehensive analysis of liberal and restrictive transfusion strategies in pediatric intensive care unit. J Trop Pediatr 2017;64:118-25.
14. Faraoni D, DiNardo JA, Goobie SM. Relationship between preoperative anemia and in-hospital mortality in children undergoing noncardiac surgery. Anesth Analg 2016;123:1582-7.
15. Musallam KM, Porter JB, Sfeir PM, Tamim HM, Richards T, Lotta LA, *et al*. Raised haematocrit concentration and the risk of death and vascular complications after major surgery. Br J Surg 2013;100:1030-6.
16. Cohen JA, Alan N, Seicean A, Weil RJ. Risk associated with perioperative red blood cell transfusion in cranial surgery. Neurosurg Rev 2017;40:633-42.
17. Khanna R, Harris DA, McDevitt JL, Fessler RG, Carabini LM, Lam SK, *et al*. Impact of anemia and transfusion on readmission and length of stay after spinal surgery: A single-center study of 1187 operations. Clin Spine Surg 2017;30:E1338-42.
18. Liu Y, Li L, Hu H, Yang J, Zhang X, Chen L, *et al*. Association between preoperative hematocrit and postoperative 30-day mortality in adult patients with tumor craniotomy. Front Neurol 2023;14:1059401.
19. Alan N, Seicean A, Seicean S, Neuhauser D, Weil RJ. Impact of preoperative anemia on outcomes in patients undergoing elective cranial surgery. J Neurosurg 2014;120:764-72.

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