Anaesthetic management of craniosynostosis repair – A retrospective study

INTRODUCTION

Craniosynostosis, the premature fusion of skull sutures, results in failure of normal bone growth perpendicular to the suture and the compensatory growth at other suture sites resulting in an abnormally shaped head. Eighty percent of craniosynostosis occurs in isolation; the remaining occur as part of a syndrome.[1] Syndromic craniosynostosis (SC) is commonly associated with multiple suture involvement with facial bone anomalies and congenital aberrations involving many organ systems.[1]

Early corrective surgery during infancy allows normal brain development and prevents blindness. Total of 40 to70% of SC children present with raised intracranial pressure (ICP) due to hydrocephalus, craniocerebral disproportion, or abnormalities in the cerebral venous drainage.[1] Early corrective surgery presents with many anaesthetic challenges that include management of a difficult airway,[2] massive blood loss, transfusion and its associated complications. We review the anaesthetic management of craniosynostosis corrective surgery at a tertiary center in a developing country.

METHODS

After institutional review board approval, we extracted data on children who underwent corrective surgery from 2008-2018. Relevant preoperative, intraoperative, and postoperative variables were collected from in-patient hospital and anaesthesia records. Single neurosurgeon, the same team of neuro-anaesthesiologists, and plastic surgeons were involved in the intraoperative management.

Statistical analysis was performed using SPSS (Version 18, Chicago, IL, USA). Parametric variables were presented as mean ± SD and were analysed by Student's *t*-test or analysis of variance (ANOVA) and the Pearson correlation test as appropriate. For non-parametric variables, an analysis was performed using Chi-square or Mann–Whitney-U test and Spearman correlation coefficients. *P* value <0.05 was considered significant.

RESULTS

Twenty-five children with craniosynostosis underwent reconstructive surgery over a period of 10 years. The demographic details are in Table 1. Of the 25 children, 12 (48%) were syndromic, 10 had Crouzon syndrome, and 2 had Apert syndrome. The most common suture involved was coronal, followed by sagittal, metopic, and lambdoid. There was no association between the child being syndromic and the number of sutures involved. Their average preoperative packed cell volume (PCV) percentage was 35.06 ± 3.33. Out of 25 children, 9 children had raised ICP, of which 2 children needed ventriculoperitoneal shunt. Two children had associated cardiac abnormality, one had Tetralogy of Fallot and the other had patent foramen ovale with left to right shunt.

Sevoflurane induction was carried out in 19 (76%) children and rest had intravenous induction. Anaesthesia was maintained with inhalational agents in 21 (84%), and 4 (16%) had received a combination of intravenous and inhalational. Out of 25, 19 (76%) had an anticipated difficult airway, of which 12 (63%) were syndromic, and 7 (37%) were non-syndromic. Though a difficult airway was anticipated in 19 children, only 1 (4%, syndromic) required intubation with a fiberoptic bronchoscope. Two other syndromic children (8%) required the assistance of a video laryngoscope. The

Table 1: Patient demographics

	Mean	SD
Age (months)	21.4	14.6
Weight (Kg)	8.86	2.41
Pre-op PCV (%)	35	3.5
	Count	**(%)**
Gender		
Male	15	60%
Female	10	40%
Syndromic	14	56%
ASA grade		
1	20	80%
2	4	16%
3	1	4%
Number of sutures involved		
1	7	28%
2	8	32%
3	3	12%
4	7	28%
Distribution of suture involved		
Lambdoid		22%
Coronal		33%
Metopic		23%
Sagittal		22%

rest were intubated with direct laryngoscopy using Macintosh blade and styleted endotracheal tube. Five syndromic children and one non-syndromic child had a Cormack–Lehane laryngoscopic grade of 3. Syndromic children had a higher incidence of difficult airway (66%) compared to non-syndromic children (14%).

Average blood loss was 39.6 ml/kg (range: 6–133 ml/kg); syndromic group had higher loss compared to the non-syndromic children (51 vs. 29 ml/kg; *P* value = 0.04). Average blood loss in terms of blood volume percentage was 52 ± 35%. All children had received tranexamic acid (TXA) except three. Those who did not receive TXA had increased blood loss compared to those who received (56 vs. 35 ml/kg; *P* = 0.14). Those who had intraoperative coagulation abnormality (seven) had higher blood loss of 68 vs. 28.5 ml/kg (*P* = 0.0003). The average lowest PCV recorded during the intraoperative period was 25.6 ± 6.2%. All 25 children received packed red blood cell (PRBC) transfusion, five received fresh frozen plasma (FFP), three received cryoprecipitate, and three received platelets. The average amount of PRBC, FFP, platelet transfusion, and cryoprecipitate transfusion was 30.3, 14.5, 6.2, and 4.3 ml/kg. Hypofibrinogenemia was the most common coagulation abnormality seen during the intraoperative period. None of them had hypothermia (Temperature <35°C) during surgery despite massive transfusion.

Out of 25, 16 (64%) had required noradrenaline infusion for maintaining mean arterial blood pressure within 20% of baseline, and the infusion was tapered and stopped at the end of surgery in 14 children, the other two required it during the postoperative period as well. One child needed both noradrenaline and adrenaline to maintain haemodynamic stability. Of 25, 15 children had intraoperative arterial blood gas analysis towards the end of surgery; of which, 6 (45.3%) had lactate of >2 mmol/L, 10 (66%) had hyperchloremia; 9 (60%) had hypocalcaemia, and 1 (6.6%) had hyperkalaemia. The duration of anaesthesia and surgery was 6 (5–6.5) and 4.5 (4–5) hours in median and IQR respectively. There was no correlation between the number of sutures involved and the duration of surgery (*P* = 0.418) and with the blood loss (*P* = 0.331). All children were extubated at the end of surgery except 4 (16%) children who needed postoperative ventilation among which three were syndromic, and one was non-syndromic. All of them were ventilated because of massive blood transfusion, and one had associated airway edema as well.

The mean duration of intensive care unit (ICU) and hospital stay was 1.7 ± 1.21 and 5.1 ± 1.5 days, respectively. Among the four who were ventilated postoperatively, the mean duration of postoperative ventilation was 2.75 (range 1–5) days. The intraoperative blood loss was positively correlated with the duration of ICU stay (correlation coefficient- 0.744, *P* = 0.001) and the hospital stay (correlation coefficient-0.57, *P* = 0.003). The amount of PRBC transfusion was positively correlated with the duration of ICU stay (correlation coefficient-0.58, *P* = 0.002) and hospital stay (correlation coefficient of 0.5, *P* = 0.01). The average postoperative PCV was 32.2 ± 5.8% (First postoperative day).

Postoperative coagulation profile was done in 8/25 (32%); of these, five were abnormal. Hypofibrinogenemia was the most common abnormality (3/5), followed by thrombocytopenia (1/5) and deranged activated partial thromboplastin time (1/5). Out of 25 patients, five received postoperative transfusion, two received only PRBC, one received PRBC, FFP, and cryoprecipitate, one child received only cryoprecipitate, and the other one received PRBC and platelets.

Two (8%) children had a postoperative wound infection. We did not find a significant correlation between the volume transfused and the risk of wound infection (66.3 vs 37.2 ml/kg, *P* = 0.15). None of them needed a tracheostomy, and there was no 30-day mortality.

DISCUSSION

SC is associated with other congenital anomalies involving multiple organ systems. A thorough pre-surgical evaluation by the otorhinolaryngologist, ophthalmologist, and neuroanaesthesiologist is needed. Our study results were comparable with other study results with regards to the management of difficult airway, blood loss, blood transfusion and the use of TXA to reduce blood loss.

As compared to the Cárdenas study,[3] our study had a higher number of children with predicted difficult airway (58.3 vs. 76%) and difficult intubation (5.2 vs. 15%) needing fiberoptic bronchoscopy (FOB) or video laryngoscope. In terms of blood loss, our study results were similar to other studies that showed that

SC had more blood loss as compared to non-syndromic children.[4]

Our results confirmed the reduction in blood loss and transfusion requirement in children who received TXA, which was similar to other randomized trials and meta-analysis results.[5,6] Though the reduction in blood loss is clinically significant in the TXA group; it is not statistically significant due to a smaller number (only three did not receive TXA). Different dose regimens of TXA have been used to reduce the blood loss in various surgeries ranging from 10–100 mg/kg, followed by 1–10 mg/kg/hr infusion.[3] In our institution, we used 20 mg/kg bolus followed by 1 mg/kg/hr infusion or 5 mg/kg bolus after 3 hours of administration of the first dose, which was similar to the study by Dadure *et al*.[7]

Studies have shown that the average transfusion in craniosynostosis surgery was about 50–100 ml/kg.[5,8] In our study, the average PRBC transfusion volume was 30 ml/kg. We found a correlation between the intraoperative blood loss, the volume of blood transfused, and the duration of ICU stay which is supported by other studies.[9] In our study population, 64% received noradrenaline for the haemodynamic support, which was higher than the other study results.[3] This may be due to the routine practice of starting a low dose of noradrenaline (0.02 μg/kg/min) to combat the anaesthesia-induced vasodilation and to keep the haemodynamics within 20% of baseline. One child received adrenaline along with noradrenaline because of a severe allergic non-haemolytic blood transfusion reaction. Consistent with the findings of Christian *et al*., we too failed to find a significant association between the volume of blood transfused and the risk of wound infection.[10]

CONCLUSIONS

Syndromic children had a higher incidence of difficult airway and more prone to higher blood loss as compared to non-syndromic children. Higher volume of blood loss and the PRBC transfusion is associated with increased duration of ICU and hospital stay. Clinically, the administration of TXA decreased intraoperative blood loss. Prevention of dilutional coagulopathy by avoiding excessive use of crystalloids, transfusing appropriate volumes of blood and blood products at the correct time, preventing the intraoperative hypotension by administering a low dose of vasopressors, and preventing hypothermia helped in reducing the complications in our series.

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Conflicts of interest

There are no conflicts of interest.

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