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**Does the participation of a senior plastic surgeon improve perioperative care
in craniosynostosis repair surgery?**

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ABSTRACT

Introduction. The real impact of the participation of other surgical specialties together with neurosurgeons on perioperative care in craniosynostosis repair surgery has not been determined. The purpose of this study was to determine whether the participation of a second senior surgeon (plastic surgeon) during surgical repair of pediatric monosutural craniosynostosis improved perioperative medical care.

Material and methods. The authors retrospectively reviewed 2 cohorts of patients who had consecutively undergone primary repair surgery for trigonocephaly and unicoronal craniosynostosis. Infants were operated on by a single senior pediatric neurosurgeon before December 2017, and with the collaboration of a senior plastic surgeon after January 2018.

Results. Overall, 60 infants were included in the study: 29 in group 1 (single surgeon, 2011-2017), and 31 in group 2 (pair of surgeons, 2018-2021). Median surgery time was significantly shorter in group 2 than group 1: 180 vs 167 minutes; $p = 0.0045$. There was no significant difference between the 2 groups in blood loss or intra/postoperative packed erythrocyte transfusion. Postoperative drain output was significantly lower in group 2. Median length of hospital and intensive care stay were significantly shorter in group 2, by 1 and 2 days, respectively; $p < 0.0001$. Volume of infused solution, diuresis, immediate postoperative hemoglobin level, hematocrit, hemostasis (platelet count, fibrinogen, prothrombin time and activated partial thromboplastin time), and return to oral feeding did not differ from one group to the other.

Conclusion. Results confirmed our impression of an improvement in perioperative medical care. However, the role of surgical experience and the influence of the medical/nursing staff must not be minimized in these complex surgical procedures.

Keywords:

Craniosynostosis; blood loss; perioperative care; craniofacial surgery; surgeon collaboration

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1. Introduction

Craniosynostosis repair surgery is a major surgical procedure. Practice has varied exceedingly from one center to another, even for management of isolated craniosynostosis [1-3]. These variations concerned surgeon profiles, methods of patient evaluation, imaging, surgical technique and timing, and follow-up [4]. It is well-established that management of faciocraniosynostoses needs multidisciplinary expertise and collaboration of pediatric neurosurgeons with maxillofacial surgeons for surgical procedures, especially when midface distraction is needed [5]. Similarly, cooperation of pediatric neurosurgeons with plastic/maxillofacial surgeons is recommended when facial corrections or complex skull shape corrections are necessary in isolated single-suture craniosynostoses in order to optimize cosmetic results, even if there are no minimal requirements of team members for management of these craniosynostoses [5]. Since low surgical case volumes have been associated with increased perioperative transfusion volumes in this surgery [6], the real impact on perioperative care of the participation of other surgical specialties together with neurosurgeons during the surgical procedure has not been yet demonstrated.

The purpose of this study was to determine whether the participation of a second senior surgeon (plastic surgeon) during surgical repair of pediatric monosutural craniosynostoses improved conditions of hospitalisation.

2. Material and methods

2.1 Patient population

We retrospectively reviewed 2 cohorts of patients who consecutively underwent primary repair surgery for trigonocephaly and unicoronal craniosynostosis in our Department. Infants who needed an fronto-orbital “bandeau” were operated on by a single senior pediatric neurosurgeon (LR) before December 2017, and those who were treated after January 2018 were operated on both by senior

pediatric neurosurgeon (LR) and senior plastic surgeon (SA). We began the study after routinely introducing use of tranexamic acid (TXA) for craniosynostosis surgery in our institution in March 2011 [7]. The last child included was operated on in July 2021. We included in our study only craniosynostoses for which the surgical technique and timing did not change over time *i.e.* trigonocephaly and unilateral craniosynostoses, and we also excluded brachycephaly and atypical cranionynostoses. This study was approved by the “Collège de Neurochirurgie” IRB#1: 2022/44 n° IRB00011687. The study was designed as a monocentric before-after study.

2.2 *Surgical procedure*

Since 2000, the same standardized procedures had been performed for trigonocephaly and unilateral plagiocephaly [7]. These procedures were open cranial vault reconstructions since endoscopic procedures are not performed in our institution. A senior plastic surgeon (SA) started to collaborate during surgery after December 2017 when fronto-orbital advancement was required. The contribution of this surgeon was in observance of the conditions required by our French center of reference in surgical procedures involving the facial features. Duration of anesthesia was calculated from the induction of general anesthesia to extubation, and duration of surgical procedure from skin incision to the end of skin closure.

2.3 *Perioperative management*

During the 2 periods, anesthetic management was homogenized by the team of pediatric anesthesiologists for general anesthesia, patient monitoring, decisions regarding blood transfusions and TXA administration [7]. TXA was used in all the patients with a standardized protocol reported previously: a loading dose of 10 mg/kg over 15 minutes was followed by a 10 mg/kg per hour infusion until skin closure, and no TXA was used postoperatively. No patient with hematologic or

hemostasis abnormalities was included in the study. The timing of leaving intensive care unit and that of leaving hospital were decided by both the pediatric neurosurgeon and the pediatric anesthetist.

2.4 *Assessment of blood loss*

Numbers of patients transfused intra- and postoperatively and volume of packed erythrocytes (PE) transfusion were examined in both groups. Hemoglobin, hematocrit, platelet count, fibrinogen, prothrombin time and activated partial thromboplastin time were also analyzed. The estimated blood volume lost (EBV_{lost}) was calculated with a formula detailed in previous reports [7,8]. The EBV for children younger and older than 12 months was respectively 80 and 75 mL/kg, and the hematocrit of transfused packed red blood cells (PRBCs) was 0.65 at our hospital.

2.5 *Statistical analysis*

Age at surgery, sex, weight, American Society of Anesthesiologists (ASA) physical status, type of craniosynostosis, duration of anesthesia and surgery, volume of solution infused during the procedure, use of dopamine, diuresis, drain output, length of stay in intensive care unit and in hospital and postoperative day on which the patient started oral food were also recorded for statistical analysis. Quantitative variables were described as number, mean \pm SD, and median interquartile range [Q1; Q3]. Groups were then compared using Student test (S) or Mann-Whitney Wilcoxon nonparametric test (W). Qualitative variables were presented as numbers and percentages, and groups were compared using the chi-square (K) or Fisher's exact (F) tests. Association with duration of surgery was performed using Spearman coefficients.

Analyses were achieved using SAS version 9.4 (SAS Institute, Inc.), and $p < 0.05$ was considered for statistical significance.

3. Results

3.1 Patient characteristics

Overall, sixty infants were included in the study: 29 infants in group 1 (single surgeon, 2011-2017), and 31 in group 2 (pair of surgeons, 2018-2021). The median age of the patients was 8 months for both groups ($p = 0.7436$). There was no significant difference between groups concerning weight, ASA class and type of craniosynostosis. Group 2 included more female patients than group 1 ($p = 0.0292$). Preoperative biological data (hemoglobin, hematocrit, ERCV, thrombin time, fibrinogen and activated partial thromboplastin time) were identical in both groups. Platelet count was lower in group 1, but within normal ranges (Table 1).

3.2 Duration of surgery

The median duration of surgical procedures was significantly lower in group 2 (pair of surgeons) compared with group 1 (single surgeon): 167 vs 180 minutes; $p = 0.0045$ (Table 2). Median timesaving was 5% in trigonocephaly procedures with the pair of surgeons (172 minutes in group 2 vs 182 in group 1, $p = 0.0146$) and 21% in unicoronal craniosynostosis (140 minutes vs 177, $p = 0.0302$) (Table 3).

3.3 Estimated Blood Volume lost and blood product transfusion

Median Hemocue® values before transfusion were the same in both groups. There was no statistical difference between 2 groups regarding EBV_{lost} or intra/postoperative packed erythrocytes

transfusion (Table 4). Postoperative drain output was significantly lower in group 2 (pair of surgeons).

3.4 *Intraoperative and postoperative data*

Median lengths of stay in hospital and in intensive care were statistically lower in the group of pair surgeons: the median timesaving was estimated respectively as one and two days; $p < 0.0001$ (Table 2).

Volume of solution infused, diuresis, immediately postoperative hemoglobin, hematocrit, hemostasis (platelet count, fibrinogen, prothrombin time and activated partial thromboplastin time), and the return to receiving food orally were not different from one group to the other.

3.5 *Multivariate analysis*

Spearman coefficient values demonstrated that duration of surgical procedures positively influenced drain output (coefficient > 0.5), but was slightly correlated to the median volume of PE transfusion or the length of stay in hospital and in intensive care (Table 5).

4. Discussion

During the last two decades, our impression was a progressive improvement in perioperative care and management of child craniosynostosis patients, which appeared to result not only from the surgeon's level of experience. Consequently, we initially conducted a study assessing the impact of the routine use of TXA in our practice after its initiation in March 2011: we observed that TXA not only significantly reduced blood loss and the need for transfusions, but also decreased the hospital length of stay and minimized medical care costs, thus having major impact on

postoperative care. This result was in agreement with the subjective impression of the medical staff: pediatric anesthesiologists, intensive care unit doctors and the neurosurgeon.

A second question concerned the effect of cooperation with a senior plastic surgeon, which we initiated a few years ago in some cases of craniosynostosis repair surgery: did this collaboration influence our surgical performance, and consequently perioperative medical care? Although retrospective, our study allowed a reliable comparison of the two practices: a single senior pediatric neurosurgeon or a pair of senior surgeons, in the particular context of two complex monosutural craniosynostoses. Results from statistical analysis suggested a positive impact of collaboration: duration of general anesthesia and of surgical procedures remained significantly shorter, both for unicoronal craniosynostoses and trigonocephaly. Despite the significant reduction in operating time observed in the group of patients operated on by the pair of surgeons, we did not observe any improvement in blood loss and transfusion. This finding was probably the consequence of several factors but we assume that the duration of surgical procedures was too limited to observe a positive influence on blood loss, given the important benefit brought about by the use of TXA. Another significant consequence was shorter hospital stay in the group of patients operated on by the pair of surgeons. This result needs to be seen in the context of multivariate analysis: a shorter surgical procedure mainly influenced output drainage, with little impact on other factors such as blood loss, PE transfusion, length of stay in hospital or in intensive care. By reducing blood loss and thus output drainage, routine use of TXA may already have changed our practice over the years: drains have progressively been removed earlier (on day 1) reducing postoperative pain and therefore hospital stay [7]. In other words, we suppose that the progressive adjustment of our habits may have induced a potential bias, and the positive role of TXA should not be underestimated in the interpretation of the results. Furthermore, the role of surgical experience must not be minimized in this 10-year overall study. We have already demonstrated the relationship between surgical practice

and surgical experience in live surgery by recording the surgical processes: surgical expertise is synonymous with shorter procedures and greater efficiency in manual gesture [9]. On the other hand, it has been demonstrated that the learning curve generally reached a plateau after about fifty cases in craniofacial procedures firstly [10] and secondly the senior neurosurgeon in this report already had more than 10 years' experience of craniostomosis surgery at the beginning of this study. For these reasons, we suppose that the influence of experience on results was potentially real but limited. In a previous study comparing monosutural craniostomoses operated on by the same pediatric neurosurgeon, the median duration of operation was not statistically different between 2 successive groups of patients over a 7-year period [7].

A further unanswered issue is whether the contribution of a senior plastic surgeon influenced the cosmetic results in this population? This question remains scientifically very difficult to demonstrate, with a strong element of subjectivity. However, our opinion is largely positive: the emulation resulting from working in partnership, the intellectual stimulation of potential exchange looking for new solutions and concepts, in association with the pediatric anesthetic staff, have indubitably contributed to improving both cosmetic results and overall medical care. Furthermore, the presence of 2 senior surgeons was an important psychological factor generating confidence in the families and stimulating new ideas in the operating theatre.

Study limitations

Data were collected retrospectively, which suggested possibilities of inaccuracy. This being so, there was very little missing data, and all the recovery was done by a single researcher, which limited potential imprecision of data collection. Furthermore, this study compared a homogeneous population of patients operated on in a standardized manner in terms of surgical technique and physician team.

5. Conclusion

To the best of our knowledge, this study is the first to evaluate the added benefit of the presence of a second senior surgeon in craniostomy repair. The results confirmed our impression of an improvement in perioperative medical care. However, the role of surgical experience and the influence of the medical/nursing staff must not be minimized in these complex surgical procedures.

Disclosure of interest

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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Table 1

Patient characteristics

Parameter	Group 1 (single surgeon)	Group 2 (pair of surgeons)	P-value
	2011-2017	2018-2021	
Patients, n	29	31	
Median age, months	8 [8; 10]	8 [8; 10]	0.7436 (W)
Sex M/F, n	25/4	19/12	0.0292 (χ^2)
Type of craniosynostosis, n			0.3152 (χ^2)
Trigonocephaly	15	20	
Unicoronal	14	11	
Mean weight, kg	8.2 \pm 1.2	8.6 \pm 1.2	0.2636 (S)
ASA class I/II, n	25/4	25/6	0.7324 (F)
Preoperative biological values			
Mean hemoglobin, g/dL	11.7 \pm 0.7	11.7 \pm 0.7	0.8592 (S)
Mean hematocrit, %	35.1 \pm 2.0	34.4 \pm 1.9	0.1567 (S)
Mean ERCV, mL/kg	28.1 \pm 1.6	27.3 \pm 1.5	0.0878 (S)
Median platelet count, giga/L	346.0 [305.0; 425.0]	405.0 [356.0; 458.0]	0.0357 (W)
Mean thrombin time, %	99.8 \pm 12.3	102.5 \pm 11.9	0.4050 (S)
Median aPTT	1.1 [1.0; 1.2]	1.1 [1.0; 1.1]	0.4221 (W)

F: Fisher's exact test; S: Student's test; χ^2 : Chi-square test; pts: patients; W: Mann-Whitney Wilcoxon test; ERCV: estimated red cell volume; aPTT: activated partial thromboplastin time

Median values are presented as the median [Q1; Q3]. Boldface type indicates statistical significance.

Table 2

Intraoperative and postoperative data

Parameter	Group 1 (single surgeon) 2011-2017	Group 2 (pair of surgeons) 2018-2021	P-value
Intraoperative			
Mean duration of anesthesia, minutes	270.7 ± 39.1	241.5 ± 23.7	0.0011 (S)
Median duration of op, minutes	180.0 [170.0; 190.0]	167.0 [151.0; 180.0]	0.0045 (W)
Mean volume of solutions infused, mL/kg	69.6 ± 14.9	70.0 ± 15.1	0.9243 (S)
Median diuresis, mL/kg/h	1.3 [1.0; 2.3]	1.8 [1.2; 2.8]	0.2244 (W)
Postoperative			
Median length of stay, days			
Intensive care unit	4 [3; 4]	2 [2; 3]	< 0.0001 (W)
Hospital	4 [4; 4]	3 [3; 3]	< 0.0001 (W)
Nutrition			
Postop day 0/1/2, n	2/19/4	3/23/0	0.1344 (F)
Mean hemoglobin, g/dL	8.8 ± 1.7	8.0 ± 1.2	0.1366 (S)
Mean hematocrit, %	31.6 ± 4.7	29.5 ± 5.1	0.1955 (A)
Median platelet count, giga/L	278.0 [241.0; 322.0]	270.0 [228.0; 338.0]	0.9477 (W)
Mean fibrinogen, g/L	1.6 ± 0.5	1.4 ± 0.4	0.3012 (S)
Mean prothrombin time, %	67.1 ± 12.7	60.9 ± 9.5	0.0985 (S)
Median aPTT	1.1 [0;9; 1.1]	1.0 [1.0; 1.2]	0.7253 (W)

F: Fisher's exact test; S: Student's test; W: Mann-Whitney Wilcoxon test; aPTT: activated partial thromboplastin time

Median values are presented as the median [Q1; Q3]. Boldface type indicates statistical significance.

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Table 3

Duration of surgical procedure according to type of craniosynostosis

Parameter	Patients, n	Group 1 (single surgeon) 2011-2017	Group 2 (pair of surgeons) 2018-2021	P-value
Median duration of operation, minutes				
Trigonocephaly	35	182.0 [173.5; 194.0]	172.5 [165.0; 180.0]	0.0146 (W)
Plagiocephaly	25	177.3 [154.0; 190.0]	140.0 [130.0; 165.0]	0.0302 (W)

W: Mann-Whitney Wilcoxon test

Median values are presented as the median [Q1; Q3]. Boldface type indicates statistical significance.

Table 4

Intra- and postoperative data regarding blood product transfusion, estimated blood loss and drain output

Parameter	Group 1 (single surgeon) 2011-2017	Group 2 (pair of surgeons) 2018-2021	P-value
Intraoperative transfusion, n (%)	27 (93%)	28 (90%)	1.0000 (F)
Postoperative transfusion, n (%)	7 (20%)	10 (32%)	0.4855 (K)
Median volume of PE transfusion, mL/kg			
Total	20.0 [17.0; 20.5]	20.0 [15.0; 30.5]	0.7883 (W)
Intraoperative	20.0 [15.0; 20.0]	20.0 [11.0; 20.0]	0.6518 (W)
Postoperative	0.0 [0.0; 0.0]	0.0 [0.0; 15.0]	NA
Median EBV _{lost} , mL/kg	38.3 [26.8; 51.8]	44.6 [32.2; 54.3]	0.2974 (W)
Median drain output, mL/kg	13.9 [10.5; 21.6]	6.1 [4.5; 10.2]	0.0005 (W)
Median hemocue® pretransfusion, g/dL	8.4 [7.8; 9.3]	8.4 [7.1; 8.7]	0.1814 (W)

PE: packed erythrocytes; EBV: estimated blood volume

F: Fisher's exact test; W: Mann-Whitney Wilcoxon test

Median values are presented as the median [Q1; Q3]. Boldface type indicates statistical significance.

Table 5

Spearman correlation coefficients of operation duration

Parameter	Spearman coefficient	P-value
Total median volume of PE transfusion, mL/kg	0.337	0.0083
EBV _{lost} , mL/kg	0.231	0.0798
Hospital stay, days	0.340	0.0077
Intensive care stay, days	0.330	0.0100
Drain output, mL/kg	0.557	< 0.0001

PE: packed erythrocytes; EBV_{lost}: Estimated Blood Volume lost

Boldface type indicates statistical significance.