A comparison of costs associated with endoscope-assisted craniectomy versus open cranial vault repair for infants with sagittal synostosis

Clinical article

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Object. The surgical management of infants with sagittal synostosis has traditionally relied on open cranial vault remodeling (CVR) techniques; however, minimally invasive technologies, including endoscope-assisted craniectomy (EAC) repair followed by helmet therapy (HT, EAC+HT), is increasingly used to treat various forms of craniosynostosis during the 1st year of life. In this study the authors determined the costs associated with EAC+HT in comparison with those for CVR.

Methods. The authors performed a retrospective case-control analysis of 21 children who had undergone CVR and 21 who had undergone EAC+HT. Eligibility criteria included an age less than 1 year and at least 1 year of clinical follow-up data. Financial and clinical records were reviewed for data related to length of hospital stay and transfusion rates as well as costs associated with physician, hospital, and outpatient clinic visits.

Results. The average age of patients who underwent CVR was 6.8 months compared with 3.1 months for those who underwent EAC+HT. Patients who underwent EAC+HT most often required the use of 2 helmets (76.5%), infrequently required a third helmet (13.3%), and averaged 1.8 clinic visits in the first 90 days after surgery. Endoscope-assisted craniectomy plus HT was associated with shorter hospital stays (mean 1.10 vs 4.67 days for CVR, p < 0.0001), a decreased rate of blood transfusions (9.5% vs 100% for CVR, p < 0.0001), and a decreased operative time (81.1 vs 165.8 minutes for CVR, p < 0.0001). The overall cost of EAC+HT, accounting for hospital charges, professional and helmet fees, and clinic visits, was also lower than that of CVR ($37,255.99 vs $56,990.46, respectively, p < 0.0001).

Conclusions. Endoscope-assisted craniectomy plus HT is a less costly surgical option for patients than CVR. In addition, EAC+HT was associated with a lower utilization of perioperative resources. Theses findings suggest that EAC+HT for infants with sagittal synostosis may be a cost-effective first-line surgical option.

Key Words • sagittal synostosis • cost analysis • helmet therapy • endoscope • craniofacial

Sagittal synostosis is the most common form of craniosynostosis requiring treatment in infants. Its incidence is estimated to be 0.2 cases per 1000 persons. Sagittal synostosis warrants treatment in this age range because of the associated risk of decreased cranial volumes and cephalic indices that are thought to impair underlying cortical development. In addition, certain patients may have an elevated risk for hydrocephalus as a result of any untreated sagittal synostosis. Traditional therapeutic strategies were first pioneered in the late 1800s and then improved upon by Tessier in the 1970s. These approaches have relied on open cranial vault remodeling (CVR) methods that require removal and contouring of large portions of the calvaria and subsequent stabilization of the remaining bone segments. These procedures, while effective in augmenting cranial volume and cranial index measurements, have been associated with a longer operative time, increased intraoperative blood loss, and prolonged hospitalizations.

Recent surgical advances have led to improvements in and thus a focus on minimally invasive therapeutic strategies in infants affected with various forms of craniosynostosis. First pioneered by Jimenez and Bar-
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one, endoscope-assisted craniectomy (EAC) performed in the first 6 months of life has helped to decrease operative time, blood loss, transfusion requirements, and hospital stays. Following surgery, patients are fitted with several custom helmets that help to augment the reshaping of their calvaria; a process that relies on the underlying brain growth to affect changes on cranial shape. A number of orthotic helmets may be required during the next year following surgery to account for changes in cranial shape and size. The surgical costs, molding of helmets, and hospital charges have been documented for CVR and EAC. It appears from these initial studies that CVR is associated with increased expenses as compared with EAC procedures; however, confirmation of these cost analyses has not been performed.

To determine the total costs of CVR as compared with those for EAC in infants with sagittal synostosis, we designed the following case-control cost-comparison study accounting for hospital, physician, and orthotic helmet costs. We took into account the family cost of hospital visits for follow-up clinical evaluation. We also measured the perioperative factors, such as operative time, duration of hospital stay, and rate of blood transfusions, to determine if our results were consistent with previous surgical outcome reports on the CVR and EAC procedures.

Methods

Study Design

This was a retrospective case-control study performed at a single institution (St. Louis Children’s Hospital) to evaluate the costs and perioperative factors involved in CVR and EAC treatment in infants with sagittal synostosis between 2006 and 2011. Our primary hypothesis was that EAC procedures would be associated with a lower overall cost than CVR. Secondary aims of the study included a comparison of blood loss, transfusion rates, duration of hospital stay, and duration of surgical procedures for EAC and CVR. The institutional review board at the participating site approved this study.

Study Patients

Patients eligible for this study were younger than 1 year of age and had sagittal synostosis diagnosed by a craniofacial team that included both a neurosurgeon and a craniofacial surgeon in all cases. Sagittal synostosis was diagnosed through a combination of physical examination, skull radiographs, and 3D head CT scans (Fig. 1A and B). Patients were also eligible for study inclusion if they had undergone either CVR or EAC. Twenty-one contiguous patients who had undergone EAC and 21 contiguous infants who had undergone CVR for the treatment of sagittal synostosis were selected from a cohort of 111 patients who had received surgery for sagittal craniosynostosis during the study period. We chose patients who had undergone procedures during the same treatment period to control for variations in cost. Only patients with at least 1 year of clinical follow-up data were included for analysis.

Data Collection and Processing

Clinical data were recorded for these patients, including age at the time of surgery, duration of hospital stay, use of blood transfusion during the operative procedure or hospitalization, and operative time. Estimated blood loss (EBL) was obtained from anesthesia records, and a weight-based calculation was made for estimated circulating blood volume (ECBV). The percentage of ECBV lost during the surgical procedure was then calculated. Postoperative data included any visits for fitting the helmet orthoses or clinical evaluation that occurred within the 1st year of surgery.

Operative Technique

The decision to perform either EAC or CVR was offered to all patients presenting before an age of 5–6 months. When patients presented early enough for the endoscopic option, we scheduled the surgery as soon as possible. Patients who presented after an age of 5–6 months were offered the open technique only, which was scheduled electively.

Cranial Vault Remodeling. After inducing general anesthesia and performing endotracheal intubation, we placed the patients supine while also utilizing a gel-padded horseshoe Mayfield headrest (Integra). The patient’s eyes were protected with Tegaderm adhesives, and the surgical field from the orbits, nares, and top of the cranium was prepared with povidone-iodine scrub solution, followed by alcohol and povidone-iodine. A local anesthetic was injected along a marked bicoronal incision with a zigzag pattern. The incision was marked to lie posterior to the coronal suture and behind the insertion of the temporalis muscle. Incisions were made with a scalpel, and Colorado needle tip electrocautery was used to deepen the incision to the level of the periosteum. Blood transfusions for open CVR procedures were routinely started at the time of skin incision. The scalp and periosteum were then retracted to expose the frontal and parietal bones. Bur holes were placed using a high-speed drill to aid in the removal of the frontal bones above the orbital bar and the parietal bones above the temporoparietal suture. The affected sagittal suture was removed. The frontal and parietal bones were then contour ed as needed by using Tessier bone benders, wedge osteotomies, and barrel-stave osteotomies. The bones were replaced and secured with an absorbable plating system (KLS Martin Resorb-x plates and SonicWeld pins). Subgaleal Jackson-Pratt drains were placed and left to bulb suction in all patients.

Endoscope-Assisted Craniectomy. As mentioned above, general anesthesia was induced and endotracheal intubation was performed in patients, who were positioned in the modified sphinx position on a DORO headrest (Pro Med Instruments) or a padded beanbag. Horizontally placed gel pads were used to pad the temporal bone, and separate pads were used for securing the chin. The top of the cranium was then prepared in the same manner as described above, but two 3-cm-long incisions were marked. The first incision was marked just posterior to the anterior fontanelle, and the second incision was marked just ante-
rior to the lambda. The incision was infiltrated with a local anesthetic and incised with a scalpel, with Colorado needle tip electrocautery used to deepen the incision through the galea. The galea was then dissected from the pericranium between the two access incisions using a combination of monopolar electrocautery and sharp dissection. The periosteum was then stripped off the suture and calvaria under each access incision, and bur holes were placed at the edge of each marked incision. Kerrison rongeurs were then used to remove bone along the 3-cm length of the incision. A rigid endoscope (MINOP, Aesculap) with a 0° lens and suction was then placed in the epidural space and advanced under visualization to dissect the dura mater from the overlying suture. When epidural vessels were encountered, they were coagulated with bipolar electrocautery. Sharp dissection with bone cutting scissors were then used to cut a strip of bone the length of the suture spanning the two skin incisions. Paired-wedge barrel-stave osteotomies in the temporal and parietal bones were then completed with sharp dissection under direct visual inspection. The bone edges were then coagulated using a suction bipolar tip with endoscopic assistance for visualization and protection of the underlying dura. Gelfoam and Floseal (Baxter) were also used for hemostasis. Bone remaining around the anterior fontanelle and junction of the lambdoid sutures was contoured and removed using rongeurs.

**Hospital Course and Follow-Up**

For each surgical procedure, we recorded duration of hospital stay, rate of blood transfusions at any point during a hospitalization, and duration of operative procedure. Patients undergoing open CVR were admitted to the pediatric intensive care units overnight with postoperative hemoglobin and hematocrit studies sent to ensure that transfusion was not required. All CVR patients had subperiosteal drains placed to aid in the drainage of postoperative serosanguineous discharge. The drains were left in place until the 2nd or 3rd postoperative day depending on their output. Patients were left on antibiotic prophylaxis for the duration of drain placement. Patients were discharged and evaluated 3 weeks after surgery, and the majority returned for a 1-year follow-up evaluation (Fig. 1).

Patients who underwent EAC were admitted to the neurosurgical ward following surgery where postoperative hemoglobin and hematocrit studies were also sent. Patients were observed and routinely discharged to home the next day. Admission to the neurosurgical ward and routine discharge on the 1st postoperative day evolved from our earlier experience of admitting patients undergoing EAC to the pediatric intensive care unit overnight. Patients were fitted for a cranial molding helmet orthotic in the 1st week after surgery and followed the recommendations of orthotists based on head growth and helmet fitting. Our craniofacial team then evaluated patients every 3–4 months to ensure adequate cranial remodeling (Fig. 2).

**Cost Analysis**

**Medical Costs.** We obtained medical cost and financial data from our hospital financial database for inpatient charges. These hospital charges account for the various line items such as medical equipment, hospital bed utilization, lab and medical services rendered, anesthesia, medications, and operating room supplies. Hospital
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Fig. 2. Preoperative and postoperative 3D CT images obtained in an infant with diagnosed sagittal synostosis. Preoperative axial (A) and sagittal (B) scans from a patient undergoing EAC. Axial (C) and sagittal (D) views in the immediate postoperative period showing extent of endoscopic bone removal. (Note that portions of the frontal bones were not removed. The 3D CT with low radiation dose and rendering overestimates the extent of bone removal.) The barrel-stave osteotomies are seen in the parietal bones. Axial (E) and sagittal (F) scans obtained on postoperative follow-up examination, revealing correction of the ridge and saddle deformity.

charges account for those direct and indirect costs related to a patient’s hospitalization. Data for each patient were obtained and recorded for EAC and CVR procedures.

In addition to the hospital-related costs, surgeon costs were calculated based on current procedural terminology (CPT) coding for the procedure and on relative value unit (RVU) charges for craniofacial procedures. Surgeon costs are separate from the line items accounted for in the hospital-based system.

**Orthotic Costs.** To determine the orthotic costs for each helmet, the private orthotic companies were contacted for each patient. The number of helmets and costs billed for the company’s services were recorded. We also determined the cost billed to insurance companies and, if applicable, the cost to the patients’ families.

**Patient Costs.** To determine the economic burden of evaluation by our craniofacial team, we calculated the number of hospital visits to St. Louis Children’s Hospital for each patient for a 1-year period following the surgical procedure. The cost for each visit was estimated to be on average $200 per patient per visit. This figure takes into account mileage and missed time from work.

Total costs were then calculated from the sum of the medical, orthotic, and patient costs and compared between those who underwent CVR and those who underwent EAC.

**Statistical Analysis**

Statistical computations were performed using SPSS (version 20, IBM) with the Student t-test. Statistical significance was chosen at a p < 0.05.

**Results**

**Patient Population**

For the period of 2006–2011, we selected 21 contiguous patients younger than 1 year of age who had undergone either EAC or CVR with our craniofacial team. This team consisted of 1 pediatric neurosurgeon (M.D.S.) and 3 plastic surgeons (A.S.W., A.A.K., and K.B.P.). Sixteen males and 5 females with a mean age of 6.8 months (range 4–12 months) underwent CVR. Twelve males and 9 females with a mean age of 3.1 months (range 2–5 months) underwent EAC (Fig. 3). The age difference was statistically significant between these 2 groups (p < 0.0001, Student t-test; Table 1).

**Surgical Procedures**

Twenty-one patients undergoing the EAC or CVR procedure were compared in terms of duration of procedure, length of hospital stay, and rate of blood transfusion. The results are shown in Table 1. The mean duration of the surgical procedure for the CVR group was significantly longer at 165.8 minutes compared with a mean of 81.1 minutes for those undergoing the EAC procedure (p < 0.0001, Student t-test). The EBL for patients undergoing CVR was 213.1 ml, significantly higher than the 28.9 ml recorded for the EAC cohort (p < 0.0001, Student t-test). To control for patient weight during the surgical procedure, ECBV was calculated using widely reported blood volumes based on age for each of the 42 patients, and the percentage of ECBV lost was then computed. The per-
percentage of ECBV lost was also significantly higher in the CVR group at 34% compared with 6% for the EAC group (p < 0.0001, Student t-test). Similarly, the rate of blood transfusion was significantly higher in the CVR patients at 100% as compared with 9.5% in those undergoing EAC (p < 0.0001, Student t-test). Finally, patients undergoing CVR had significantly longer hospital stays at a mean of 4.67 days compared with 1.10 days for the EAC cohort (p < 0.0001, Student t-test).

Clinical Follow-Up

Patients were followed up for 1 year postoperatively, and all visits to our children’s hospital were recorded. The CVR patients had one postoperative visit in the first 90 days to evaluate surgical incision and cranial remodeling results. After this initial visit, 57% of the patients (12 of 21) were seen for an additional visit 1 year following their procedure. Examinations were performed to assess the child’s progress and to evaluate long-term results of the CVR procedure. Additional visits were necessary in only 14% of the patients (3 of 21) and did not exceed 3 total visits.

Each infant in the EAC cohort was evaluated and fit for a helmet 1 week following surgery and had one additional visit in the first 90 days postoperatively. After the first helmet fitting and the second visit to ensure adequate compliance in wearing the orthotic device, a private orthotic company evaluated patients. The maximum number of visits to our craniofacial center was 6. All 21 patients received an initial helmet; however, only 62% of them (13 of 21) required a second helmet, and 10% (2 of 21) required the use of a third orthotic. When patients undergoing CVR or EAC were compared for the number of visits in the first 90 days and 1 year postoperatively, there were significant differences between the 2 groups.

TABLE 1: Comparison of perioperative utilization for CVR and EAC*

<table>
<thead>
<tr>
<th>Variable</th>
<th>CVR</th>
<th>EAC</th>
</tr>
</thead>
<tbody>
<tr>
<td>mean age at surgery in mos†</td>
<td>6.8 ± 0.4</td>
<td>3.1 ± 0.2</td>
</tr>
<tr>
<td>mean op time in mins†</td>
<td>165.8 ± 5.7</td>
<td>81.1 ± 3.2</td>
</tr>
<tr>
<td>EBL in ml†</td>
<td>213.1 ± 19.1</td>
<td>28.9 ± 3.5</td>
</tr>
<tr>
<td>% ECBV lost†</td>
<td>34.0 ± 3.9</td>
<td>6.0 ± 0.76</td>
</tr>
<tr>
<td>% of transfusion†</td>
<td>100</td>
<td>9.5</td>
</tr>
<tr>
<td>length of hospital stay in days†</td>
<td>4.7 ± 0.4</td>
<td>1.10 ± 0.1</td>
</tr>
</tbody>
</table>

* Values expressed as means ± standard error of the mean.
† p < 0.0001, Student t-test.
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The CVR patients had a mean of 0.95 visits in the first 90 days after surgery, whereas the EAC cohort had 1.81 visits (p < 0.0001, Student t-test). Likewise, these differences remained significant at 1 year with a mean of 1.62 visits for the CVR patients compared with 3.76 visits for the EAC group (p < 0.0001, Student t-test; Fig. 4).

Cost Analysis

Cost analysis was performed for patients who underwent CVR or EAC, and the values for medical costs, surgeon costs, patient costs, and orthotic costs (if applicable), as detailed above, were totaled. The mean hospital charges for the CVR group was $40,687. These same hospital charges were calculated for the EAC cohort and were significantly different at a mean of $18,450 (p < 0.0001, Student t-test). While the length of hospital stay, admission to the intensive care unit, and other more intensive medical care was thought to be responsible for this difference, we wanted to determine if the additional number of visits and helmet costs would offset the higher hospital charges seen in the CVR group. The average helmet charges for the EAC group were calculated as $2813. When overall costs were calculated for patients in the CVR or EAC cohort, the mean cost for the CVR remained significantly higher at $56,990 compared with $37,256 for the EAC (p < 0.0001, Student t-test; Fig. 5).

Further analysis of the costs associated with helmet orthotics was performed and revealed that 90% (19 of 21) of the EAC patients did not have to pay for their first helmet, as their insurance covered the cost of the device. Of the 13 patients who required a second helmet, 77% (10 of 13) did not have to pay for the helmet, as again their insurance company paid for the orthotic. The families that did have to pay for the second helmet had an average out-of-pocket expense of $1081. The third helmet, if necessary, was covered by insurance for the 2 patients.

Discussion

Increased utilization of minimally invasive surgical approaches combining EAC with helmet orthoses in infants with sagittal synostosis has been seen in the past 15 years. The successful application of this technique has been thoroughly documented and reveals reductions in the length of hospital stays, operative times, and the use of perioperative resources such as admission to pediatric intensive care units and blood transfusions. The results in our study are consistent with those previously described in other such studies. Jimenez et al. have described the largest patient cohort treated with EAC and helmet orthoses and found transfusion rates of 9% and an average hospital stay of 1.07 days. Our results of a transfusion rate of 9.5% and a hospital stay of 1.1 days are consistent with their findings, suggesting that EAC and helmet therapy can be successfully used to treat this patient cohort in a reproducible manner across different populations.

While the advantages of minimally invasive strate-
gies are well documented for the treatment of infants with sagittal synostosis,2,3 the economic benefits to health care have only recently been explored. In a climate emphasizing savings to reduce medical costs, there have been relatively few studies to document the potential cost of EAC treatment relative to CVR. One such study from Boston Children’s Hospital in 2012 documented an average total cost of $23,377 for EAC as compared with $55,121 for CVR. This meant a mean savings of $31,744 for patients undergoing the EAC surgery followed by helmet orthotic.1 Our results of a mean CVR cost at $56,990 and mean EAC cost at $37,256 are consistent with those of the Boston group. The mean savings in our study was $19,734. The difference in these results may relate to a difference in surgical technique, small sample size, patient selection, regional cost differences, and the narrow study period. While differences exist, our results confirm that EAC is a significantly more cost-effective treatment strategy for eligible infants.

It is also important to note that our endoscopic surgical techniques have improved and that technological advancements have been made in available endoscopic equipment. These factors along with our progression toward a less invasive technique have contributed to our increased performance of only an endoscope-assisted strip craniectomy without the barrel-stave osteotomies.1 With this technique, however, there is a greater emphasis on postoperative helmet orthoses. This less invasive procedure avoids additional blood loss, and we have not had to transfuse since adopting this surgical approach. Preventing transfusion in the EAC population will further reduce its associated cost. An additional factor that has played a role in decreasing the overall cost of the EAC procedure has been our transition away from routinely admitting these infants to the pediatric intensive care unit. We have found that with improved exposure and nursing education, these patients can be safely admitted and treated on the neurosurgical ward. Therefore, we were able to avoid the additional perioperative resources and costs associated with an intensive care unit.

While cost is an important element in the decision to utilize EAC as a treatment method, ultimately the procedure’s efficacy and long-term results must be discussed. Infants eligible for EAC are ideally 2–4 months of age. In this age group cranial molding with helmet orthotics is optimal given suture pliability. There is some concern that in children older than 6 months of age, the effects of helmet orthoses may not be as successful and the effects on augmenting the cranial index may be limited. In the largest study to report effects of EAC on cranial index measurements,14 87% of patients attained an excellent outcome with a postoperative measurement > 0.75 from a preoperative level of 0.67. Patients in this study were treated with helmets for 1 year and had bitemporal and biparietal barrel-stave osteotomies. Similar studies22 with a less invasive endoscopic surgery without barrel-stave osteotomies and a mean helmet treatment period of 7.5 months have reported a 75% rate of achieving cranial index measurements > 0.75. These results reveal that EAC followed by helmet orthotics is effective in postoperatively augmenting the cranial index, a measurement that has been reported to stabilize after 18 months of treatment.14

There are a number of limitations to our study, including the aforementioned retrospective design, small sample size, and selection bias for treating patients younger than 6 months of age with EAC while older children underwent the CVR procedure. There may be an element of sagittal synostosis pathophysiology that differs in older and younger children and that necessitates increased hospitalization in older children.3 The main reason for the age difference seen in the patients undergoing CVR or EAC depended on age at presentation. Surgeon preference was not a factor in determining which surgery to perform; instead, it depended on the patient’s age at presentation and the family’s preference if their child was a candidate for both types of procedures. The ideal study would compare EAC and CVR for similarly aged patient populations, matching cases and controls on preoperative cranial index measurements and age. The patients in our study did not uniformly have preoperative and postoperative cranial index measurements; consequently, we have since started prospective data collection for the aforementioned study and comparison. An additional aspect of our study that may limit its universal application is our institutional use of postoperative pediatric intensive care admission for all patients undergoing CVR and the initiation of aggressive intraoperative blood transfusions in all of these patients. It is also essential to note that while decreased hospitalization times and utilization of perioperative resources may be easier on families, EAC requires compliance with a helmet orthotic, a time demand that may not be possible for all patients because of socioeconomic limitations. Therefore, each case being considered for surgical correction for sagittal craniosynostosis should be discussed on an individual basis.

While these limitations may exist in our study, our findings harmonize with those of other groups with respect to perioperative transfusion rates, EBL,13 length of hospital stays, length of surgery, and cost savings for EAC compared with CVR.

Conclusions

In summary, our study confirms that the ever-evolving field of endoscopic treatment for infants with sagittal synostosis is cost effective as compared with the more aggressive open CVR techniques. In the current landscape of health care reform, where there is increasing attention on safe and effective patient care with minimal costs, endoscopic treatment followed by helmet orthotics appears to be a viable therapeutic option for neurosurgeons and craniofacial teams. Future studies comparing different endoscope-assisted techniques and helmet treatment durations are warranted to determine the optimal minimally invasive treatment strategy for this patient population.

Disclosure

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

Author contributions to the study and manuscript preparation include the following. Conception and design: Vogel, Woo, Patel, Smyth. Acquisition of data: Vogel, Patel, Naidoo. Analysis and

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interpretation of data: Vogel, Patel. Drafting the article: Vogel, Woo, Smyth. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: Vogel. Statistical analysis: Vogel. Administrative/technical/material support: Woo, Patel, Smyth. Study supervision: Woo, Naidoo, Smyth.

References


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