Endoscopically Assisted Correction of Sagittal Craniosynostosis

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ABSTRACT

Craniosynostosis is premature fusion of one or more of the cranial sutures of an infant’s skull. Several sutures may be fused, alone or in combination. The endoscopically assisted approach to correcting craniosynostosis is an alternative to more traditional techniques, such as open-strip craniectomy and the Pi procedure for infants younger than four months of age and the cranial vault remodeling procedure for older children. The endoscopic procedure is less invasive and decreases the time patients spend under anesthesia, the need for transfusions, and lengths of hospital stay. The endoscopic approach relies on early diagnosis and surgery because the bones of very young infants are thin and pliable, which makes it easier to cut and remove the fused suture via a minimally invasive approach. After surgery, a cranial remolding helmet is used to direct skull growth. AORN J 93 (May 2011) 566-579. © AORN, Inc, 2011. doi: 10.1016/j.aorn.2010.11.035

Key words: craniosynostosis, cranial sutures, open-strip craniectomy, Pi procedure, cranial vault remodeling procedure, endoscopically assisted strip craniectomy

The newborn skull is composed of five main bones, two frontal, one occipital, and two parietal. Sutures (ie, flexible bands of connective tissue) lie between these bones. The sutures allow an infant’s head to mold during the birthing process and are also growth plates that accommodate the rapid brain growth that occurs in the first year of life. The infant’s skull has one metopic suture, one sagittal suture, two coronal sutures, and two lambdoid sutures (Figure 1). The metopic suture should close when an infant is between three and nine months of age. The lambdoid, sagittal, and coronal sutures should close when an adult is between 22 and 39 years of age.

During the first year of life, an infant’s head increases in circumference by approximately 9 cm in the first six months and another 3 cm during the next six months. Skull development is reliant on rapid brain growth, which causes the bones to spread apart at the cranial sutures. The normal skull-growth pattern occurs in a direction perpendicular to the open sutures of the skull.

When a suture prematurely fuses, which results in growth arrest, the brain can no longer push the bones apart perpendicular to the suture. Rudolf

 indicates that continuing education contact hours are available for this activity. Earn the contact hours by reading this article, reviewing the purpose/goal and objectives, and completing the online Examination and Learner Evaluation at http://www.aorn.org/CE. The contact hours for this article expire May 31, 2014.

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Ludwig Karl Virchow, a German physician in the late 1800s, defined this phenomenon and stated that “premature closure of [cranial] sutures prevent[s] growth perpendicular to the suture and [accompanies] compensatory growth at others.”3 This growth pattern leads to an abnormally shaped skull. Infants with abnormal skull development secondary to craniosynostosis (ie, premature ossification [fusion] of the skull and closure of cranial sutures) should be referred to a neurosurgeon or craniofacial surgeon for diagnosis and treatment. It is not uncommon for a parent, family member, or pediatrician to notice that the infant’s head has an abnormal shape, and this leads to the eventual diagnosis.

The reason craniosynostosis occurs is unclear and possibly multifactorial, although genetics seems to play a major role in this condition as well as many syndromic craniosynostosis conditions (eg, Crouzon syndrome, Pfeiffer syndrome, Apert syndrome).4,5 There may be a familial pattern in craniosynostosis that is not a result of a recognized syndrome. In 2007, Koh and Gries4 noted that 2% to 6% of infants with sagittal synostosis have family members with the condition. Komotar et al5 noted that 70% to 90% of sagittal craniosynostosis occurs in male infants.

The most common premature fusion is that of the sagittal suture, which results in a head shape known as scaphocephaly. In scaphocephaly, the midline sagittal suture, which separates the two parietal bones that meet at the top of the head, fuses. The parietal bones cannot be pushed apart by brain growth, therefore, lateral skull growth is restricted, and an overgrowth occurs in an anterior-posterior direction. This results in a long, narrow-shaped head with frontal and occipital “bossing” or bulging and a palpable ridge along the infant’s sagittal suture (Figure 2).2 Typically, scaphocephaly is an isolated condition and not associated with a syndrome or a known genetic condition.6

For patients with sagittal craniosynostosis, the clinician makes a diagnosis based primarily on skull measurements and physical examination and by obtaining a family history. Computed tomographies or radiographs are generally not necessary but may be used to confirm the diagnosis. Based on this information, the clinician can make a definitive diagnosis and counsel family members about treatment options.

COMPLICATIONS OF UNTREATED CRANIOSYNOSTOSIS

Untreated craniosynostosis may cause increased intracranial pressure (ICP), delayed or blunted cognitive and psychomotor development, and problems with psychosocial development. In 2006, Komotar et al5 reported that 20% of patients with nonsyndromal, single-suture
craniosynostosis and 60% of patients with syndromal craniosynostosis experience increased ICP, although the effects this might have on an infant are not completely understood. Clinical signs of ICP (eg, papilledema, irritability, vomiting, fontanelle bulging) are often not evident in infants with craniosynostosis as a result of physiological adaptation. Numerous studies have examined whether nonsyndromal, single-suture craniosynostosis has an effect on cognitive and psychomotor development. Study results are inconclusive, and no true randomized studies have been performed to evaluate the effects of surgery on the outcome of cognitive development. In addition to concerns about the cognitive and psychomotor effects of craniosynostosis, other concerns relate to the development of an abnormally shaped head, which could lead to psychosocial issues, poor self-esteem, and social development problems.

SURGICAL TREATMENT OPTIONS

The open-strip craniectomy (ie, surgical removal of the fused suture) was first performed in 1892 by American surgeon L. C. Lane. Initially, this procedure was performed as life-saving surgery to relieve ICP; however, later surgeons began to perform this procedure for a combination of more subtle brain growth and cosmetic reasons. The open-strip craniectomy procedure requires an anesthetic time of two to four hours and a large incision with a significant possibility that the patient will need blood products. Most importantly, the results often are not optimal because suture refusion occurs before a significant shape change has taken place.

In 1978, John Jane, MD, and John Pershing, MD, developed the Pi procedure, which results in an immediate correction of the skull deformity (Figure 3). Unlike the open-strip craniectomy procedure in which the fused suture is removed, during the Pi procedure, the surgeon makes several cranial bone cuts and removes and repositions the bone, and the resulting gap is allowed to close naturally. The results of this procedure are typically better than those of the strip craniectomy, but the procedure still requires opening the cranium, which often results in blood loss significant enough to require a transfusion and hospital stays of two to four days.

Cranial vault remodeling is a much more complex procedure that involves making a large incision, removing and replacing the cranial bones, and implanting plates. The procedure results in greater blood loss that often requires blood transfusion and much longer anesthetic time and hospitalization. It generally is reserved for children older than eight months whose brains have significantly matured in size.

ENDOSCOPICALLY ASSISTED STRIP CRANIECTOMY

Recent child care recommendations have affected the development of infant skull deformities. Although the relationship between
positioning and sudden infant death syndrome was suggested as early as the 1960s, it was not until decades later that the American Academy of Pediatrics made an official statement regarding sleep position for infants. The Back-to-Sleep program was formally adopted by the American Academy of Pediatrics in 1992; to decrease the incidence of sudden infant death syndrome, the program recommends that infants sleep on their backs or sides. As a result, many children have developed sleep-related deformational plagiocephaly (ie, an abnormally shaped head caused by external forces applied to the skull). This increased incidence of cranial flattening led to widespread use of helmets to correct the condition, which gave clinicians expertise in the use of cranial remolding helmets. At the same time, endoscopy has become more widely used in many surgical specialties. The combination of these two technologies has led to the development of the endoscopically assisted strip craniectomy.

Endoscopically assisted strip craniectomies for correction of craniosynostosis have been performed at Children’s Hospital Boston (CHB), Massachusetts, since 2004. This procedure is less invasive than traditional surgeries, which decreases the time spent under anesthesia, the need for transfusions, and the lengths of hospital stay. This method of treatment relies on early surgery because the correction requires rapid brain growth to help recontour the cranial bones. The optimal age for an infant to undergo this procedure is younger than three months. The bones of infants in this age group are very thin and pliable, which makes it easier to cut and remove the fused suture. In addition, the rapid head growth that occurs during the first year of life allows the orthosis (ie, the custom-made external helmet) to assist in molding skull growth in the desired direction. The infant may need to wear the helmet from three to nine months after surgery, depending on the severity of his or her original craniosynostosis. Overall, the results have been excellent, and this procedure has become a valuable alternative to traditional treatment options.

PREOPERATIVE CARE
The preoperative nurse reviews the preoperative laboratory work and confirms that blood products are available. The parents are given the opportunity to donate blood for directed donation to their child, provided their blood types are compatible. Blood bank personnel place a unit of packed red blood cells and a bottle of 25% albumin into a cooler and deliver the cooler to the OR. The need to transfuse these patients is rare, but when a transfusion is needed, it is imperative to have blood products immediately available.

On the day of surgery, the circulating nurse visits the patient and his or her family members in the preoperative waiting area. The nurse identifies the patient with two identifiers (eg, name, date of birth, medical record number), which the parent or legal guardian verifies. The nurse reviews the patient’s medical record and allows the family members time to ask questions. After assessing the patient, the circulating nurse develops a nursing care plan specific to this patient (Table 1). The surgeon greets the patient and family members, and marks the location of the surgical site with his or her initials. The anesthesia professional also speaks with the family at this time, questioning the parents about the infant’s medical and surgical history, discussing the planned anesthesia care, and verifying NPO status. According to the NPO guidelines at CHB, infants in this age group are allowed

- solid food eight hours before surgery,
- formula six hours before surgery or breast milk four hours before surgery, and
- clear liquids two hours before surgery.

The perioperative period is a very difficult time for parents of infants younger than three months undergoing this procedure. Many parents have never been away from their child. At CHB, the parents do not accompany the infant into the OR. Perioperative team members (ie, preoperative nurse, circulating nurse, anesthesia professional, surgeon) attempt to
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<th>Interim outcome criteria</th>
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| Risk for fluid volume deficit | ■ Identifies factors associated with an increased risk for hemorrhage or fluid and electrolyte imbalance.  
                                 | ■ Monitors physiological parameters (eg, decreased blood pressure, increased heart rate).  
                                 | ■ Implements hemostasis techniques.  
                                 | ■ Collaborates in fluid and electrolyte management by  
                                 | ■ monitoring blood loss,  
                                 | ■ ensuring that blood products are present in the OR, and  
                                 | ■ administering fluid and electrolyte and blood product therapy as prescribed.  
                                 | ■ Evaluates response to administration of fluids and electrolytes and blood product therapy. | ■ The patient’s blood pressure and pulse are within the expected range and remain stable with position change at the time of transfer to the postanesthesia care unit (PACU) and discharge from the PACU.  
                                 | ■ The patient’s fluid, electrolyte, and acid-base balances are maintained at or improved from baseline levels. |
| Risk for perioperative positioning injury | ■ Identifies baseline tissue perfusion.  
                                 | ■ Identifies physical alterations that require additional precautions for procedure-specific positioning by anticipating positioning equipment needed for the specific operative procedure.  
                                 | ■ Positions the patient by  
                                 | ■ using equipment within safe parameters,  
                                 | ■ coordinating patient positioning with team members, and  
                                 | ■ monitoring the patient’s body alignment.  
                                 | ■ Implements protective measures to prevent skin/tissue injury related to mechanical sources by  
                                 | ■ protecting bony prominences and  
                                 | ■ protecting all body areas at risk for injury when the patient is positioned in the prone position on a headrest.  
                                 | ■ Applies safety devices.  
                                 | ■ Evaluates tissue perfusion by  
                                 | ■ assessing for signs and symptoms of skin injury related to positioning and  
                                 | ■ evaluating postoperative neurologic status. | ■ The patient’s pressure points demonstrate hyperemia for less than 30 minutes.  
                                 | ■ The patient has full return of movement of the extremities at the time of discharge from the OR or procedure room.  
                                 | ■ The patient’s peripheral tissue perfusion is consistent with preoperative status at discharge from the OR or procedure room.  
                                 | ■ The patient is free from signs and symptoms of injury related to positioning.  
<pre><code>                             | ■ The patient has skin perfusion consistent with or improved from baseline levels established before surgery. |
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| Risk for imbalanced body temperature | ■ Assesses risk for inadvertent hypothermia.  
  ■ Implements thermoregulation measures by increasing room temperature, minimizing skin exposure, selecting temperature-regulating devices based on patient need, and administering warmed fluids and solutions.  
  ■ Monitors body temperature.  
  ■ Evaluates response to thermoregulation measures. | ■ The patient’s temperature is higher than 36°C (98.6°F) at the time of discharge from the operating or procedure room. | ■ The patient is at or returning to normothermia at the conclusion of the immediate postoperative period. |
| Risk for infection                | ■ Assesses susceptibility to infection.  
  ■ Classifies the surgical wound.  
  ■ Implements aseptic technique.  
  ■ Performs skin preparation.  
  ■ Monitors for signs and symptoms of infection.  
  ■ Monitors the sterile field and maintains continuous surveillance.  
  ■ Protects from cross-contamination.  
  ■ Minimizes the length of the surgical procedure by planning care.  
  ■ Initiates traffic control.  
  ■ Administers prescribed prophylactic treatments.  
  ■ Administers care to the wound site.  
  ■ Evaluates factors associated with increased risk for postoperative infection at the completion of the procedure. | ■ The patient has a clean, primarily closed surgical wound covered with a dry, sterile dressing at discharge from the OR. | ■ The patient is free from signs and symptoms of infection. |
| Compromised family coping         | ■ Identifies psychosocial status.  
  ■ Assesses coping mechanisms.  
  ■ Identifies barriers to communication.  
  ■ Determines knowledge level.  
  ■ Identifies designated support person’s educational needs.  
  ■ Assesses readiness to learn.  
  ■ Assesses coping mechanisms.  
  ■ Includes designated support person in perioperative teaching.  
  ■ Elicits perceptions of surgery.  
  ■ Explains the expected sequence of events.  
  ■ Implements measures to provide psychological support.  
  ■ Provides status reports to the designated support person.  
  ■ Evaluates psychosocial response to the plan of care.  
  ■ Evaluates response to instructions. | ■ The designated support person verbalizes the sequence of events to expect before and immediately after surgery.  
  ■ The designated support person states realistic expectations regarding recovery from the procedure.  
  ■ The designated support person identifies signs and symptoms to report to the surgeon or health care provider.  
  ■ The designated support person describes the prescribed postoperative regimen accurately. | ■ The designated support person demonstrates knowledge of the expected psychosocial responses to the procedure.  
  ■ The designated support person demonstrates knowledge of the expected responses to the operative or invasive procedure. |
reassure and comfort the parents as much as possible and answer all of their questions. During surgery, the circulating nurse communicates with the liaison nurse who continually updates the family members during the procedure.

**INTRAOPERATIVE CARE**

There are many considerations in the management of an infant undergoing surgery. Most importantly, OR personnel must work as a team. The surgeons, anesthesia professional, nurses, and scrub personnel all have important roles in providing safe, expert care and in ensuring the best possible outcome for the patient. The perioperative team must take a number of considerations into account when caring for infants this young during surgery, including managing the patient’s airway, managing fluid and blood loss, monitoring for venous air embolus, positioning safely, and maintaining body temperature.

**Airway and Fluid Management**

The anesthesia professional administers an inhalation anesthetic by mask for induction. After the patient is anesthetized, an anesthesia professional inserts an IV line. It is important to have adequate and secure venous access, which may be needed for rapid fluid administration to manage volume loss or for blood product administration to replace surgical blood loss, as well as for administration of standard intraoperative anesthetic medications. The anesthesia professional administers IV antibiotics within 30 minutes of the surgeon making the initial incision. The surgeon prescribes two additional doses of antibiotics to be administered after surgery. Initially, anesthesia professionals at CHB prophylactically placed arterial lines in most patients for the unlikely event that heavy bleeding would be encountered. Surgical results and patient outcomes at CHB have been very positive, however, so the surgeons and anesthesia professionals decided that routine arterial line placement is unnecessary.

After inserting an endotracheal (ET) tube, the anesthesia professional carefully secures the tube to the patient’s face because the prone position and the position of the OR bed (ie, turned 90 degrees away from the anesthesia professional) prevent easy access to the ET tube during the surgery. Inadvertent extubation would be a serious problem because infants have very little respiratory reserve, and it would be necessary to reposition the patient for re-intubation.

**Monitoring for and Treating Venous Air Embolus**

The anesthesia professional places a precordial Doppler (ie, an ultrasonic probe used to detect venous air embolus) on the patient’s chest to the right of the midline at the second or third intercostal space. The Doppler produces characteristic sounds when it detects air in the bloodstream. This is especially important during this surgical procedure because air can inadvertently enter the bloodstream through apertures in the bone or a tear in a venous sinus or the dura. Typical patient positioning for this surgery results in the surgical site being higher than the right atrium, which increases the risk for venous air embolus. The entire surgical team should remain attentive to the sound of the Doppler and communicate any noted changes. Other clinical signs, such as decreased end-tidal carbon dioxide levels, oxygen saturation levels, and blood pressure can present when a true air embolus occurs. Most often, there is no hemodynamic response when air sounds are heard via Doppler; however, when this occurs, the surgeon floods the surgical field with normal saline solution to reduce bone, sinus, and dural exposure to air until the anesthesia professional has ruled out the presence of a venous air embolism.

**Positioning**

Positioning is of crucial importance because of the delicate nature of an infant’s skin, the prone position required for the surgery, and surgical duration. When turning a patient to the prone position, the surgical team pays careful attention to the ET tube and IV lines to ensure that these
are not accidentally dislodged. This procedure requires the use of a special headrest that maintains the infant’s head in a modified prone position with significant extension (Figure 4).\textsuperscript{12} A team member who is familiar with this headrest should be in charge of positioning and placement of the infant’s head to reduce complications. Before surgery, the surgeon should evaluate the infant for cervical anomalies, especially if the infant has syndrome-related synostosis.

The areas of the headrest that are in contact with the patient’s head are U-shaped gel rings that cup around the patient’s ears and small gel pads that support the chin. Care must be taken to prevent corneal abrasions or pressure on the eyes or ears. The eyes are held closed with latex-free eye coverings. The anesthesia professional does not use ophthalmic lubricant because this can cause the protective eye coverings to fall off. Surgical team members place the patient prone while maintaining the patient’s proper body alignment with his or her chest and abdomen on gel rolls,

\begin{itemize}
  \item knees on gel pads,
  \item lower legs elevated enough to ensure that the toes are free from pressure or contact with the mattress, and
  \item both arms at the patient’s sides supported by blankets and foam.
\end{itemize}

The circulating nurse places the electrosurgical unit grounding pad on the patient’s back and places a safety strap over the patient to prevent movement.

\section*{Maintaining Normothermia}

Maintenance of body temperature is particularly important when caring for infants because they lose body temperature very rapidly when exposed to ambient air. While the team prepares the patient for surgery, the circulating nurse places warm blankets on the OR bed and over the patient to help prevent onset of hypothermia. After the patient is positioned, the nurse places a forced-air temperature-regulating blanket on the patient from the neck down. This provides a flow of warm air over the patient throughout the procedure.

\section*{Prepping and Draping}

The surgeon prepares the surgical site by confirming the proposed location of the incisions with the information on the surgical consent (Figure 5). The surgeon preps the surgical site with povidone-iodine scrub and alcohol and paints it with povidone-iodine solution. While the prep solution dries, the circulating nurse inspects the area around the surgical site to ensure that prep solutions have not dripped onto the patient’s face or pooled under the patient. The surgical team members then drape the patient, after
which they assemble the surgical field. At this time, the entire surgical team stops and performs a verbal time out to confirm the correct patient, procedure, site, and position. Each member of the team then identifies himself or herself for the record.

THE SURGICAL PROCEDURE

The scrub person stands at the patient’s head with the Mayo stand and the back table positioned to his or her right and positions the drill near the sterile field for easy access for the surgeon. The scrub person sets up the Mayo stand with all essential instruments because there is very little room for retrieving supplies at the patient’s head. The routine Mayo stand setup includes a towel that holds each size of compressed rayon cotton pledgets or strips as well as two 1/2-inch by 4-inch strips and 3/4-inch squares of absorbable gelatin sponge soaked in thrombin. If a dural tear occurs near the sagittal sinus or an emissary vein, then the surgeon uses compressed rayon cotton pledgets or strips, and gelatin sponges very rapidly to cover the tear and apply pressure to that area. The scrub person also places toothed Adson forceps, bayonet forceps, Penfield and Woodson elevators, two Senn retractors, two straight hemostats, a Cushing periosteal elevator, and a small curette on the Mayo stand. The scrub person places Tessier bone-cutting scissors, 3-mm and 4-mm Kerrison rongeurs, a large Lexel rongeur, and curved Mayo scissors on the back table (Figures 6 and 7).

The surgeon injects 0.25% bupivacaine with 1:200,000 epinephrine locally at the site of the incisions for the hemostatic effect of the epinephrine. The surgeon uses a #15 knife blade to make a 2-cm incision in a medial-to-lateral direction over the midline of the skull just behind the coronal suture and at the location of the lambdoid suture. This allows access to the sagittal suture both proximally and distally.

By using a needle tip on the electrosurgical unit handpiece, the surgeon opens the tissue down to the periosteum and removes the periosteum from the bone with a periosteal elevator. The surgeon makes a burr hole with a 5-mm acorn burr, being especially careful not to tear the dura. The surgeon inserts a Woodson elevator into the burr hole and moves it circumferentially to free the dura from the underside of the bone. The surgeon enlarges the hole to approximately 1 cm with a Kerrison rongeur under direct vision. Then, the surgeon removes as much bone as possible with a Lexel rongeur in an area that is approximately 1 cm by 2 to 3 cm. This is the time that a venous air embolism is most likely to occur, so team members monitor the precordial Doppler closely. The scrub person soaks a 3/4-inch by 3/4-inch piece of absorbable gelatin sponge soaked in thrombin and passes it to the surgeon who places it over the incision to provide hemostasis while making the second incision in the same fashion (eg, making a burr hole and enlarging it with rongeurs).

Unlike some intracranial procedures and most intra-abdominal procedures, this procedure...
is not truly endoscopic; it is considered an endoscopically assisted procedure because the surgeon can directly see portions of the surgical area. The endoscope allows the surgeon to see the area between the dura and the fused suture and to transilluminate tissue. After making two incisions, the surgeon uses a 4-mm, 0-degree endoscope to view the fused suture to look for attachments of dura and blood vessels and observe for bleeding. Transillumination with the endoscope ensures that the entire segment is free of underlying tissue before the bone is cut. Unlike a normal skull, the dura in infants with craniosynostosis is not adhered to the bones at the site of the fusion and is easily separated by using a blunt dissector and suction while observing with the endoscope.

The scrub person wipes blood from the end of the scope by using a clean, moistened sponge to restore the visual field. The surgeon uses Tessier bone cutters to cut along each side of the fused suture. Pieces of bone often come out in small fragments with the bone cutter, but occasionally a large segment of bone that represents the entire suture will come out at once. The surgeon performs the entire procedure quickly to decrease anesthetic time and blood loss but at the same time is vigilant not to cause any harm. When the surgeon has removed the suture, he or she places a 1-inch by 3-inch strip of absorbable gelatin soaked in thrombin over the area for hemostasis. The surgeon then irrigates the surgical site with antibiotic irrigation, closes the galea (ie, the thick aponeurotic layer of the scalp) with 4-0 polyglactin suture, and closes the skin with 4-0 rapidly absorbed polyglactin suture.

Throughout the procedure, the circulating nurse communicates with the liaison nurse who updates the family on the patient’s status. Before the end of the procedure, the circulating nurse gives a report to the postanesthesia care unit (PACU) nurse who will be caring for the patient. The circulating nurse communicates pertinent information regarding the surgery and the patient’s postoperative status.
When the procedure is finished, a surgical team member places an impregnated nonadherent dressing and a nonadherent pad on the incision sites and secures them with paper tape. Team members reposition the patient supine on the bed, taking care to prevent the ET tube and IV lines from being dislodged. The surgeon finishes bandaging the patient’s head by placing an abdominal pad over the top of the head along the suture removal site and securing it with stretchable netting over the infant’s head. The netting applies added pressure to the site to decrease postoperative venous bleeding (Figure 8). This pressure dressing remains in place for approximately eight hours. The nurse assesses the patient’s skin for pressure points or skin breakdown on the chest, forehead, chin, and knees where there was contact with the headrest or the gel pads. The circulating nurse increases the temperature in the OR to help maintain the patient’s body temperature. The nurse remains at the patient’s side until the patient is extubated by the anesthesia professional.
circulating nurse and PACU nurse confirm the patient’s identity by using two patient identifiers. The anesthesia professional and circulating nurse each provide a transfer of care report to the PACU nurse.

To determine whether a blood transfusion is necessary, the PACU nurse draws a blood sample from the patient’s IV and sends it to the laboratory for a hematocrit level before transferring the patient to the neurosurgical floor. The threshold for transfusion is a hematocrit level of 20% along with symptoms such as tachycardia or decreased blood pressure. If the patient is stable, then the PACU nurse transfers the patient to the inpatient neurosurgical unit after approximately two hours of monitoring in the PACU.

The patient receives IV antibiotics every eight hours for three doses—the first of three doses is administered before surgery—and nurses administer rectal acetaminophen and IV morphine as needed for pain. Signs and symptoms of pain in infants include irritability, crying that is not consoled by being held or fed, and increased heart and respiratory rate. Typically, the surgeon discharges the patient the day after surgery.

An orthotist fits the patient with a cranial remolding helmet between one and five days after discharge. The helmet is made of a hard plastic with a firm foam lining and weighs between 8 oz and 16 oz (Figure 9). The patient wears the helmet until he or she is approximately nine to 10 months of age; although some surgeons may require the infant to wear the helmet until one year of age. Although the infant’s head shape is corrected in the first three to four months, if helmet therapy is discontinued at this time, regression of the skull shape can occur. The next two to three months of helmet use are required to maintain the head shape. The patient normally wears the helmet for 21 to 23 hours a day. The orthotist instructs family members regarding use of the helmet and outlines a schedule that includes an initial break-in period. The orthotist also provides additional skin care tips and advice for cleaning the helmet. Increased moisture can occur inside the helmet as a result of sweating. Family members may apply corn starch or medicated baby powder to keep the infant’s skin dry. The parents should check the infant’s skin for redness or irritation each time the helmet is removed. Heat rash can be treated with hydrocortisone cream. After the first postoperative week, the parents should shampoo the infant’s head daily. The parents should wipe the helmet with 70% alcohol, rinse it well, and completely dry it before putting it back on the infant.

Parents must return the infant to the orthotist every two to three weeks until the surgeon discontinues helmet therapy. The procedure is performed while the infant’s head is still growing rapidly; therefore, the helmet must be adjusted periodically to prevent excessive pressure on the sensitive skin of the infant’s head. Patients with sagittal synostosis usually require only one helmet. A modified helmet, known as the “Mohawk” helmet, is open on the sides, which allows for significant growth without the sides becoming too tight.

The first postoperative visit with the surgeon occurs one month after surgery and then approximately every two months until the patient is one year of age. When helmet treatment is discontinued, the surgeon performs a set of cranial measurements, and continues this annually until the child is six to

Figure 9. A baby wearing a specially designed cranial remolding helmet.
Endoscopically Assisted Repair of Sagittal Craniosynostosis

Overview
Craniosynostosis is premature closure of one or more of the cranial sutures of your baby’s skull. Sutures are bands of connective tissue between the skull bones that allow the skull to mold during birth and allow the brain to grow rapidly in the first year of life. When a suture closes too soon, the skull may become misshapen.

What are the signs of craniosynostosis?
A long, narrow head with frontal and occipital bossing (a ridge or bulge along a suture line).

How is craniosynostosis diagnosed?
Craniosynostosis is diagnosed by skull measurements, physical examination, and computerized tomography scan or x-rays to confirm the diagnosis.

What are the treatment options?
Surgery is the only option. Endoscopic surgery is much less invasive than traditional surgical procedures and decreases your baby’s anesthesia time, hospital time, and need for blood transfusions. After surgery, your baby will wear a custom-made helmet to help the skull mold to the appropriate shape.

What will preoperative care include?
- Your baby should have an empty stomach before surgery. You may be instructed to feed your baby:
  - solid food 8 hours before surgery,
  - formula 6 hours before surgery or breast milk 4 hours before surgery, and
  - clear liquids 2 hours before surgery.
- Before surgery, a nurse will measure your baby’s vital signs and ask about your baby’s allergies, previous surgeries, current medications, and skin condition.
- The OR nurse, anesthesia professional, and your surgeon will talk with you in the preoperative area where you can ask questions.

What happens during surgery?
We position your baby on his or her stomach with his or her head on a special headrest that allows the surgeon to work. The surgeon makes 2 small incisions on your baby’s head and uses an endoscope to see the fused suture. The surgeon uses special scissors to cut and remove the fused bone. Your baby will be in the OR for about 2 hours before he or she is taken to the recovery area.

What are possible complications of surgery?
- Your baby could get an infection, pneumonia, or bleed too much.
- Your baby might require a blood transfusion or further surgery.

What will postoperative care include?
After surgery,
- your baby is admitted to the recovery area and monitored closely.
- you may hold your baby and feed him or her fluids.
- your nurse will provide pain medicine for your baby as needed.
- patients are typically discharged the day after surgery.

What happens after discharge?
- Keep your baby’s incisions dry for the first 7 to 10 days. Then wash your baby’s incisions daily with mild, perfume-free soap and gently pat dry. Do not use lotion or powder on the incisions until they are completely healed. You may then use medicated baby powder to keep your baby’s skin dry under the helmet.
- 1 to 5 days after discharge, an orthotist will fit your baby for a cranial remolding helmet. This is worn 21 to 23 hours a day for 3 to 9 months. Take your baby to the orthotist every 2 to 3 weeks until the surgeon discontinues treatment.
- See the surgeon 1 month after surgery and then every 2 months until your baby is 1 year old.
- Follow helmet instructions. Failure to do so may result in the skull returning to its previous shape.

Call your doctor immediately if your baby experiences:
- nausea or vomiting not relieved with nausea medication;
- increased fussiness or crying not relieved with pain medication;
- increased sleepiness or decreased alertness;
- increased redness, swelling, or drainage at the incisions site; or
- fever greater than 101°F (38.3°C) or chills.

Resource
seven years of age. Imaging is not routinely performed. The orthotist generally obtains serial three-dimensional laser scans during the helmeting process, which is part of the helmet manufacturing and maintenance, but the scans are not used for analysis of results.

**SUMMARY**

Endoscopic correction along with postoperative orthosis has proven to be a safe and effective method to treat sagittal synostosis and have a positive effect on head growth and cranial morphology. From 2004 to 2008, 52 patients with isolated sagittal synostosis were treated by endoscopically assisted correction of sagittal craniosynostosis at CHB with excellent cosmetic and functional outcomes. Furthermore, as surgical teams gained experience with the procedure, length of hospital stay, surgical time, and blood loss decreased (Table 2). Specific issues, such as positioning, hypothermia, and blood loss, must be addressed in the care of such young children undergoing surgery. Diligent preparation by all perioperative team members ensures the best outcome for these young patients.

**References**


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**TABLE 2. Data for Infants Who Underwent Endoscopically Assisted Strip Cranectomy at Children’s Hospital Boston Between 2004 and 2008 (N = 52)**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age at surgery</td>
<td>3.08 months</td>
</tr>
<tr>
<td>Mean surgical time</td>
<td>44.7 minutes</td>
</tr>
<tr>
<td>Mean length of hospital stay</td>
<td>1.17 days</td>
</tr>
<tr>
<td>Need for transfusion</td>
<td>4 patients</td>
</tr>
<tr>
<td>Average length of helmet therapy use</td>
<td>7.14 months</td>
</tr>
<tr>
<td>Mean time of follow-up</td>
<td>1.92 years</td>
</tr>
</tbody>
</table>

Endoscopically Assisted Correction of Sagittal Craniosynostosis

PURPOSE/GOAL

To educate perioperative nurses about endoscopically assisted correction of sagittal craniosynostosis.

OBJECTIVES

1. Describe craniosynostosis.
2. Explain how craniosynostosis is diagnosed.
3. Discuss treatment of craniosynostosis.
4. Identify problems that may occur if craniosynostosis is not treated.
5. Describe perioperative care of an infant undergoing endoscopically assisted correction of sagittal craniosynostosis.

The Examination and Learner Evaluation are printed here for your convenience. To receive continuing education credit, you must complete the Examination and Learner Evaluation online at [http://www.aorn.org/CE](http://www.aorn.org/CE).

QUESTIONS

1. Premature fusion of a suture results in arrest of growth that normally occurs
   a. parallel to the suture.
   b. perpendicular to the suture.
2. Scaphocephaly is characterized by
   a. a short, wide skull with occipital bossing and a palpable ridge along the sagittal suture.
   b. a long, narrow-shaped skull with frontal and occipital bossing and a palpable ridge along the sagittal suture.
   c. a short, wide skull with parietal and coronal bossing and a palpable ridge along the coronal suture.
   d. a long, narrow skull with parietal bossing and a palpable ridge along the lambdoid suture.
3. The clinician makes a diagnosis of sagittal craniosynostosis based primarily on
   1. a family history.
   2. color Doppler ultrasound.
   3. physical examination.
   4. skull measurements.
      a. 1 and 3
      b. 2 and 4
      c. 1, 3, and 4
      d. 1, 2, 3, and 4
4. Untreated craniosynostosis may cause
   1. blunted cognitive development.
   2. delayed psychomotor development.
   3. increased intracranial pressure.
   4. problems with psychosocial development.
      a. 1 and 3
      b. 2 and 4
      c. 1, 2, and 4
      d. 1, 2, 3, and 4
5. Treatment options for repair of craniosynostosis include
1. cranial vault remodeling for older children.
2. endoscopically assisted correction of craniosynostosis.
3. open-strip craniectomy.
4. the Pi procedure.
   a. 1 and 3  
   b. 2 and 4  
   c. 1, 2, and 4  
   d. 1, 2, 3, and 4

6. The optimal age for an infant to undergo endoscopically assisted correction of sagittal craniosynostosis is
   a. younger than three months of age.
   b. three to six months of age.
   c. six to nine months of age.
   d. older than nine months of age.

7. If a change in the sound of the Doppler indicates it detects air in the bloodstream, then the surgeon floods the surgical field with normal saline solution to reduce bone, sinus, and dural exposure to air.
   a. true  
   b. false

8. Using an endoscope to perform this procedure allows the surgeon to
   1. decrease bone bleeding.
   2. prevent venous air embolus.
   3. see the area between the dura and the fused suture.
   4. transilluminate tissue to ensure that the entire segment is free of underlying tissue before the bone is cut.
   a. 1 and 2  
   b. 3 and 4  
   c. 1, 2, and 3  
   d. 1, 2, 3, and 4

9. The threshold for transfusion is a hematocrit level of _____, along with symptoms such as tachycardia or decreased blood pressure.
   a. 20%  
   b. 25%  
   c. 30%  
   d. 35%

10. After surgery, the infant wears a cranial remolding helmet for 21 to 23 hours a day until he or she is approximately nine to 10 months of age.
    a. true  
    b. false

The behavioral objectives and examination for this program were prepared by Rebecca Holm, MSN, RN, CNOR, clinical editor, with consultation from Susan Bakewell, MS, RN-BC, director, Center for Perioperative Education. Ms Holm and Ms Bakewell have no declared affiliations that could be perceived as posing potential conflicts of interest in the publication of this article.
LEARNER EVALUATION

CONTINUING EDUCATION PROGRAM

Endoscopically Assisted Correction of Sagittal Craniosynostosis

This evaluation is used to determine the extent to which this continuing education program met your learning needs. Rate the items as described below.

OBJECTIVES

To what extent were the following objectives of this continuing education program achieved?

1. Describe craniosynostosis.
   Low 1  2  3  4  5  High
2. Explain how craniosynostosis is diagnosed.
   Low 1  2  3  4  5  High
3. Discuss treatment of craniosynostosis.
   Low 1  2  3  4  5  High
4. Identify problems that may occur if craniosynos-
tosis is not treated.
   Low 1  2  3  4  5  High
5. Describe perioperative care of an infant undergo-
ing endoscopically assisted correction of sagittal craniosynostosis.
   Low 1  2  3  4  5  High

CONTENT

6. To what extent did this article increase your
   knowledge of the subject matter?
   Low 1  2  3  4  5  High
7. To what extent were your individual objectives
   met? Low 1  2  3  4  5  High
8. Will you be able to use the information from
   this article in your work setting?
   1. Yes  2. No
9. Will you change your practice as a result of
   reading this article? (If yes, answer question 
   #9A. If no, answer question #9B.)
9A. How will you change your practice? (Select all 
   that apply)
   1. I will provide education to my team regard-
      ing why change is needed.
   2. I will work with management to change/ 
      implement a policy and procedure.
   3. I will plan an informational meeting with 
      physicians to seek their input and acceptance 
      of the need for change.
   4. I will implement change and evaluate the 
      effect of the change at regular intervals until 
      the change is incorporated as best practice.
5. Other: ______________________
9B. If you will not change your practice as a result 
   of reading this article, why? (Select all that 
   apply)
   1. The content of the article is not relevant to 
      my practice.
   2. I do not have enough time to teach others 
      about the purpose of the needed change.
   3. I do not have management support to make a 
      change.
   4. Other: ______________________

10. Our accrediting body requires that we verify the 
    time you needed to complete the 3.4 continuing 
    education contact hour (204-minute) program: __

This program meets criteria for CNOR and CRNFA recertification, as well as other continuing education requirements.

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Event: #11013; Session: #4066 Fee: Members $17, Nonmembers $34

The deadline for this program is May 31, 2014.

A score of 70% correct on the examination is required for credit. Participants receive feedback on incorrect answers. Each applicant who successfully completes this program can immediately print a certificate of completion.