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Evaluation of the necessity of postoperative imaging after craniosynostosis surgery

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Object. Childhood radiation exposure increases the lifetime risk of cancer from an estimated 0.07 to 0.35%. Neurological evaluation of patients after cranial vault reconstruction for synostosis repair is often complicated by pain medication, sedation, intubation, swelling, and dressings; therefore computed tomography (CT) scans are routinely ordered by some surgeons on the 1st postoperative day. The object of this study was to evaluate the utility of these scans.

Methods. Medical records and CT scans were reviewed for patients at the authors' institution who underwent cranial vault reconstruction to repair synostosis between January 1, 2003, and July 31, 2005.

Results. Of the 111 patients identified in the review, 84 had a CT scan on postoperative Day 1, and seven of these patients underwent shunt insertion for treatment of hydrocephalus. Thirty-three patients underwent bifrontal craniotomies, whereas 51 underwent total vault reconstruction (TVR). Postoperative CT scans revealed minor contusions in three (9%) of 33 patients in the bifrontal craniotomy group and in seven (14%) of 51 patients in the TVR group. No significant subdural or epidural hematomas were observed. In the seven patients who required shunt placement, two (29%) had CT evidence of shunt malfunction, leading to shunt revision.

Conclusions. None of the CT findings analyzed in this series was associated with clinical events such as seizures, prolonged intensive care unit stay, or reoperation in patients without shunt placement after cranial reconstructive procedures, although a relatively high incidence of CT evidence of shunt malfunction was found in patients with shunts. These data do not support the routine use of CT scanning after cranial reconstructive procedures unless the patient has received a shunt for hydrocephalus. Patients who experience unexpected intraoperative or postoperative events should be examined using CT. *(DOI: 10.3171/PED-07/07/043)*

KEY WORDS • computed tomography • cranial vault reconstruction • craniosynostosis • hydrocephalus • pediatric neurosurgery • radiation dose

IN the US approximately 10% of all CT scans are performed in pediatric patients, equating to an estimated 2.7 million pediatric CT examinations per year.[3] It has been estimated that only 10% of all diagnostic radiological exams are CT scans, but their contribution to the overall radiation exposure is closer to 67% because the doses are higher.[3,5] In 2001, Brenner and colleagues[2] estimated that the lifetime cancer mortality risk attributable to the radiation exposure from a head CT scan in a 1-year-old child is 0.07% (one in 1500), a rate that is considerably higher than that for adults. These data do not really take into account children who undergo serial CT scanning. Mettler and coworkers[5] estimated that 30% of all pediatric and adult patients who undergo CT evaluation of any body part have at least three scans, 7% have at least five, and 4% have at least nine. In 2005, Ashley et al.[1] estimated that 50% of their patients with hydrocephalus had undergone more than four brain imaging studies (CT or magnetic resonance imaging) in their lifetimes. For the many patients who had undergone more than 15 studies, the estimated total lifetime cancer mortality risk attributable to imaging was calculated to be at least 0.35%.

Complications following craniosynostosis surgery have been well reported.[4] As would be expected, complication rates increase as the complexity of the surgical procedure increases. Whereas complication rates of strip craniectomy are low, as more bone is exposed or removed the risk of dural tears, direct injury to the brain, and blood loss resulting in epidural collections increases. Because the difficulty of patient neurological evaluation after extensive craniotomy for synostosis repair is often increased by pain medication, sedation, intubation, swelling, and dressings that cover the anterior fontanelle, it is common in our practice to obtain a postoperative head CT scan after craniosynostosis surgery in patients who have had TVR or bifrontal craniotomy for craniosynostosis. Postoperative scans are not routinely performed in infants undergoing sagittal synostosis surgery (vertex craniectomy with parietal bone barrel staves). It is rare, however, to have clinically significant CT results. Therefore, the goal of this retrospective chart review was to evaluate the utility of these scans.

Abbreviations used in this paper: CT = computed tomography; ICU = intensive care unit; SIADH = syndrome of inappropriate antidiuretic hormone; TVR = total vault reconstruction.

Clinical Material and Methods

At Primary Children's Medical Center, bifrontal craniotomies and TVRs are performed for craniosynostosis in conjunction with plastic surgery. The University of Utah neurosurgical database (Opcoder, Accreditation Council for Graduate Medical Education) contains data dating back to January 1998. An operative database search was undertaken to obtain the total number of craniosynostosis surgeries performed between January 1, 2003, and July 31, 2005. Patient records were reviewed in accordance with University of Utah regulations and Health Insurance Portability and Accountability Act guidelines. Charts were retrospectively reviewed for the following variables: diagnosis, age, sex, shunt placement, and operation performed. Head CT scans obtained on postoperative Day 1 were reviewed for notation of one of four types of lesions (pneumocephalus, epidural lesions, subdural lesions, and intraparenchymal hematomas), and it was noted in each case whether these lesions occurred with or without mass effect. All findings on postoperative head CT scans were compared with the hospital notes and discharge summaries outlining any complications or significant events during the hospitalization. Complications or clinically significant outcomes were defined as a return to the operating room, seizures, or shunt malfunction.

Results

One hundred eleven patients who underwent cranial reconstructive surgery for craniosynostosis were identified; 84 of these patients underwent a head CT scan on postoperative Day 1. The mean age of these patients was 2.1 years (range 0.3–17.4 years). Thirty patients were female (36%) and 54 were male (64%). Among these patients, five had syndromic craniofacial disorders as follows: Apert syndrome in two patients; and Crouzon, Furlong, and Pfeiffer syndromes in one patient each. Of the 79 nonsyndromic patients, 38 had sagittal synostoses, 13 coronal, 15 metopic, one had lambdoid synostosis, and 12 patients had multiple synostoses. Thirty-three patients underwent bifrontal craniotomies for reconstruction, whereas 51 underwent TVR. Seven patients had a shunt placed. Two of these seven patients had craniofacial syndromes (one Furlong, one Pfeiffer), two had late sagittal synostoses (secondary to shunt placement), and three had nonsyndromic multiple-suture synostosis.

Intraparenchymal contusion without mass effect was seen in 10 (12%) of 84 patients (three [9%] of 33 who underwent bifrontal craniotomies and seven [14%] of 51 who underwent TVR) (Fig. 1A). No clinically significant events were reported in this group, and all patients (100%) were noted to have at least a small amount of postoperative epidural blood without mass effect. The blood was found in all patients along the sphenoid ridge where bone had been removed (Fig. 1B). Although one patient in this group experienced a postoperative seizure, the seizure was not attributed to the presence of epidural blood and repeated imaging results were unchanged. In addition to epidural blood, all patients were found to have at least a small amount of pneumocephalus without mass effect (Fig. 1B). This condition was also found in the patient who experienced a postoperative seizure but it was not attributed to the seizure. No culprit lesions, such as contusions or subdural hematomas, could be identified on postoperative imaging in this patient. The patient did not have a history of epilepsy and the postoperative seizure was an isolated event.

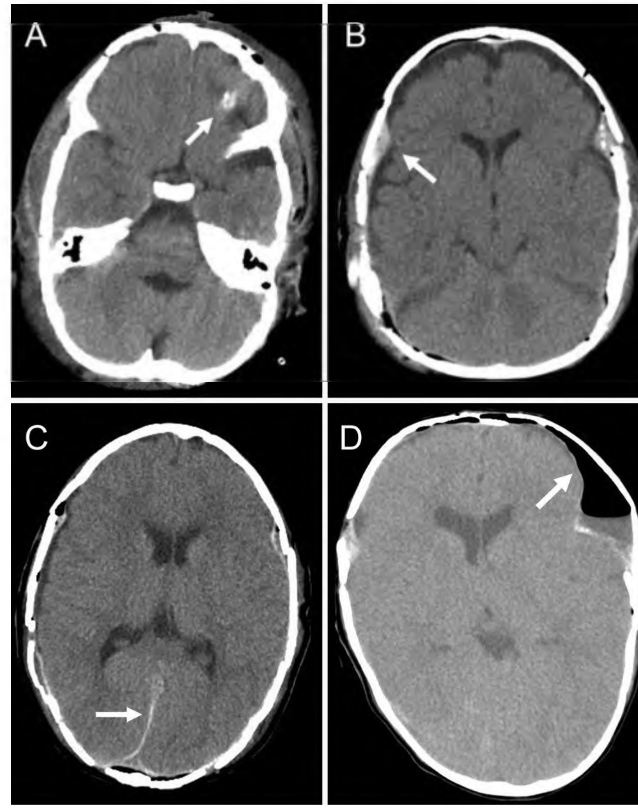

FIG. 1. Axial CT scans without contrast enhancement obtained from four patients on postoperative Day 1 after craniosynostosis surgery, demonstrating typical findings that generally lack clinical significance. A: Intraparenchymal contusion without mass effect *(arrow)*. B: Epidural blood *(arrow)* along the sphenoid ridge and pneumocephalus (a common finding in all the patients). C: Subdural blood along the posterior interhemispheric falx without mass effect *(arrow)*. D: Pneumocephalus with mass effect *(arrow)*.

Two patients in this series had evidence of SIADH. Their stay in the ICU was prolonged 1 and 2 days to correct hyponatremia. In these patients, postoperative head CT scans again demonstrated only the common findings of epidural air and a small amount of epidural blood along the sphenoid ridge. These CT findings were also not believed to correlate with the development of SIADH, as all findings were extra-axial, without mass effect, and without evidence of hypothalamic or other intraparenchymal injury.

Subdural blood without mass effect was seen in 12 (14%) of 84 patients (four [12%] of 33 patients who underwent bifrontal craniotomies and eight [16%] of 51 patients who underwent TVR) (Fig. 1C). No patients showed intraparenchymal hemorrhage with mass effect, epidural hematoma with mass effect, or subdural hematoma with mass effect. Pneumocephalus with mass effect was seen in seven (8%) of 84 patients (four [12%] of 33 patients who underwent bifrontal craniotomies and three [6%] of 51 patients who underwent TVR) (Fig. 1D). None of these patients with pneumocephalus and mass effect had clinically significant events defined as seizures, a return to the operating room, or shunt malfunction. Overall, none of the CT scans obtained in 84 patients showed clinically significant findings as defined previously. The upper limit of the 95% confidence interval on this proportion (0 of 84) was 3.6%.

In the seven patients who had shunts placed for treatment of hydrocephalus, two shunt malfunctions (29%) were reported (Fig. 2). These malfunctions were found on both clinical examination and postoperative imaging. One of the other patients underwent shunt revision at the time of the initial surgery without any postoperative sequelae.

Discussion

Although it is common to obtain postoperative head CT scans in patients after craniosynostosis surgery, the imaging findings are not often clinically relevant. In this patient series, we have demonstrated that postoperative imaging is useful in patients with shunt placements but of little benefit in other patients with craniosynostosis. It should be noted, however, that both patients with shunt malfunctions also demonstrated clinical signs and symptoms in addition to changes on CT scans. These clinical changes would have warranted a CT evaluation, leading to a diagnosis of shunt malfunction, even if no postoperative head CT scan was initially planned. Routine postoperative imaging in patients with implanted shunts is suggested, however, because of the high incidence of shunt malfunction after craniosynostosis surgery. Imaging may be helpful in identifying shunt malfunction in patients without clinical symptoms or in whom the clinical examination may be difficult because of the use of sedating and analgesic medications.

One patient had a seizure on postoperative Day 2. This patient had undergone CT evaluation on postoperative Day 1 that demonstrated only a small amount of epidural blood along the sphenoid ridge and pneumocephalus without mass effect. Another CT scan was obtained after the seizure and no changes were noted. The patient had to be reintubated for the seizure but was extubated the next day and transferred out of the ICU. The seizure was an isolated event and the patient had no history of pre- or postoperative epilepsy. As in the other cases, the imaging results on postoperative Day 1 did not alter the patient care provided, and a CT scan would have been performed after the seizure to ensure that it was not caused by any intracranial pathology. Similarly, for the two patients with SIADH, the routinely ordered postoperative CT evaluation did not demonstrate any lesions that changed our management of the patient. In each case the patient's stay in the ICU was prolonged to manage hyponatremia and a second CT scan was performed when the SIADH occurred.

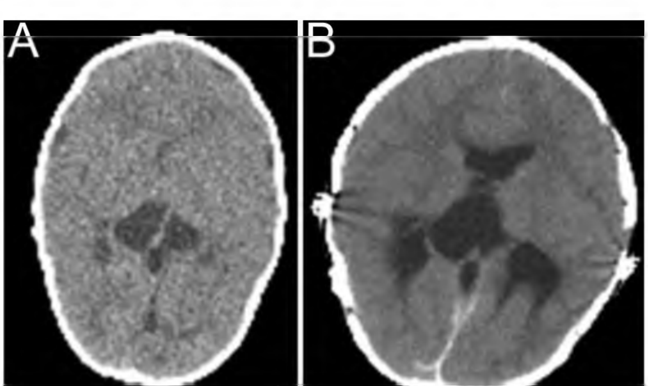

FIG. 2. Axial CT scans without contrast enhancement obtained preoperatively (A) and on postoperative Day 1 (B) in a patient with shunt placement after craniosynostosis surgery. The postoperative CT scan shows significant enlargement of ventricles consistent with shunt malfunction.

As stated by Brenner and colleagues,[2,3] the overall benefits of obtaining a CT evaluation of the patient when clinically warranted typically outweigh the risks. Yet there are undoubtedly situations in which pediatric head CT evaluation is overused and may not be necessary. In our experience, the overall benefit from following a universal policy of obtaining postoperative CT scans in these patients is low (no significant findings in 84 patients, 95% confidence interval 0–3.6%). Thus, it seems appropriate to use discretion in deciding which patients should undergo postoperative imaging. For example, if a dural tear, venous sinus injury, or brain injury occurs, postoperative imaging should be obtained. In addition, for the rare patient who has an atypical postoperative course (such as seizures, SIADH, or neurological changes), postoperative CT evaluation is a logical and often necessary step in evaluation of the patient. Finally, in patients with shunt placement for hydrocephalus, we recommend routine postoperative imaging because the incidence of postoperative shunt failure is considerable.

Conclusions

Clinically significant observations were not found on routine postoperative head CT scans in patients without shunts after a cranial reconstructive procedure. Conversely, a relatively high incidence (29%) of CT evidence of shunt malfunction was found in patients with shunt placement. These data do not support the routine use of CT scans after cranial reconstructive procedures unless the patient has shunt placement for hydrocephalus. Nevertheless, CT evaluation can be used more selectively if the surgeon has any concerns intraoperatively or postoperatively.

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