Surgical management of diastatic linear skull fractures in infants

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In seven infants, nondepressed diastatic linear skull fractures occurred with extrusion of brain tissue into the subgaleal space. These patients exhibited a triad of clinical findings that should encourage early surgery. Craniotomy and duroplasty seem to offer the most satisfactory long-term results.

KEY WORDS infant trauma diastatic linear skull fracture extruded brain tissue craniotomy duroplasty “growing skull fracture”

Surgical intervention in cases of non-depressed skull fracture is usually unnecessary. The peculiar resilience of the infant skull, however, can lead to serious dural laceration and brain herniation without posttraumatic depression of bone. Certain clinical features and radiographic findings in some of these cases suggest the importance of early surgery.

Clinical Material

This report concerns the surgical management and follow-up of seven infants, each of whom had a nondepressed diastatic linear skull fracture associated with extrusion of brain tissue into the subgaleal space. Each patient had experienced some form of head trauma followed by pronounced swelling of the scalp over the fracture site immediately before hospitalization. The patients ranged in age from 9 days to 9 months and all but one had a contralateral neurological abnormality on admission. Radiologically, the skull fracture margins were diastatic, and the distance between the bone edges measured between 4 and 10 mm. Table 1 summarizes these cases.

Surgical Technique

When first seen, four of the seven patients were anemic due to blood loss beneath the scalp, and one was in profound shock. These patients were transfused and allowed to stabilize prior to surgery.

In our first surgical efforts we developed a scalp flap over the fracture site. This maneuver commonly uncovered extruded brain tissue in the subgaleal space and between the fracture margins, which maintained diastasis. Suction and coagulation were used to remove the brain tissue, and a craniectomy was performed to completely expose the underlying dural laceration. The dura was opened wide, and additional devitalized brain was suctioned away from the injured hemisphere. A synthetic dural...
**TABLE 1**

*Summary of seven infants with diastatic linear skull fracture*

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age at Injury</th>
<th>Time to Surgery</th>
<th>Cause of Injury</th>
<th>Fracture Location</th>
<th>Initial Neurological Problem</th>
<th>Operation</th>
<th>Present Neurological Examination</th>
<th>Seizures</th>
<th>Present Medication</th>
<th>Follow-up Period (yrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 mo</td>
<td>10 days</td>
<td>fall from mother's arm</td>
<td>rt parietal</td>
<td>rt arm, seizures, focal</td>
<td>craniectomy, brain debridement, dural graft</td>
<td>normal</td>
<td>none</td>
<td>none</td>
<td>9½</td>
</tr>
<tr>
<td>2</td>
<td>11 mos</td>
<td>3 mos</td>
<td>auto accident</td>
<td>rt frontal</td>
<td>none</td>
<td>craniectomy, brain debridement, dural graft</td>
<td>normal</td>
<td>none</td>
<td>none</td>
<td>6½</td>
</tr>
<tr>
<td>3</td>
<td>6 wks</td>
<td>7 days</td>
<td>fall from mother's arm</td>
<td>rt parietal</td>
<td>left hemiparesis</td>
<td>craniectomy, brain debridement, dural graft, later cranioplasty</td>
<td>moderate rt parietal lobe dysfunction</td>
<td>controlled</td>
<td>phenobarb.</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>4 mos</td>
<td>1 day</td>
<td>auto accident</td>
<td>rt parieto-occipital</td>
<td>coma &amp; rt hemiparesis</td>
<td>subgaleal brain debridement, no craniectomy, no dural graft</td>
<td>controlled</td>
<td>controlled</td>
<td>phenobarb.</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>9 days</td>
<td>2 days</td>
<td>fall from mother's arm</td>
<td>rt parieto-frental</td>
<td>marked lt hemiparesis</td>
<td>craniectomy, brain debridement, dural graft</td>
<td>moderate lt hemiparesis</td>
<td>none</td>
<td>none</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>9 mos</td>
<td>5 days</td>
<td>fall down stairs</td>
<td>rt parietal</td>
<td>coma and lt hemiparesis</td>
<td>craniotomy, brain debridement, dural graft</td>
<td>normal</td>
<td>none</td>
<td>phenobarb.</td>
<td>2½</td>
</tr>
<tr>
<td>7</td>
<td>3 mos</td>
<td>1 day</td>
<td>fall from table</td>
<td>rt parietal</td>
<td>rt hemiparesis</td>
<td>craniotomy, brain debridement, dural graft</td>
<td>normal</td>
<td>none</td>
<td>none</td>
<td>1</td>
</tr>
</tbody>
</table>
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graft* was sutured into place and the scalp flap approximated over the cranial defect. These patients made an excellent neurological recovery but were left with an obvious cranial defect. Cranioplasty was performed later, at which time one case became infected and in a second, the tantalum mesh used in the cranioplasty eroded through the skin.

*Dura Substitute N100 manufactured by Codman & Shurtleff, Inc., Randolph, Mass. 02368.

More recently the surgical technique has been changed to avoid creating an unsightly cranial defect (Fig. 1). The fracture site is still exposed with the usual scalp flap, but a large free bone plate divided by the fracture line is removed. The bone fragments are then approximated with either fine wire or silk sutures through juxtaposed drill holes in the bone edges. The dural laceration and devitalized brain tissue are handled as described above. The approximated bone is repositioned and sutured into the cranial

Fig. 1. Artist's drawing to show surgical steps. Upper Left: Marked swelling of scalp over fracture site. Upper Right: Scalp flap developed showing skull fracture and extruded brain tissue. Lower Left: Free bone removed and dural graft completed. Lower Right: Bone repositioned and sutured into place.
defect. A double-layered scalp closure completes the operation. The two patients handled in this way have no neurological deficit or major cranial defect.

Results

The seven patients reported here have been followed from 1 to 9½ years (Table 1). No deaths have occurred. Three patients have neurological deficits; in one of these the abnormalities are mild. Case 4 is the most disabled; in this instance surgery was not completed in the usual manner because the child's condition became critical during the operation and it was necessary to terminate the procedure.

Three children are on anticonvulsant medication, but only two of them have had seizure activity. No patient has uncontrolled epilepsy. The two children who are of school age are doing well and have no problem with memory or integrative thought.

Discussion

In 1953, Taveras and Ransohoff described the pathological findings in seven children with posttraumatic erosion of the skull. Many of their patients were injured during infancy, and in two cases where initial skull films were available, diastatic skull fractures were evident. The common pathology at the time of late surgery was single or multiple fluid-filled cysts interposed between the bone edges of a large cranial defect. Some of the cystic lesions were made up of degenerated brain tissue. In 1954 Penfield suggested that progressive widening of skull fractures as seen by x-ray in children was caused by herniation of brain tissue between the bone edges. Following an extensive review of the world literature concerning “growing skull fractures of childhood,” Lende and Erickson described five of their own cases. Many of their patients sustained blunt trauma during infancy and soon thereafter demonstrated marked swelling of the scalp and a contralateral neurological abnormality. Several patients were shown by skull films to have diastatic fractures immediately after injury. These authors placed emphasis on the importance of dural and brain laceration beneath the fracture site, in the pathogenesis of growing skull fractures.

More recently Tenner and Stein described the angiographic appearance of post-traumatic cerebral herniation. They stressed the importance of cerebral tissue within fracture margins in the production of enlarging skull fractures and encouraged the use of both angiography and pneumography in the preoperative evaluation of patients suspected of having this lesion. With one exception, a triad of findings was present in each of our cases. These included: 1) a diastatic skull fracture with the fracture margins separated at least 4 mm; 2) overlying scalp swelling greater than would be anticipated from a simple skull fracture; and 3) a neurological abnormality contralateral to the fracture. Case 2 did not have an obvious neurological deficit but the fracture was anterofrontal rather than frontoparietal, and therefore the motor cortex was probably not injured during the traumatic incident.

Unfortunately there were no control patients in our series. Consequently we are uncertain as to how patients with this problem might have fared without surgery. However, some of the cases described by Taveras and Ransohoff, Tenner and Stein, and Lende and Erickson exhibited the same triad of clinical findings; initially these patients were not operated on, and a few developed severe motor deficits, retardation, and pulsating cranial defects. Ramamurthi and Kalyanaraman suggested that conservative treatment can lead to reasonable results in some cases of growing skull fracture, and they even advocated this approach. Interestingly, their cases either became worse neurologically or failed to improve significantly under observation. They concluded that surgery would not offer improvement to patients in this late static clinical situation. We agree with this conclusion but believe that surgery might have been beneficial if performed soon after injury.

On the basis of clinical information gathered from previous publications and our own case material, we believe that infants suffering from diastatic skull fractures associated with marked swelling of the scalp and a contralateral neurological abnormality
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merit early surgery. Exploration will usually demonstrate a dural laceration with extrusion of brain tissue into the subgaleal space. Proper early surgical management will lead to more rapid neurological recovery and reduce the chances of the late complications of an expanding skull fracture and seizure activity. The use of angiography and pneumography may be helpful in the preoperative evaluation of these cases but is not always necessary.

References


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