Growing Skull Fractures: Clinical Study of 10 Patients

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ABSTRACT

Background: Cranial burst fracture is a wide diastic skull fracture associated with dural laceration and extrusion of cerebral tissue outside the calvaria beneath an unbroken scalp. Growing skull fractures can develop when dural and arachnoid tears remain unrepaird. To improve the early detection and evaluation of infants with growing skull fractures, meticulous clinical examinations and radiological investigations including MR imaging must be evolved. Objective: The aim of this retrospective study was to evaluate the role of early repair of cranial burst fracture in prevention of complications associated with growing skull fractures. Methods: Ten infants aged 1 through 13 months who sustained cranial burst fractures, all initially imaged with skull radiography and CT, were studied and treated from 2004 through 2008. MR imaging was obtained after resuscitation and stabilization in some selected cases. Reduction of hemiated neural tissue, dural repair, and skull reconstruction are best performed after acute cerebral swelling has subsided but before cortical parasitization of scalp vessels and scarring have occurred. Results: Neuroimaging studies delineate the injury: dural laceration and extrusion of cerebral cortex. Surgery confirmed radiological findings (dural laceration and extracalvarial cerebral tissue) in all our patients. Prompt reduction of the cerebral hemia followed by dural repair prevents a growing skull fracture. Conclusion: Identification and follow up of diastic skull fracture before the chronic neuropathologic changes of growing fracture developed, facilitates safe repair and may minimize ongoing cerebral injury. Early prompt repair of diastic skull fractures with scalp swelling in young child may prevent further brain dehiscence and neurologic injury. (Egypt J Neurol Psychiat Neurosurg. 2010; 47(2): 249-254)

Key words: Diastatic skull fractures, dural tear, leptomeningeal cyst, growing skull fractures

INTRODUCTION

Growing skull fracture (GSF), recently termed as cranio-cerebral erosion, is a rare complication of skull fractures seen mainly in infancy and early childhood. It is characterized by progressive diastic enlargement of the fracture line. This late complication is also known as leptomeningeal cyst because of its frequent association with a cystic mass filled with Cerebrospinal fluids (CSF)¹. GSF are rare lesions complicating 0.6% of skull fractures follows cranial injuries in 50% < 1 year old and occurred from birth to 7 years of age; most (90%) are seen in children < 3 years old. Three requirements are needed for development of GSF: 1. Rupture of the dura and with an intact arachnoid underlying the original fracture, resulting in subgaleal fluid collection accumulates. 2. The concurrence of immature membranous bone. 3. An outward driving force, such as normally growing brain, hydrocephalus, edema². These three factors interpose tissue that may inhibit normal healing by preventing osteoblasts migration to the fracture site³.

Pathophysiology of growing skull fractures remains unclear⁴⁻⁶; however, there appears to be some consensus that these fractures result from progressive diastic enlargement of a fracture line, often located in the parietal region⁷. Dense arachnoid loculations and cystic degeneration of the brain may occur. Pulsations of the brain gradually push more leptomeninges through the tear in the dura. The arachnoid protrusion may grow in size because fluid that enters the cyst is partially prevented from escaping by a flap valve mechanism. The enlarging arachnoid cyst aided by normal pulsations of the brain gradually erodes the edges of the fracture and causes progressive enlargement of the skull defect and compresses the underlying cortex leading to atrophy and underlying brain destruction, a ventriculo-subarachnoid fistula, or low-grade hydrocephalus may be present⁸.

A fracture with a diastasis of more than 4 mm may be considered at risk of developing a growing skull fracture⁹. A depressed fracture usually does not become a growing fracture but a linear fracture extending from a depressed one can become a growing fracture¹⁰. A three-type classification has been suggested by Rahman et al.¹¹. Type I, a leptomeningeal cyst, corresponds to minimal cerebral lesion that is expressed clinically several months to several years after the causal trauma; type II (damaged and gliotic brain), and type III (a porencephalic cyst extended through the skull defect into the subgaleal space) are associated with severe lesions and have early clinical expression.

The aim of this retrospective study was to evaluate the role of early repair of cranial burst fracture in prevention of complications associated with growing skull fractures.
**PATIENTS AND METHODS**

Ten infants aged 1 to 13 months (seven girls and three boys; mean age of 4.1 months) with growing skull fracture were treated from 2004 to 2008 (Table 1) at Neurosurgery department, Benha University Hospitals. Seven fractures were due to falls and three were involved in a motor vehicle accident. All patients presented with marked scalp swelling, six patients were admitted with recent head trauma and a GCS score of 12 or less, four patients were admitted one to four months after head trauma and were fully conscious. Four patients were presented with seizures, four with loss of consciousness, one with hydrocephalus and three with focal neurological deficit, as contralateral hemiparesis.

All patients were examined with skull X-ray (Fig. 1) and CT scan brain (Fig. 2). Anteroposterior and lateral skull X-ray revealed wide diastatic fractures. MRI brain was performed for six patients without contrast (Fig. 3). In any child with multiple trauma, a quick primary and secondary survey was performed with prompt attention to air way, breathing and circulation. Comatose patients needed to be intubated with rapid sequence intubation technique, with due attention to cervical spine stabilization. Head tilt and chin lift maneuvers was avoided. A cervical spine collar was placed until cervical spine X-ray was performed for six patients. Ten infants aged 1 to 13 months (seven girls and three boys; mean age of 4.1 months) with growing skull fracture were treated from 2004 to 2008 (Table 1) at Neurosurgery department, Benha University Hospitals. Seven fractures were due to falls and three were involved in a motor vehicle accident. All patients presented with marked scalp swelling, six patients were admitted with recent head trauma and a GCS score of 12 or less, four patients were admitted one to four months after head trauma and were fully conscious. Four patients were presented with seizures, four with loss of consciousness, one with hydrocephalus and three with focal neurological deficit, as contralateral hemiparesis.

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Surgical technique included: enlarging of craniotomy in order to find normal borders of dura, lysis of adhesion, resection of cerebro-periosteal scar, exposure of the cyst (Fig. 4) opening of the cyst to subarachnoid space or ventricle, closure of the dura and duraplasty with or without cranioplasty (Fig. 5). Eight patients were managed with duraplasty only, after separation of herniated cortex from dural edges, skull and surrounding soft tissues. Duraplasty was done using epicranium, and artificial dura. Duro- and cranioplasty were done for two patients aged 11 and 13 months with wide diastatic skull fracture. Cranioplasty were done using (autologous bone) (Fig. 6). Four burr holes around the fracture sites and the bones reconstructed and fixed by sutures. One patient had associated hydrocephalus and was treated with ventriculo-peritoneal shunt.

**RESULTS**

Clinical data, imaging characteristics, and operative findings in the ten infants with cranial burst fracture are shown in table (1).

All patients in this study presented with scalp mass: four patients (40%) presented with seizure, three (30%) with neurological deficit, four (40%) with loss of consciousness, and one (10%) with hydrocephalus. Frontoparietal and parietal sites of GSF were (60%). Three patients were type I growing skull fracture, four were type II and three were type III

Duroplasty alone was performed in 8 patients (80%); duro- and cranioplasty was performed in 2 patients (20%) and cranioplasty was performed using autogenous bone, in 2 patients (20%) aged 11 and 13 months.

Post-operative status epilepticus occurred in one patient (10%) and was controlled by Phenobarbital IV drip and IV phenytoin. One patient (10%) presented with associated hydrocephalus and was operated upon with ventriculo-peritoneal shunt. Three patients (30%) had post operative superficial wound infection and were controlled with repeated wound dressing and IV antibiotics. No recurrence of leptomeningeal cyst or neurological deterioration occurred. Post-operative skull X-ray and CT scan brain were performed to all patients before discharge (Figs. 7 and 8).

The patients were followed at out-clinic after discharged from the department on regular visits ranged from 1 month to 18 months with mean follow up period of 10 months, motor deficit unlikely to improve but seizure disorder improved in 2 patients from 5 (40%).

**Table 1.** Clinical data, imaging characteristics, and operative findings in the ten infants with cranial burst fracture.

<table>
<thead>
<tr>
<th>No.</th>
<th>Age (mo)</th>
<th>Sex</th>
<th>Injury</th>
<th>CT Findings</th>
<th>MR Imaging Findings in 6 patients</th>
<th>Operative Findings</th>
<th>Type</th>
<th>Clinical Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>F</td>
<td>Fall</td>
<td>Left Parietal Widely diastatic fracture traversed by soft-tissue density continuous with that seen within the subgaleal space</td>
<td>Wide dural and calvarial defects traversed by cerebral tissue, discontinuity of overlying gray matter</td>
<td>6-cm dural laceration filled with herniated cerebrum, 3-cm-long fracture of cortical surface</td>
<td>II</td>
<td>Scalp swelling Seizures</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>M</td>
<td>Fall</td>
<td>Right Fronto-parietal Mildly diastatic skull fracture with underlying focal superficial hemorrhagic contusion</td>
<td>-</td>
<td>5-cm dural defect and 3-cm cortical laceration</td>
<td>I</td>
<td>Scalp swelling Loss of consciousness</td>
</tr>
</tbody>
</table>
Table 1. Continued

<table>
<thead>
<tr>
<th>No.</th>
<th>Age (mo)</th>
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</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>3</td>
<td>M</td>
<td>MVA*</td>
<td>Left Parieto-temporal diastatic slightly depressed fracture with underlying focal hemorrhagic cortical contusion</td>
<td>Paramedian herniation of posterior parietal cortex, sparing of superior sagittal sinus</td>
<td>6-8 cm laceration parallel to and sparing superior sagittal sinus, herniated and burst cortex</td>
<td>II</td>
<td>Scalp swelling Seizures</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>F</td>
<td>Fall</td>
<td>Right fronto-parietal diastatic fracture with panneciphalic cyst extended through the skull defect into the subgial space and hydrocephalus</td>
<td>-</td>
<td>5-7 cm dural defect and large panneciphalic cyst extended through the skull defect into the subgial space</td>
<td>III</td>
<td>Scalp swelling hydrocephalus</td>
</tr>
<tr>
<td>5</td>
<td>11</td>
<td>F</td>
<td>MVA</td>
<td>Left Frontal Mildly diastatic skull fracture with underlying focal superficial hemorrhagic contusion</td>
<td>Posterior edge of fracture seen to be driven into cerebral cortex</td>
<td>4-cm dural and cortical laceration</td>
<td>I</td>
<td>Scalp swelling Loss of consciousness</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>F</td>
<td>Fall</td>
<td>Right parieto-occipital Slightly depressed diastatic skull fracture with underlying cortical contusion; subgialal mass of high attenuation</td>
<td>-</td>
<td>Dural and cortical laceration, incarcation of cortex within dural defect</td>
<td>II</td>
<td>Scalp swelling Focal neurological deficit</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>F</td>
<td>Fall</td>
<td>Left Fronto-parietal Non-depressed mildly diastatic skull fracture with underlying focal hemorrhagic cortical contusion, minimal mass effect, subgialal swelling of intermediate attenuation</td>
<td>Cortex and cortical vessel traversing dural and cranial defect into subgialal space</td>
<td>Dural and cortical laceration with incarcation of cortex within the dural defect</td>
<td>II</td>
<td>Scalp swelling Loss of consciousness</td>
</tr>
<tr>
<td>8</td>
<td>2</td>
<td>M</td>
<td>MVA</td>
<td>Right Parieto-temporal diastatic skull fracture with underlying hemorrhagic cortical contusion</td>
<td>-</td>
<td>large panneciphalic cyst extended through the skull defect into the subgialal space</td>
<td>III</td>
<td>Scalp swelling Seizures Focal neurological deficit</td>
</tr>
<tr>
<td>9</td>
<td>3</td>
<td>F</td>
<td>Fall</td>
<td>Right posterior Parietal diastatic skull fracture with underlying hemorrhagic cortical contusion.</td>
<td>Wide dural and calvarial defects traversed by cerebral tissue</td>
<td>large panneciphalic cyst extended through the skull defect into the subgialal space</td>
<td>III</td>
<td>Scalp swelling Seizures Focal neurological deficit</td>
</tr>
<tr>
<td>10</td>
<td>13</td>
<td>F</td>
<td>Fall</td>
<td>Left Posterior parietal diastatic fracture with underlying focal hemorrhagic contusion</td>
<td>Dural defect lateral to superior sagittal sinus traversed by cortex</td>
<td>6-cm laceration parallel to but sparing superior sagittal sinus</td>
<td>I</td>
<td>Scalp swelling Loss of consciousness</td>
</tr>
</tbody>
</table>

CT computerized tomography, F female, M male, MR magnetic resonance, MVA motor vehicle accident
**Figure 1.** Plain X-ray skull antoposterior view showing preoperative skull defect.

**Figure 2.** Preoperative CT scan brain showing a leptomeningeal cyst & skull defect.

**Figure 3.** T2 weighted MRI Brain showing the cyst with underlying brain contusion.

**Figure 4.** The leptomeningeal cyst is plugging through the skull defect.

**Figure 5.** Duroplasty after excision of the cyst.

**Figure 6.** Cranioplasty with autogenous bone graft.

**Figure 7.** Plain X-ray skull lateral view showing postoperative cranioplasty.

**Figure 8.** Postoperative CT scan brain after excision of the cyst & cranioplasty.
DISCUSSION

There were 7 girls and 3 boys ranging in age in this study from 1 month to 13 months with mean age 4.1 months. In Ersahin et al., the mean age was 12.4 months. In Gupta et al., study 80.5% of patients were less than 5 years of age also in Michael et al., study 9 of 10 patients being under one year of age. In this study falling was the most frequent cause of injury (70%) this agree with Gupta et al., study (93%), Ersahin et al., study and Sharma et al., study.

All patients in this study presented with scalp mass, 4 patients (40%) presented with seizure, three (30%) with neurological deficit, four (40%) with loss of consciousness, and one (10%) with hydrocephalus. In Ersahin et al. study of 22 growing skull fracture patients, five patients presented with seizure (22%), four with hemiparesis (18%), one with hydrocephalus (4.5%) and was shunted. In the study by Pezzotta et al., of 132 growing skull fracture, 46% developed seizures, 38% focal neurological deficit and 21% loss of consciousness. The study also concluded that in the parieto-temporal localization there is a higher probability of seizures (62.5%) and loss of consciousness (62.5%).

In this study ventriculo-peritoneal shunt was performed to 1 patient (10%), in Guilburd and Rakier, study of 15 patients, 2 patients had accumulation of CSF requiring Ventriculo-peritoneal shunt in 1 patient (6.5%) and repeated lumbar puncture in another patient. In Ersahin et al., study one patient out of 17 needs V-P shunt (5.9%), Sharma et al. performed V-P shunt in 4 patients from 28 (14%).

Gupta et al., and Ersahin et al., found that the most common site of growing skull fracture was parietal or frontoparietal (56%). In our study the frontoparietal and parietal sites of GSF were (60%).

In our study, motor deficit unlikely to improve but seizure disorder improved in 2 patients from 4 (50%), this agree with Halliday et al., who reported a case with no postoperative improvement in motor deficit.

Djientcheu et al., recommended that duroplasty alone with a flap of pericranium remains the simplest and least expensive method of treatment. Miranda et al., also recommended duroplasty alone. In Gupta et al., study duroplasty alone was performed in 8 patients (19%) from 41 patients with no recurrence, twenty four patients (58%) underwent a duro and cranioplasty. The material used for cranioplasty included acrylic, wire mesh, steel plates or autologous bone. In Ersahin et al., study duroplasty alone was performed in 21 patients from 22 (95%) with no recurrence. In Sharma et al., duroplasty and cranioplasty were performed to all 28 patients with no recurrence. Kazukivo et al., and Ruberti recommended autogenous bone for cranioplasty with the following advantages: no additional skin incisions, no bone taken from other parts of the body, physiological fusion can be expected; foreign body reaction is avoided. In our study duroplasty alone was performed to 8 patients (80%), duro-and cranioplasty was performed in 2 patients (20%). Cranioplasty was performed using autogenous bone, in 2 patients (20%) aged 11 and 13 months. No post operative recurrence of leptomeningeal cyst in all patients after duroplasty or duro and cranioplasty with good results. It could be concluded that all patients under age of 3 years with diastatic skull fracture should be closely followed up. children with linear skull fractures should be examined 2-3 months later to look for evidence of a growing skull fracture. Linear fractures and burst fractures in an infant with a scalp swelling must be corrected early to prevent a growing skull fracture. Early management can avoid difficult surgical dissection and progressive neurological sequel seen with delayed intervention.

REFERENCES


الملخص العربي
الكسر الجمجمي النامي في الأطفال

الكسر الجمجمي النامي في الأطفال يحدث نتيجة وجود شرخ منتشر بالجمجمة مع وجود قطع بالمجمجمة ونتوء أنسجة المخ خارج عظام الجمجمة تحت فروة الرأس.

وقد أجريت هذه الدراسة على 10 أطفال مصابين بكسر الجمجمة النامي ويترواح أعمارهم بين شهر و 13 شهر في الفترة من 2004 إلى 2008 بقسم جراحة المخ والأعصاب بكلية طب بنها وتم إجراء أشعات عادية (X-ray) ومقاشع ورنين مفتوحة على المرضى المصابين وتم إجراء الجراحة لجميع الحالات و إراج الجزء النامي من المخ إلى داخل الجمجمة وترقيع الأم الجافية في جميع الحالات وتم عمل تقييم لنتائج الجمجمة في حالات قليلة.

وقد أوضحت هذه الدراسة أن التشخيص المبكر والتدخل الجراحي يؤدي إلى تجنب الكثير من المضاعفات التي تحدث في مثل هذه الحالات.