CASE REPORT

Bilateral abducens nerve palsy associated with diabetes insipidus following crushing head injury: A case report

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Introduction

Skull base fractures are usually caused by remote deformation or spreading of stress patterns from fractures of the cranial vault. The location near the anatomic centre of the skull base enables the clivus to protect the brain stem, cranial nerves, and vertebrobasilar circulation, but makes diagnosis of injuries to this lesion difficult. Compression of the skull beyond a certain degree may result in bilateral transverse basal fractures that cross the middle fossa and extend to the petrous bone, sometimes crossing the midline through the sphenoid sinus, sella turcica, dorsum sellae, and clivus. The extent and pattern of the deformation varies with the location, shape, and force of the impact. In contrast to longitudinal fractures, transverse fractures of the clival complex have been known to be associated with a high incidence of multiple cranial nerve palsies. Moreover, posterior pituitary dysfunction in the form of diabetes insipidus has also been reported in several cases of transverse clival fractures. Thus, extensive skull base fracture can produce a wide variety of complications, including septic, neuroendocrine, neurovascular, and neuroophthalmologic problems. Here, we present a case of a young patient with a skull base fracture presenting with bilateral abducens palsy associated with diabetes insipidus caused by a low-velocity, crushing head injury, focusing on the clinico-anatomical correlations.

Case report

An 18-year-old male suffered a bilateral crushing injury to the head. The accident involved his head being compressed by an industrial machine on both temporal legions. On admission about 2 h after the injury, he was awake and alert with no hemiparesis but moderate epistaxis. On neurological examination, bilateral sixth-nerve palsy with failure of lateral gaze was noticed, which was treated conservatively. CT scan revealed massive pneumocephaly with air in the basal anterior and middle fossa, the basal cisterns, and intraventricular spaces. No haematoma was observed in the intracranial space nor in the extradural space of the clivus. An extensive temporal bone fracture extending into the petrous ridges bilaterally, continuing...
transversely through the clivus was detected. The fracture line continued anteriorly into the left spheno-

noid sinus wall and sellar floor with accompanying haematosinus (Fig. 1A—C). On detailed examination 

using 3-dimensional bone CT, diastasis of the sphenoid-occipito synchondrosis as well as a slightly 

widened both foramen lacerum was noted (Fig. 1D). The superior orbital fissures, foramina rotunda, and 

foramina ovale were intact. Two days after the trauma, the patient started to complain of thirst, 

polydipsia, and polyuria. Urine output was 350 ml/h, with specific gravity values of 1.004. He was 

initially treated by intravenous aqueous pitressin (AP) 4 IU every 6 h, following which his urine output 

decreased to 100 ml/h. After 2 days, treatment with 1-deamino-8- D-arginine vasopressin (DDAVP) 

was initiated and his urine output decreased to 1500 ml/day. Base line endocrine evaluation includ-

ing the hormones secreted from the anterior pituitary lobe was normal. Magnetic resonance imaging 

performed 28 days after admission demonstrated the disappearance of the normal high signal inten-

sity of the posterior lobe on T1-weighted images (Fig. 2). A 3-month follow up showed complete 

recovery of abducens nerve function on both sides, but his polyuria and polydipsia remained unchanged 

without an appropriate amount of DDAVP.

**Discussion**

To our knowledge, only 16 cases manifesting bilateral abducens nerve palsy caused by low-velocity, crush-

ing head injury have been reported (Table 1). These 16 cases share certain similarities in regard to the following characteristics:

(1) Most cases showed a massive cerebrospinal leakage immediately following the head injury.

(2) Other cranial nerve neuropathies such as third, fifth, seventh, or eighth nerve dysfunction were present.

(3) The abducens palsy was markedly improved within 6 months.

However, our case differs greatly from others in that the injury gave rise to an endocrinopathy. The mechanism of skull base fracture produced by crushing head injuries was studied in detail by Russel and Schiller. They found that a lateral crushing force resulted in fractures that crossed the middle fossa and in longitudinal fractures of the petrous bones that sometimes crossed the midline through the sella turcica, dorsum sella, or the clivus. With respect to the pattern of these mediobasal skull
Table 1 Summary of 17 cases with bilateral abducens palsy caused by crushing head injury

<table>
<thead>
<tr>
<th>Serial number</th>
<th>Author(s) Year</th>
<th>Age</th>
<th>Sex</th>
<th>Con. Type</th>
<th>H</th>
<th>P</th>
<th>CSF leakage</th>
<th>C.N.</th>
<th>D.I.</th>
<th>Residuum</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Russell &amp; Shiller 1949</td>
<td>29 M</td>
<td>Semicoma</td>
<td>3b</td>
<td>SAH</td>
<td>—</td>
<td>—</td>
<td>Otorrhea right V, bilateral VI, bilateral VII, bilateral VIII</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Summers 1979</td>
<td>8 M</td>
<td>Semicoma</td>
<td>3c</td>
<td>SAH</td>
<td>—</td>
<td>—</td>
<td>Rhinorrhea, otorrhea bilateral V, bilateral VI</td>
<td></td>
<td></td>
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<tr>
<td>3</td>
<td>Yasue 1981</td>
<td>?</td>
<td>Coma</td>
<td>3c</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>Otorrhea bilateral VI, bilateral VII</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Kobayashi 1988</td>
<td>29 M</td>
<td>Alert</td>
<td>2</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>Rhinorrhea bilateral III, bilateral VII, bilateral VIII, right VII</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Duhahie 1995</td>
<td>6 M</td>
<td>Somnolence</td>
<td>2</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>Rhinorrhea bilateral II, III, bilateral VII</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Uchkado 1998</td>
<td>20 M</td>
<td>Somnolence</td>
<td>3b</td>
<td>SAH</td>
<td>—</td>
<td>—</td>
<td>Rhinorrhea bilateral VI, bilateral VII</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Prasad 1999</td>
<td>2 M</td>
<td>Semicoma</td>
<td>3c</td>
<td>SAH</td>
<td>—</td>
<td>—</td>
<td>Otorrhea bilateral VI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Khan 2000</td>
<td>19 M</td>
<td>Alert</td>
<td>3c</td>
<td>ICH + EDH</td>
<td>—</td>
<td>—</td>
<td>Rhinorrhea bilateral III, bilateral VI, right VII</td>
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<tr>
<td>9</td>
<td>Tortosa (1) 2004</td>
<td>10 M</td>
<td>Alert</td>
<td>3c</td>
<td>—</td>
<td>—</td>
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<td>Rhinorrhea bilateral VI, bilateral VII, bilateral VIII, D.I.</td>
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<td>10</td>
<td>Tortosa (2) 2004</td>
<td>12 M</td>
<td>Alert</td>
<td>?</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>Rhinorrhea bilateral VI, right VII, bilateral VIII, D.I.</td>
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<td></td>
</tr>
<tr>
<td>12</td>
<td>Tortosa (4) 2004</td>
<td>42 M</td>
<td>Somnolence</td>
<td>?</td>
<td>—</td>
<td>—</td>
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<tr>
<td>13</td>
<td>Tortosa (5) 2004</td>
<td>13 M</td>
<td>Alert</td>
<td>?</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>Rhinorrhea bilateral VI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Tortosa (6) 2004</td>
<td>14 M</td>
<td>Alert</td>
<td>?</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>Rhinorrhea bilateral VI, bilateral VII</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Present case 2004</td>
<td>18 F</td>
<td>Alert</td>
<td>3b + 3c</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>Rhinorrhea bilateral VI, bilateral VIII, bilateral VIII</td>
<td></td>
<td></td>
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</table>

Con., consciousness state on admission; Type, type of skull base fracture classified by Yasue; H, intracranial haematoma; P, pneumatic ventricle; C.N., cranial nerve palsy; D.I., diabetes insipidus; SAH, subarachnoid haemorrhage; ICH, intracerebral haematoma; EDH, epidural haematoma; ? , not described.
fractures, Yasue demonstrated that the patterns of the fractures could be classified into four types from the impact site as follows. 22 Type 1, frontal blow; Type 2, frontolateral blow; Type 3, temporal blow; Type 4, occipital blow. Seven of sixteen cases (44%) shown in Table 1 belonged to Type 3. Moreover, Y-asue divided Type 3 into three subtypes, that is, the anterior type = 3a, the middle type = 3b, and the posterior type = 3c according to the location of the fracture. In the anterior type named as 3a, there is a fracture line extending to the anterior part of the middle fossa including bilateral sphenoid ridges, superior orbital fissure, and anterior clinoid process. In the middle type named as 3b, there is a fracture line extending to the middle part of the middle fossa including squamous portion of the temporal bone and sella turcica. In the posterior type named as 3c, there is a fracture line extending to the posterior part of the middle fossa including petrous portion of the temporal bone and clivus. He concluded the patterns of the fracture depended on impact site. As shown in Table 1, 1 case is categorized as Type 2, 2 cases as Type 3b, and the other 5 cases as Type 3c. When areas of ‘outbending’ or ‘inbending’ invariably occurred, however, the fracture lines were sometimes located at points distant to the impact zone, as observed in our case. Evidence that compound stresses could be concentrated in the middle cranial base can be seen in the existence of the sellar floor fracture extending to the sphenoid sinus, which lead us to assume that the fracture of our case was composed of both 3b and 3c. It has been hypothesized that upward or downward displacement of the brainstem is responsible for the occurrence of lesions of the sixth cranial nerve. 17 However, we agree with Russel and Schiller in that the true cause of the injury of the sixth cranial nerve is the displacement of the petrous apex. When excessive posterolateral impact with the force transmitted through the petrous ridge results in transverse and partly oblique fractures, the petrous apex tends to be displaced backwards and inward, creating a gap between the sphenoid and petrous bone. In such a case, the petrous apex acts as a fulcrum so that both abducens nerves are easily compressed, contused, and stretched against the ridge of the petrous pyramid. 8, 18

Whether diabetes insipidus occurs more frequently in association with sellar fracture caused by crushing head injury than with closed head injury in general has not been addressed. The onset of diabetes insipidus seems relevant to compound stress loading to the skull base. Corradino et al. 1 reported that posterior pituitary dysfunction was noted most commonly in those with transverse clival fractures. Hypothalamic dysfunction is well recognized in the context of severe head injury, however, pituitary injury has also been reported in association

Figure 3  Diagrammatic representation of the course of fracture lines through the skull base, showing how such fractures serves as an index of the direction of applied force (adapted from Ref. 22).
with fractures in the region of the sella.\textsuperscript{12,23} In particular, transverse fractures of the clival complex are frequently found in close proximity to the pituitary fossa. In this context, Kornblum\textsuperscript{10} found 62 cases of histological pituitary damage in 100 patients who died of head trauma. Porter and Miller\textsuperscript{13} have emphasized a traumatic elongation of the stalk, while Crompton\textsuperscript{2} has considered ischemic and haemorrhagic lesions in the hypothalamus, infundibulum, and pituitary stalk as the cause of the underlying pathology. These lesions may cause denervation of the posterior lobe, with Wallerian degeneration progressing upward, resulting in a disappearance of the normal hyperintense signal on T1-weighted sequences, as shown in our case. This sign appears to represent one of the findings indicating post-traumatic non-functioning neurohypophysis.\textsuperscript{4,5,7} On the other hand, Tortosa et al.\textsuperscript{19} demonstrated that skull deformation occurred in its vertical diameter, which was increased by 8 mm in the experimental crush injury model. This deformation of the cranial bones explains the upward shift of the hypothalamus, which, by being tethered to the skull base by the pituitary stalk, might suffer a bilateral stretch at the supraoptic and paraventricular nuclei. In addition, they also suggested the clinical significance of pneu-

References


