Contrecoup skull fractures

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The authors describe the frequency, pathological features, and significance of contrecoup fractures of the anterior cranial fossae, which occur commonly when falls with occipital or temporal impacts cause fatal head injuries.

KEY WORDS • head injuries • cerebrospinal fluid rhinorrhea • skull fractures • contrecoup fractures

Contrecoup brain contusions occur opposite a point of cranial impact, independently of skull fractures, and are sustained when the moving or falling head strikes a solid object. Routine experience in the medicolegal autopsy room reaffirms the validity of this well-known principle; however, occurrence of contrecoup skull fractures, a phenomenon allegedly known to Hippocrates, has received scant clinical recognition. In this paper we draw attention to the frequency and pathological features of such fractures, and discuss their significance.

General Features

Contrecoup skull fractures are located at a distance from a point of cranial impact and are not direct extensions of fractures originating at the point of impact. They occur when the victim's head strikes at the occiput or temple, and are located most frequently in the orbital roofs and ethmoid plates. Fractures may or may not be present at the point of impact.

The orbital roofs, ethmoid areas, and anteromedial recesses of the middle cranial fossae commonly show foci in which bone is so thin that it is translucent (Fig. 1). Fractures in such "egg shell" areas are produced by trivial force compared to that required to fracture thicker parts of the skull. At autopsy, we have demonstrated the delicacy of these regions in some individuals by intentionally cracking thin portions of the orbital roofs with simple fingertip pressure following removal of the dura mater.

This discussion is not concerned primarily with penetrating injuries of the skull, but gunshot wounds illustrate some of the salient features that we wish to elucidate. Furthermore, fractures in the anterior fossae induced by the transmitted forces of gunshot wounds produce palpebral ecchymoses identical with those in the contrecoup fractures of blunt trauma. Contact-range gunshot wounds (muzzle of the gun pressed against the scalp), regardless of the path of the bullet, commonly cause fractures in the anterior cranial fossae that are not extensions of fractures radiating from the margins of bullet perforations in the skull. In this situation, orbital and ethmoid fractures are not true contrecoup injuries. They are produced by the pressure of expanding gas blown into the skull behind the bullet, transmission of force through the skull, and slamming of the brain against the
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floor of the skull in response to the shock wave imparted to the cerebral parenchyma by the bullet's kinetic energy. The latter mechanism also explains the common occurrence of brain contusions distant from the bullet track.

Figure 2 shows the victim of a small caliber, contact-range gunshot wound in the right frontal area. The bullet perforated the frontal lobes of the brain and did not strike the orbital roofs. Conspicuous palpebral ecchymoses were caused by comminuted fractures of the anterior fossae with resulting hemorrhage into the orbital soft tissues. The ecchymoses are restricted by fascial planes of the eyelids (so-called “spectacle” hemorrhages), and there is no sign of blunt trauma to the front of the face. Note the similar distribution of palpebral ecchymoses in Fig. 3 upper left. Comparable fractures also are produced by distant wounds from powerful handgun ammunition and from high velocity rifle bullets; contact wounding by either of these frequently causes explosive hemidcapitation.

Materials and Method

To determine the approximate frequency of contrecoup skull fractures, we reviewed a consecutive autopsy series of adult fatalities from head injuries sustained in accidental falls in 1972 and 1973 in Cuyahoga County, Ohio (metropolitan Cleveland). Each of the subjects had a complete autopsy performed at the Coroner’s Office. We elected to study victims of accidental falls because these individuals commonly sustain a single cranial impact; in this circumstance, correlation of traumatic lesions in the scalp, skull, and brain lends itself to reliable reconstruction of the lethal mishap. In contrast, victims of homicidal assaults and vehicular crashes often have extensive and multifocal scalp and facial injuries, more difficult to interpret in the context of the present discussion.

During the 2-year study period, 119 adults died from head injuries sustained in accidental falls, with autopsies performed at the Cuyahoga County Coroner’s Office; 38 (32%) of these individuals had no skull fracture of any type. Of the 81 persons with skull fractures, six were excluded from the study because they either had multiple cranial impacts, as from tumbling down stairs, or their skulls were virtually shattered, as in a fall from a great height. In those situations the multiplicity and severity of cranial injuries precluded assignment of fractures to specific points of impact.

Of the remaining 75 individuals with fractures, nine (12%) had contrecoup fractures in the anterior or middle fossae, two of whom did not have a fracture at the point of impact. Direct extensions of fractures originating at the point of impact into the anterior or middle fossae was noted frequently, but these
Fig. 3. Case 9. Photographs depict autopsy findings in woman who fell and struck her occiput. Upper Left: Facial view showing bilateral palpebral ecchymosis which is more conspicuous on patient's right side. Her nostrils contain blood. Upper Right: Occipital scalp with an abraded laceration at the point of cranial impact. Lower Left: The scalp has been reflected anteriorly and posteriorly following coronal mastoid-to-mastoid incision. The intact calvaria is viewed from above. Contusion of the scalp is limited to the area of occipital impact (arrow). Lower Right: The dura mater has been removed from the floor of the skull exposing bilateral contrecoup fractures in the anterior fossae (arrows). There is no fracture at the point of impact.
Contrecoup skull fractures

TABLE 1

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age, Sex</th>
<th>Type of Fall</th>
<th>Point of Cranial Impact</th>
<th>Fracture at Point of Impact</th>
<th>Fossae Fractured</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>25 M</td>
<td>from horse</td>
<td>rt occiput</td>
<td>yes</td>
<td>anterior</td>
</tr>
<tr>
<td>2</td>
<td>36 M</td>
<td>standing height to floor</td>
<td>rt occiput</td>
<td>no</td>
<td>anterior, lt middle</td>
</tr>
<tr>
<td>3</td>
<td>44 M</td>
<td>down stairs</td>
<td>lt temporal</td>
<td>yes</td>
<td>anterior</td>
</tr>
<tr>
<td>4</td>
<td>49 M</td>
<td>down stairs</td>
<td>midocciput</td>
<td>yes</td>
<td>anterior</td>
</tr>
<tr>
<td>5</td>
<td>56 F</td>
<td>down stairs</td>
<td>rt occiput</td>
<td>yes</td>
<td>anterior, middle</td>
</tr>
<tr>
<td>6</td>
<td>65 M</td>
<td>down stairs</td>
<td>lt temporoparietal</td>
<td>yes</td>
<td>lt anterior</td>
</tr>
<tr>
<td>7</td>
<td>68 M</td>
<td>down stairs</td>
<td>lt occiput</td>
<td>yes</td>
<td>anterior, rt middle</td>
</tr>
<tr>
<td>8</td>
<td>70 M</td>
<td>down stairs</td>
<td>lt occiput</td>
<td>yes</td>
<td>anterior</td>
</tr>
<tr>
<td>9</td>
<td>76 F</td>
<td>down stairs</td>
<td>midocciput</td>
<td>no</td>
<td>anterior</td>
</tr>
</tbody>
</table>

were not regarded as contrecoup injuries. Each subject in this study who had a contrecoup skull fracture also had brain contusions in a corresponding distribution; however, in rare instances, we have observed such fractures without brain contusions.

Results

Table 1 summarizes the circumstances of injury, point of cranial impact, and location of fractures in the nine individuals with contrecoup fractures. Contrecoup fractures usually are bilateral in the anterior cranial fossae. They may present as single, delicate linear cracks, but more frequently are characterized by a cluster of two to five linear and curved, small fractures in an involved fossa. Their shape and distribution in any particular instance probably are determined by the unique anatomical arrangement of thin areas between bony ridges in the base of the skull as well as the amount and direction of forces acting upon these delicate foci (Fig. 1). The number and configuration of contrecoup fractures in a specific case cannot be correlated simply with the point of cranial impact.

Figure 3 depicts typical findings; this woman fell backward and struck her occiput. There were characteristic bilateral contrecoup skull fractures of the orbital roofs and no fracture at the point of cranial impact. The brain showed multiple contusions of the inferior frontal (orbital) lobes and the temporal poles.

Discussion

Contrecoup skull fractures are not rare, particularly when the autopsy pathologist seeks them. Failure to strip the dura mater from the base of the skull following removal of the brain insures that many such fractures will be overlooked, because dural tears are not invariably present. Although the orbital roofs are delicate, careful removal of the overlying dura mater per se does not inflict artifactual fractures. The antemortem occurrence of an orbital roof fracture is documented unequivocally by the presence of hemorrhage in the subjacent orbital fat.

Suspicion of fractures in the anterior fossae usually is aroused when a head-injured patient has palpebral ecchymoses and blood or cerebrospinal fluid leaking from the nose. From a practical point of view, it is important to determine whether or not the ecchymoses are limited by fascial planes of the eyelids and whether there is any sign of direct facial trauma such as contusion, abrasion, or laceration of the skin covering the orbital rim or nose. Casual observation of an unconscious individual with "black eyes" and a "bloody nose" can cause the erroneous assumption that the injured patient was assaulted.

Predictable early complications of contrecoup skull fractures include aspiration of blood and the same types of vascular and nerve injuries inflicted by fractures of other
types in the same anatomic locations. Bacterial meningitis is the cardinal late sequel of ethmoid fractures or of orbital fractures that communicate with lateral extensions of paranasal air cells. Progressive thinning of the untorn dura mater over an unhealed skull fracture may lead to fenestration and perforation many months or years following the original injury, resulting in late onset of cerebrospinal fluid fistulas.

The most likely mechanisms causing contrecoup fractures in closed head injuries are transmission of forces via the skull and direct transmission of force from the point of impact through the brain to the floor of the skull.²

References


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