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Clinical practice

Brain trauma in head injuries presenting with and without concurrent skull fractures

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ABSTRACT

Head injuries and skull fractures may be problematic in cause and manner of death. Over a 10-year period, 54 cases showing head injuries were studied. Of thsese, 34 had skull fractures and 20 had no skull fractures. Virtually all decedents with skull fractures had brain injuries. The most common injury in both groups was motor vehicle accidents (MVA), in which 50% had skull fractures. In cases of skull fracture, brain lacerations, hemorrhages, and cerebral edema were common. Of 20 decedents with head injury but no skull fracture, most were accidents, and all but 3 cases had brain injury, although often relatively minor, except for atlanto-occiptital dislocation. There were significant differences between the two groups. Decedents with skull fractures tended to by younger (mean 35 years) compared to those with head injury only (mean 52 years) ($p = 0.0021$). The use of drugs or alcohol was more likely in decedents with skull fractures than in those with head trauma only ($p = 0.0431$). Mean abbreviated injury scale scores were higher for the face and head/neck of decedents with skull fractures, while significantly lower for chest and extremities, compared to decedents without skull fractures. Brain injury of some kind occurred in 90% of cases of head trauma, so a high level of suspicion should be placed in seeking skull fractures or brain injury.

1. Introduction

Head inquiries and skull fractures are common in clinical medicine and forensic pathology.[1,2] Records of these injuries date to antiquity when Hippocrates and Galen classified different types of skull fractures and developed methods of trephination as treatments.[3] Modern technology has been brought to bear on a famous ancient case, Tutankhamen, who was determined by radiographic means to have been spared from a suspected skull fracture.[4]

Head injuries and skull fractures remain problematic in modern times, too. In forensic pathology, there is often a question of what role the injury or fracture played in the cause of death, and how to consider the injuries in terms of manner of death. We have found these issues are especially important in accidents where civil litigation is possible, and in alleged homicides where criminal charges or degree of charges brought against a defendant may be considered.

We undertook this study in order to classify the role of head injuries and skull fractures in the cause and manner of death in cases in the community, and to seek commonalities or differences that may help determine the role of the injuries in the cause and manner of death. We anticipate these findings to be useful in discerning the degree of contribution of the head injury or skull fracture in future cases.

2. Materials and methods

Cases over a 10-year period were reviewed from our files. The decedents were residents of Cedar Rapids or Eastern Iowa who had autopsies either because of legal requirements of the Iowa Code, or occasionally at family request to clarify issues that they wished to understand better on the death of their loved one. Complete autopsies were performed, including external examination of the body with and without clothing, internal examinations of the head, chest, and abdomen, and toxicological studies on blood.

Cases were selected for the presence of head injuries. Head injuries were defined as any structural, anatomic, or functional operation of the head that could be designated the cause of death or were coincident with other injuries led to death. Such findings included lacerations, abrasions, ecchymoses, hemorrhage, crepitus, or bleeding from one or both ears. The cases were then divided into groups based on the presence or absence of skull fractures. This finding was determined by both external examination of the head and open dissection of the head. Skull fractures were defined as disruptions in the integrity of the normal anatomy of the bony structures of the skull. Fractures could include hairline fissures that penetrated the full thickness of the calvarium and were evidenced by visual examination of the skull and confirmation by removal of the skullcap; multiple severe discontinuties of the integrity of the skull with one or more free-floating or absent pieces of bone; or even absence of a substantial portion of the head, as an immediate

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or proximate result of the circumstances that led to death. The major functional anatomic deficit that could be assessed postmortem was the integrity of the ligaments between the atlas and occiput, which was established by anomalous free rotation of the head in a body that was otherwise in rigor, and palpation of a discontinuity between the occiput and the atlas through the foramen magnum after the brain was removed.

Brain injuries were similarly defined as any structural or anatomic disruption of the normal configuration of the brain that could be traced proximally or immediately to the event that led to death. Such abnormalities included lacerations, hemorrhage in any site (internal, subdural, epidural, brainstem, etc.), edema, extrusion of cerebral material to the external environment through a discontinuity of the skull (e.g. one or more fractures, or significant loss of skull, head, or calvarium that would lead to concurrent loss of brain tissue), and atlanto-occipital dislocation (AOD), as described above.

Radiographs were occasionally required to find foreign objects (bullets or fragments of same), but were not used to establish skull or brain injury in decedents who were dead on arrival. In rare cases, the decedent arrived to hospital alive, and radiographs were obtained for treatment purposes, and were included in the record of the autopsy, but were not necessary for establishing our findings.

The two groups were subclassified based on manner of death, and further ranked within manner of death based on age. The cause of death in all cases was trauma caused by the incident that mandated the autopsy. The event that led to this trauma was designated. Other pertinent data were culled from autopsy, toxicology, and investigator reports. Injuries were further characterized using the abbreviated injury scale (AIS) for each body region used in the injury severity score (ISS).[5] If more than one anatomic region could be considered fatal by the AIS (score 6), both injuries were listed and scored, but the injury to the head was regarded as the immediate cause of death.

Comparisons of quantifiable data were performed using chi-square and *T*-tests.

3. Results

A total of 54 cases were recovered. All but 2 cases were dead at the scene, so no interval of survival could be established. The 2 short-term survivors are described following. While the specific brain injury may have been relatively minor in some cases of decedents with a skull fracture (e.g. a fall) compared to other decedents (e.g. MVA), the total AIS for the head/neck region regularly reached the score of 6 (fatal). The reasons for the severity of the head/neck AIS compared to other AIS areas were typically due to the degree, number, and location of skull fractures or neck injuries compared to other injuries in the AIS areas. Table 1 summarizes 34 decedents who suffered head injury including skull fractures. Table 2 summarizes 20 decedents with head injuries but no skull fractures.

All decedents had head injuries, whether they had concurrent fractures or brain injury without fracture. Most decedents with head injuries had brain injuries. All decedents with skull fractures had brain injuries except 1 case, in which the brain was too decomposed to assess. The most common mechanism of head injury in both groups was motor vehicle accidents (MVA) ($n = 30$), in which 50% had skull fractures and 90% had brain injuries.

Among decedents with skull fractures, a small majority ($n = 18$) died in accidents, the most common being MVA ($n = 15$), while a few sustained skull fractures from falls ($n = 3$). The second largest class was decedents who commit suicide ($n = 11$), of whom all sustained lethal gunshot wounds (GSW) to the head. The remaining 5 decedents were victims of homicides, of which 4 died from physical assaults and 1 died from GSW.

The external head injuries sustained by the decedents with skull fractures are summarized. Lacerations were common ($n = 29$), followed by crepitus ($n = 15$), ecchymoses ($n = 13$), hemorrhage from one or both ears ($n = 12$), abrasions and ($n = 11$).

The distribution of skull fractures was variable. Cases with multiple fractures, usually on both sides of the skull, included GSW ($n = 10$). Other sites of GSW injury were the frontal areas ($n = 1$) and temporal ($n = 1$). The other common source of multiple skull fractures was MVA ($n = 8$). In other MVA, the skull base was the identified fracture ($n = 3$), the frontal bones ($n = 2$), temporal ($n = 1$), and parietal ($n = 1$). Among falls, the skull base was involved in 3 cases, being the primary fracture in 2, an additional fracture with a large temporal fracture in 1. Among victims of physical assault, the parietal bones were most frequently broken ($n = 3$), while multiple fractures were seen in only 1 case.

The injuries to the brain that accompanied these skull fractures are also summarized in Table 1. In all but one case, the cadaveric remains were well-preserved, and could be examined thoroughly. In cases of skull fracture, brain lacerations were the most common injury seen ($n = 26$), sometimes including an AOD ($n = 4$), although this injury could occur without a cerebral laceration. Hemorrhages in different loci occurred commonly ($n = 17$), including parenchymal or pericerebral (e.g. subdural or epidural) sites. Cerebral edema was seen in many cases of skull fractures ($n = 12$), but didn't develop in all cases. Extrusion of cerebral matter through the fractures to the external environment occurred occasionally ($n = 6$). In 1 case, the body and brain were sufficiently decomposed that the brain had liquefied, and brain injuries could not be determined.

Injuries elsewhere in the body were also common ($n = 17$) including such diverse injuries as lacerations to the skin or soft tissue, lacerations to the spleen, liver, or other organs, fractures elsewhere in the body, and in 1 case, stab wounds. Such diverse injuries were most common in accident and homicide victims. Medical conditions were anatomically apparent in many decedents ($n = 14$), including fatty liver, heart disease, and a case of metastatic colon cancer. Different drugs were observed in many decedents ($n = 16$), including prescription antidepressants, painkillers, alcohol, and occasionally cannabinoids.

Most cases were dead at the scene, but 2 cases had documented periods of survival after the skull fractures occurred. In fact, 1 was lucid and under treatment for comorbid conditions before the presence of the skull fractures manifested. Curiously, both patients had been drinking heavily, and were concurrently sobering up as the skull fractures led to hemorrhage and death. One decedent was a woman who was being treated after her fall down a flight of stairs; the other was a man who was treated for injuries from a fight.

The AIS scores for each body region in decedents with skull fractures are also presented in italics in Table 1, below the descriptions of the various injuries. The presumptive cause of death in these decedents was the skull fractures and brain trauma, although in 3 cases, there were sufficient injuries in the chest region alone to cause death, while in 1 case, injury to the face was sufficient to cause death, irrespective of skull or brain injury. The mean AIS scores for each region were as follows: face, 3.29; head and neck, 6.0; chest, 0.97; abdomen 0.62; extremities 0.71; external, 0.56.

Table 2 summarizes 20 decedents with head injury but no evidence of skull fracture. All but 2 of these decedents were victims of accidents ($n = 18$). The majority were involved in MVA ($n = 16$), a small number in falls ($n = 2$), 1 homicide and 1 natural death.

Documented external head injuries in this group included lacerations ($n = 12$), abrasions ($n = 12$), or ecchymoses ($n = 6$). Bleeding from the ear was rare ($n = 1$). Intracranial or brain injuries were mostly different types of hemorrhages ($n = 13$), cerebral edema ($n = 6$), and a laceration of the brain ($n = 1$). AOD was observed in