



Closed-head injuries followed by detached brain tissue in the external auditory canals

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Abstract

We describe five cases of fatally injured males (occupational accident, car driver, pedestrian, motorcyclist and suicidal jump from great height) with one universal autopsy finding – the presence of brain tissue in one or both auditory canals. Internal examination revealed that all victims had multiple head fractures with dura lacerations. In four cases, the petrous part of the temporal bone was fractured (hinge fracture), while in one case the fracture of both the petrous part of the temporal bones and the occipital bone (ring fracture) was present. In all of these cases, considerable pressure was applied to the head, pushing brain tissue equally in all directions (due to incompressibility of the tissue). The tissue followed the path of least resistance, going through the lacerated dura into the fractured petrous part of the temporal bones and finally reaching the middle ear cavity and auditory canal. This phenomenon is almost exclusively encountered in closed-head injuries. In an open-head injury, brain tissue would be expelled through the open bone fracture and scalp wound. The presence of brain tissue in the ears could indicate a hinge or ring fracture in a closed-head injury which occurred as the result of excessive impulse force or considerable pressure applied to the head, i.e. the head was compressed and/or squeezed.

Keywords Brain tissue · Ear · Hinge fracture · Ring fracture · Head compression

Case description

Case 1 outline A 40-year-old male was fatally injured in an occupational accident. His head was squeezed between a concrete pipe and a concrete ground slab. External examination revealed the presence of brain tissue in the right auditory canal (Fig. 1a). Autopsy findings comprised multiple head fractures (including the petrous part of the temporal bone – hinge fracture) (Fig. 1b), dura lacerations, rare brain contusions, and laceration of the right temporal lobe (Fig. 1c) with detached brain tissue in the external auditory canal (Fig. 1d).

Case 2 outline A 22-year-old male was fatally injured as a car driver when his vehicle rolled over several times. Upon external examination, blood and brain tissue were found in the external auditory canals. The left temple showed a right-

sided depressed fracture (Fig. 2a). There were multiple fractures of the skull base (including the petrous part of the temporal bones – hinge fracture; Fig. 2b) with dura lacerations and detached brain tissue in the fractured petrous part of the temporal bone (Fig. 2c). The brain was with flattened gyri and narrowed sulci (Fig. 2d).

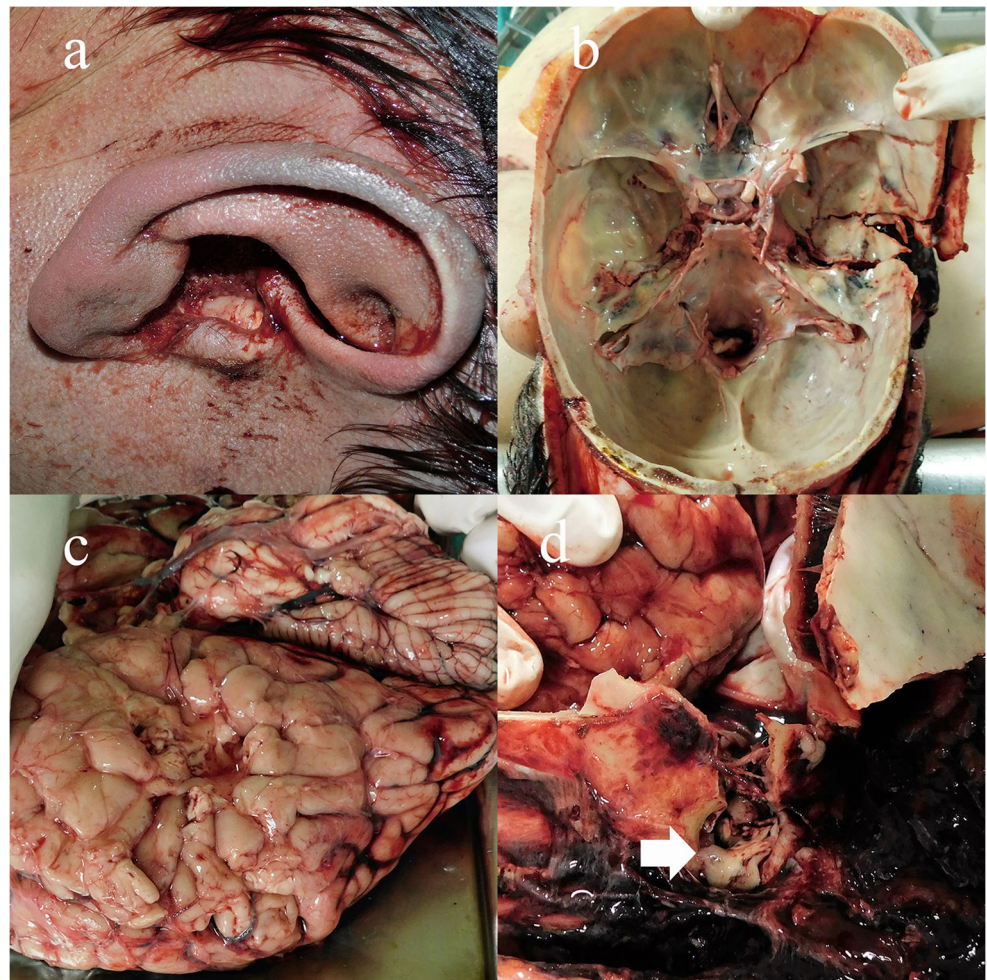
Case 3 outline A 60-year-old male was fatally injured as a pedestrian when a loader ran over him, injuring his head and trunk. The head was deformed due to side-to-side compression (Fig. 3a) and brain tissue was evident in the right external auditory canal (Fig. 3b). Multiple head fractures were present, including the fracture of the petrous part of the temporal bones (hinge fracture) with dura and brain lacerations. Detached brain tissue was found in the trachea (Fig. 3c). The victim also sustained multiple inner organ injuries and bone fractures.

Case 4 outline A 26-year-old male was fatally injured as a helmet-wearing motorcyclist (Fig. 4a) when, after collision, a truck ran over his head and trunk. The left external auditory canal showed the presence of brain tissue (Fig. 4b). His head was deformed due to side-to-side compression (Fig. 4c). Autopsy findings comprised multiple head fractures

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Fig. 1 **a** Fragments of brain tissue in the right auditory canal. **b** Fracture of the petrous part of the right and partially left temporal bone with fractured sella turcica (hinge fracture). Dura was removed. **c** Laceration of brain tissue at the ventral side of the right temporal lobe. **d** Closer view of the right external auditory canal with the brain tissue visible (arrow)



(including the petrous part of the temporal bones – hinge fracture), multiple dura and brain lacerations, as well as multiple inner organ injuries and bone fractures.

Case 5 outline A 33-year-old male committed suicide by jumping from a building about 20 m high, impacting the solid surface feet-first (Fig. 5a, b). External examination at the scene of death revealed the presence of blood and tiny brain tissue particles in the left external auditory canal (Fig. 5c). Autopsy findings comprised multiple head fractures (including the petrous part of the temporal bones and occipital bone – ring fracture) (Fig. 5d), multiple dura and brain lacerations, as well as multiple inner organs injuries and bone fractures.

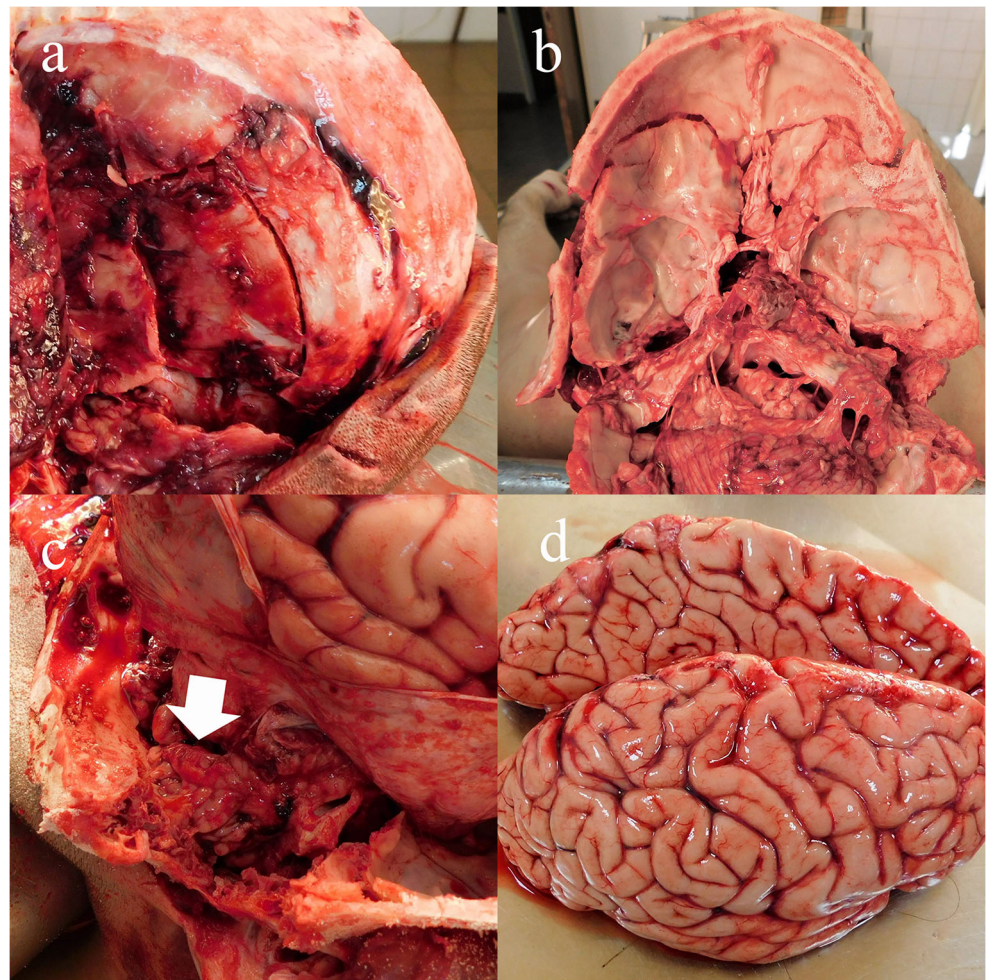
Discussion

Bleeding from the ears, nose or mouth following a closed-head injury suggests a fracture of the base of the skull. Brain tissue could be expelled through these apertures, even in the absence of external evidence of an injury [1]. The presence of brain tissue in the external auditory canal is a relatively

uncommon phenomenon, but a one that could be expected in side-to-side head compression. In those cases, the force applied to the head is considerable, resulting in excessive pressure and kinetic energy being transferred to the brain tissue. One of the mechanisms of the hinge fracture is also side-to-side head compression [1].

Many basilar skull fractures originate from impacts at the roughly same level as the skull base and the fracture lines follow predictable routes through the skull base [2]. A hinge fracture refers to a fracture that runs from side to side, across the floor of the middle cranial fossa, passing through the pituitary fossa in the midline [3]. This injury is common in road accidents and is sometimes called the “motorcyclist’s fracture”. From the site of applied force, which is usually bitemporal (latero-lateral), fracture lines lead to the separation of the petrous part of the temporal bone from the greater wing of the sphenoid and the squamous temporal bone [2], splitting the base of the skull into two. Any considerable pressure applied to the head pushes brain tissue equally in all directions, due to its incompressibility. Brain tissue then passes through the lacerated dura into the fractured petrous part of the temporal bones, finally reaching the middle ear cavity. Since this

Fig. 2 **a** Left-sided depressed fracture of the skull bones. **b** Multiple fracture lines at the skull base. Note the fracture of the petrous part of both temporal bones and sella turcica (hinge fracture). Dura was removed. **c** Detached brain tissue in the fractured petrous part of the right temporal bone (arrow). **d** Flattened brain gyri and narrowed sulci (brain swelling)



must cause a rupture in the tympanic membrane, the blood and brain tissue end up in the external auditory canal which is why they can easily be detected at external examination (as seen in all described cases). The tissue follows the path of least resistance, thus being literally “thrust into the ears” as the result of

high pressure applied on the head. This could be easily demonstrated by using a simple autopsy technique, the so called “water test” – water poured in an upwardly facing ear results in drainage from the nose and opposite ear, thus demonstrating transcranial passage [4]. The mechanism of injury could be



Fig. 3 **a** Deformed head with multiple abrasions and lacerations, indicates side-to-side compression. **b** Brain tissue in the right external

auditory canal. The ear lobe is heavily bruised. **c** Detached brain tissue in the superior part of the trachea (arrow)

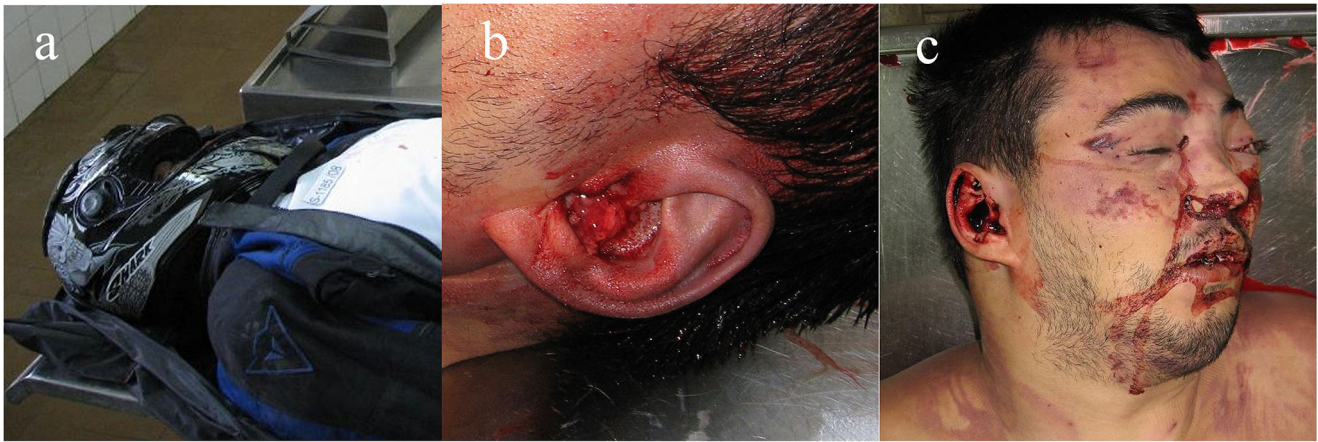


Fig. 4 **a** Fatally injured motorcyclist with his helmet on (photograph taken before autopsy). **b** Brain tissue in the left external auditory canal. **c** Head deformation due to side-to-side compression

squeezing or compression of the head, either between two solid objects (case 1) or as the result of being run over by a vehicle (cases 3 and 4). Some authors claim that these fractures do not start at the point of impact unless there is also local depressed fracturing; they are initiated at a distance due

to the compensatory deformation, but usually run back towards the impact site [3], as in case 2.

If the pressure to the head is considerable and the body of the sphenoid bone is crushed, the pieces of detached brain tissue can reach the nasopharynx, larynx and even trachea

Fig. 5 **a** Body position after suicidal jump (photograph taken from the scene). **b** Damage of the inner side of the shoes with detached soft tissue protruding through it (photograph taken from the scene). **c** Brain tissue remains drifting in a small amount of blood in the right external auditory canal (photograph taken from the scene). **d** Ring fracture of the skull base (photograph taken during autopsy)



(as in case 3). In these cases, the presence of brain tissue in the trachea should be considered a purely mechanical phenomenon (the tissue is forcefully pushed), which means that it was not a vital reaction, i.e. brain aspiration [5]. As with hinge fractures in all described cases, the fracture of the base of the skull, involving the sella turcica, provides direct communication between the cranial cavity and the airway through the sphenoid sinus situated above the posterior palate, thus permitting the blood from the base of the skull to gush into the airways [1]. Aspirated blood indicates the vitality of the head injury in these cases [1, 6].

This “brain in the ears” phenomenon is almost exclusively encountered in closed-head injuries. In an open-head injury, brain tissue would be expelled through the open bone fracture and scalp wound and not through the auditory canal. In a closed-head injury with a hinge fracture, the kinetic energy transferred from the calvaria to the brain tissue could be rather excessive and the distance between the two separated halves of the skull base so prominent that instantaneous brain swelling could occur. This is easily recognized as the flattening of the gyri and narrowing of the sulci, as in case 2. In such a closed-head injury, the mechanism of gyri flattening could be the same as in an open craniocerebral injury with brain evisceration: it could represent a biomechanical reaction (i.e. decompression) due to a sudden decrease in intracranial pressure and might be considered a vital reaction, along with other signs of vitality, such as blood aspiration [7].

Sometimes, the brain tissue fragments can be very small and hard to observe with the naked eye, as in case 5, when tiny tissue remains drifted in a small amount of blood in the external auditory canal. In this particular case, the petrous parts of the temporal bones were fractured within the ring fracture. The ring fracture characteristically extends beyond the petrous part of the temporal bone, through the squamous parts of the temporal and occipital bones, more or less encircling the foramen magnum at a variable distance [8]. In the suicidal jump from height described in case 5, the patient impacted the solid surface feet-first; therefore the energy was transmitted up the spinal column and the upper vertebrae, toward the foramen magnum and the brain: the spinal column was rammed into the base of the skull, causing the ring fracture [2, 3, 9]. Such high impulse force, transmitted from the feet to the skull base, produced pressure great enough for the blood and tiny brain tissue fragments to be thrust into the ears.

In closed-head injuries, the presence of brain tissue in the external auditory canal indicates a hinge fracture (usually including petrous parts of both temporal bones) with dura laceration and separation of the skull base into halves. This phenomenon also demonstrates that the head injury occurred because excessive impulse force or considerable pressure was applied to the head, i.e. the head was compressed and/or squeezed.

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Compliance with ethical standards

Conflict of interest The authors hereby declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

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