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Utility of post mortem computed tomography in clivus fracture diagnosis. Case illustration and literature review

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ABSTRACT

Clivus fractures are usually associated with head blunt trauma due to traffic accident and falls. A 23 – year-old man died immediately after a smash-up while he was stopping on his motorcycle. Post-mortem Computed tomography (PMCT), performed before autopsy, revealed a complex basilar skull base fractures associated with brainstem and cranio-vertebral junction injuries, improving the diagnostic performance of conventional autopsy. Imaging data were re-assessable and PMCT offers the possibility to perform multiplanar and volume rendered reconstructions, increasing forensic medicine knowledge related to traumatic injuries.

1. Introduction

The clivus is the strongest bone of the skull base, provides mechanical support for the cranial vault and protection for the brainstem and adjacent major vascular structures. Despite its deep location is very susceptible to related fractures with consequent high mortality rate or poor outcome for survivors [1,2].

Clivus fractures may be observed in a serious head blunt trauma due to traffic accidents and falls and the mortality rate and/or poor prognosis of the survivors is mainly due to concomitant injuries of the brainstem [3–8], lower cranial nerves [1,9,10] and vertebro-basilar artery [1,11–14].

In general, clivus fractures are difficult to detected in both conventional and digital radiography, instead cross-sectional imaging techniques as CT may detect fracture and add autoptic finding.

As reported by Corradino et al. [15], the clival fractures are classified according their CT imaging as longitudinal, transverse and oblique. Longitudinal types are associated with the highest mortality (67–80%), related to the concomitant injuries of the brainstem, lower cranial nerves and vertebro-basilar artery. The oblique or transverse clival fractures have been often implicated in damage of the carotid arteries [1,15,16].

The use of post mortem CT (PMCT), and the subsequent multiplanar and volume rendering reconstructions techniques, allows to obtain non-invasive, objective operator-independent imaging data set that could be also reviewed by others specialists. PMCT with multiplanar (MPR) 3D maximum intensity projection (MIP) and volume rendered reconstructions images (VR), implement forensic knowledge related to traumatic injuries [17–19].

2. Case history

We report a case of a 23-year-old man who died immediately after a smash-up while he was stopping on his motorcycle. It was not possible to exclude the presence of the helmet that was found far from the body in the accident site. The cause of death was related to a complex fracture of the skull base with brainstem and severe cranio-cervical injuries.

3. Post mortem CT: technique and findings

The post mortem interval between PMCT and the medico legalautopsy was about six hours.

PMCT was performed with a 128 slices MDCT scanner (Somatom Definition AS®, Siemens Healthcare Erlangen Germany). Volume acquisition was performed with thin collimation of 1 mm. Scan parameters were a tube voltage of 120 kVp, with an effective tube current of 120–160 effective mAs, gantry rotation time of 0.5 s, beam pitch of 1.2 and table speed of 46 mm per gantry rotation.

Images were reviewed using PACS (Elephant.net suite® AGFA HealthCare N.V., Belgium) and dedicated workstation (Singovia® Siemens Healthcare Erlangen Germany).

During the reading sessions, axial and MPR images were reviewed with a soft tissue and bone edge window manual adjustments made when needed.

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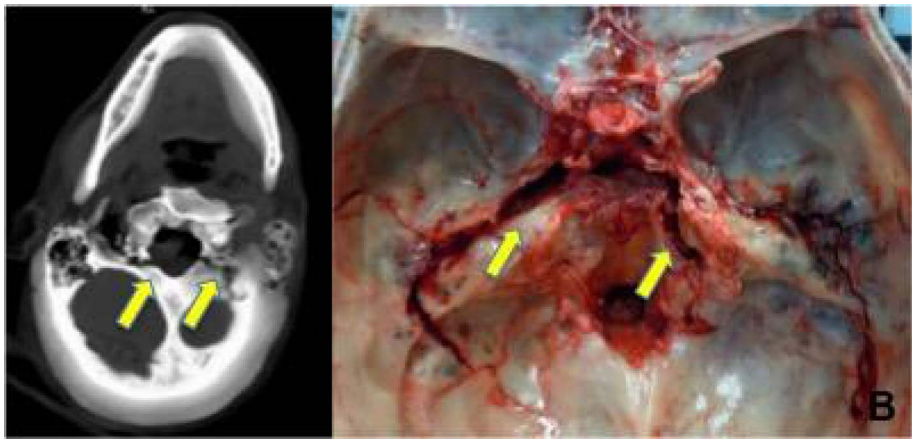

Fig. 1. 3D-MIP axial reconstruction image looking ideally the skull from the neck (A) focused on skull base, clearly shows bilateral clivus fracture (arrows) as conventional autopsy (arrows) (B).

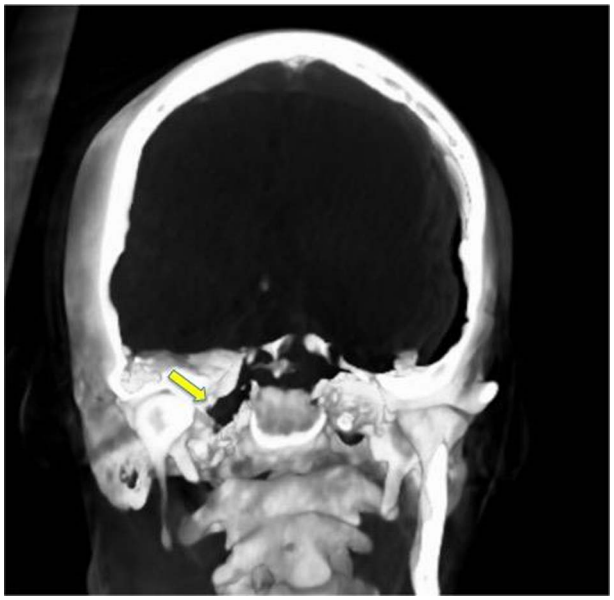

Fig. 2. 3D-MIP coronal reconstruction comprehending the skull from the base to vertex, showing clivus fracture with high-confidence in representing bone extremities detachment, particularly on the right side (arrow).

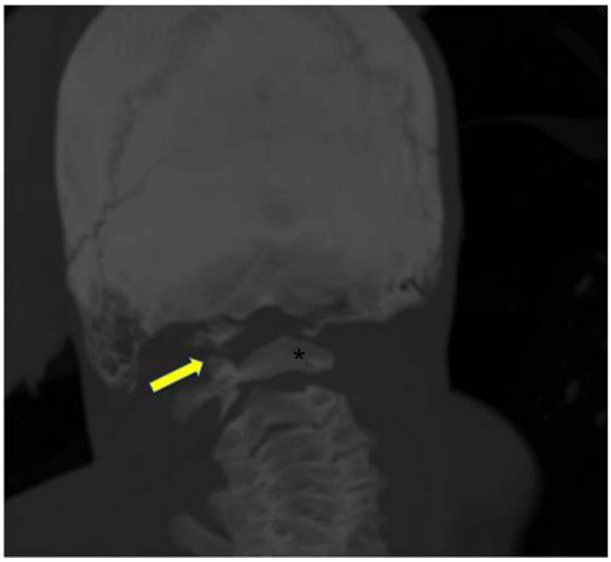

Fig. 3. VR coronal skull reconstruction with posterior view, showing clivus fracture (arrow), separation between skull base and first vertebra (*), abnormally rotate, between first and second vertebra, with consequent odontoid process fracture.

3D-MIP and VR three-dimensional reconstructions were performed in the skull and cranial base. Data set of images obtained was then compared with conventional autopsy report (Figs. 1–4).

PMCT showed fracture of the occipital foramen reaching anteriorly to the sphenoidal clivus and the mastoid on the left. The contralateral side of the occipital foramen was also involved. Fracture of plank head from the medial third of the occipital suture to left parietal bone near orbital cavity, was identified. The PMCT scan also allowed to identify odontoid process fracture, left atlanto-occipital diastase and anterior dislocation of C2. Nevertheless, the cervical spine was carefully explored to exclude the presence of haemorrhage due to direct trauma.

4. Autopsy findings

The body was 168 cm in length weighing 63 kg. At external examination only few bruises were found in the back on the left. The macroscopic examination of the brain showed diffuse oedema, (brain weight: 1260 g). Subarachnoid haemorrhage of the base and a traumatic laceration of brainstem were observed (Fig. 5). In serial cross-sections of the brain there was no evidence of intra-parenchymal haemorrhages.

A complex skull basilar fracture (Fig. 1) was detected in the PMCT investigation. Cervical spine was carefully explored and sectioned to exclude the presence of superficial haemorrhage due to direct trauma. Other organs did not show any significant abnormality.

5. Histological findings

There were haemorrhage and oedema around the brainstem laceration. No pathological evidence other than congestion was found.

6. Toxicological analysis

Neither drugs nor ethanol were detected by screening toxicological analysis.

7. Discussion

There is some evidence on effectiveness of digital autopsy in determining the cause of death due to blunt trauma [20–23]. Noteworthy, Kasahara et al. [24] reviewed 339 forensic autopsy cases observed that causes of death could be determined based on PMCT findings alone in 7% of the cases, based on suggestive PMCT findings with additional information in 54% and could not be determined in 38%.