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CASE REPORT

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Postmortem Non-Invasive Virtual Autopsy: Death by Hanging in a Car

ABSTRACT: A body was found behind a car with a noose tied around its neck, the other end of the rope tied to a tree. Apparently the man committed suicide by driving away with the noose tied around his neck and was dragged out of the car through the open hatchback. postmortem multislice-computed tomography (MSCT) and magnetic resonance imaging (MRI) indicated that the cause of death was cerebral hypoxia due to classic strangulation by hanging, and not due to a brainstem lesion because of a hang-man fracture as would be expected in such a dynamic situation. Furthermore, the MRI displayed intramuscular haemorrhage, bleeding into the clavicular insertions of the sternocleidomastoid muscles and subcutaneous neck tissue. We conclude that MSCT and MRI are useful instruments with an increased value compared with 2D radiographs to augment the external findings of bodies when an autopsy is refused. But further postmortem research and comparing validation is needed.

KEYWORDS: forensic science, virtual autopsy, non-invasive autopsy, hanging in a car, MRI, CT, postmortem, strangulation

The radiological imaging techniques such as CT (computed tomography) and MRI (magnetic resonance imaging) have achieved enormous advances in the past decades (1–8). The postmortem CT and MRI examinations have already been introduced in the field of postmortem diagnostics (9–16). The question has arisen repeatedly of whether these new virtual autopsy techniques can replace or enhance the classic autopsy (17–25).

In Switzerland, as well as in several other European countries, the district attorney may request either an external examination of the body, in Switzerland referred to as a "legal inspection," or an autopsy, for which the exterior as well as the inner organs are examined. In every case which is designated as being an unnatural or an unclear death by the death certifying physician, a legal inspection is ordered by the district attorney. The aim of this legal inspection, which is performed by forensic pathologists or specially trained practitioners, is to determine the manner of death, the time of death, and if possible, the cause of death by a thorough external examination. For this, the body must be stripped naked and cleaned if necessary. Other tampering with the corpses integrity, as shaving or removing body parts is, unless explicitly requested for by the district attorney, prohibited. If the manner of death remains unclear, or the involvement of a third party is possible or likely, the district attorney will then request an autopsy. This decision to further examine a case by autopsy is the sole responsibility of the district attorney, who generally is advised by the involved forensic pathologist. These autopsies are performed without consent of the next of kin. Rarely, and only in certain cases where an involvement of a third party is highly unlikely, the district attorney will bow to the relatives refusal towards an autopsy. This opposition on behalf of the next of kin is ever increasing. Thus, a legal inspection with an additional CT and/or MRI scan may be a viable compromise to further evaluate cases non-invasively in the future.

We describe the use of CT and MRI examinations as an adjuvant method for the classic legal inspection in an unusual case of strangulation when an autopsy was refused. This case report does not compare radiological findings with autopsy findings, but highlights a possible use of such adjuvant methods with a legal inspection to further evaluate such cases.

Case Circumstances

A body was found behind a car with a noose tied around his neck, the other end of the rope tied to a tree (Fig. 1). The noose on the neck was a slip knot that remained tight and strangulating when the corpse was found. The car engine was off, the car keys in the starter lock in the "on position" and the lights on. The car position indicated that it was stopped by a frontal collision against a stack of logs approximately 15 m away (Fig. 1), thus choking the motor off. The hatchback was open and all further doors were initially closed. The drivers seat as well as the left back seat were bent backwards and the damaged head rest of the driver seat and the storage shelf were found between the corpse and the car on the forest soil. The circumstances at the scene and preliminary examinations of the corpse were indicative of suicide. Apparently, the man committed suicide by driving away with the above-mentioned noose tied around his neck and was dragged out of the car through the open hatchback. Supporting this assumption, a suicide note was found within the deceaseds' accomodation later on. As in all forms of a compressing force towards the neck, such as hanging,

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FIG. 1—*Overview of the body lying roughly 15 m behind the car that stopped at a stack of wood. Between the corpse and the car the damaged headrest and storage shelf are seen (arrows).*

strangling and throttling, the main involved mechanism is a strangulation. In this case, as the own body weight was involved in the strangulation process, we referred to this as "hanging". The cause of death was not immediately clear upon external examination; possible causes of death were cerebral hypoxia due to strangulation by hanging or a brainstem lesion because of a hangman-fracture (26,27).

Material and Methods

Before radiological cross-section examination by MSCT and MRI the body was wrapped inside two artifact-free body bags (Rudolf Egli AG, Bern-Switzerland). MSCT scanning was executed on a GE Lightspeed QX/i unit (General Electric Medical Systems, Milwaukee, WI) with 4 × 1.25 mm collimation. The duration of MSCT scan in our case was approximately 10 min. Using a workstation (GE Advantage Windows 4.1), it was possible to calculate two-dimensional sagittal and coronal reformations and three-dimensional reconstructions (8). For MRI (1.5 Tesla Sigma Echospeed Horizon unit version 5.8 from General Electric Medical Systems Milwaukee, WI) we used T1-weighted spin echo (SE), T2-weighted fast spin echo (FSE), short tau inversion recovery (STIR), gradient recalled at steady state (GRASS) and true fast imaging with steady state precession (true FISP) sequences. MRI study required roughly 90 min and was performed to the head, neck and thorax.

All radiological images were interpreted by board-certified radiologists. The costs of the performed imaging within the current research stage amounted to about two to three times as much as a traditional autopsy would.

Results

External Examination

The tight noose around the neck resulted in a clearly visible ligature mark encompassing the whole neck circumference with abrasions located predominantly on the front side of the neck

FIG. 2—*Circular abrasion and ligature mark.*

FIG. 3—*MSCT sagittal reconstruction: No fracture of dens axis is seen.*

(Fig. 2). No congestive haemorrhages were detected in the mucosal linings of the eyes, mouth and ears.

Radiological Examination using MSCT/MRI

Based on cross-sectioned CT and MR technology, in our case the injury pattern to the neck was documented non-destructively and non-invasively (Figs. 3–7). MSCT sagittal reconstruction (Fig. 3) demonstrates that there was no fracture of the dens axis or the atlas body. A MSCT 3D reconstruction of the cervical spine (Fig. 4*a*) documented the lack of osseous lesions further. But a fracture of the hyoid bone could be detected (Fig. 4*b*). The MSCT 3D reconstruction using surface rendering SSD visualised the ligature mark (Fig. 5). Of great importance is the intramuscular haemorrhage and the bleeding at the clavicular insertions of the sternocleidomastoid muscles (28,29), the haemorrhage into the subcutaneous neck tissue and the platysma seen in the MRI sequences (Fig. 6,7). The MRI sagittal T2 weighted images (Fig. 7) ruled out any osseous bruising of the spine, injury to the spinal cord, ligaments or soft tissue haemorrhage above the spinal cord. However, the signal alteration of the subcutaneous tissue indicated a soft tissue haemorrhage in the region of the ligature mark. The MRI findings on the one hand demonstrate the enormous energy involved with the jerking of a human out of a car, on the other hand suggest, due to the extent of the cervical muscle haemorrhages, that the victim was alive when he suffered the injuries.

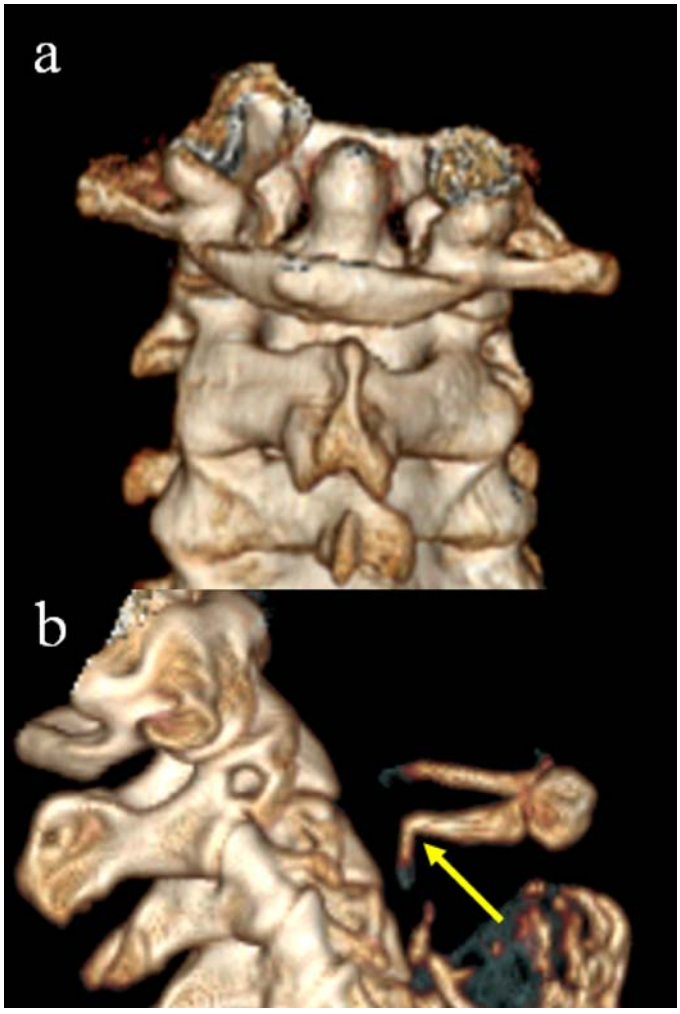

FIG. 4—*MSCT 3D-Reconstructions of the cervical spine: No vertebral fractures were seen (a). But a fracture of the right greater horn of the hyoid bone (arrow) becomes visible (b).*

Discussion and Conclusion

The use of radiological examination techniques has a history of over 100 years in forensic medicine (30). The main disadvantage of

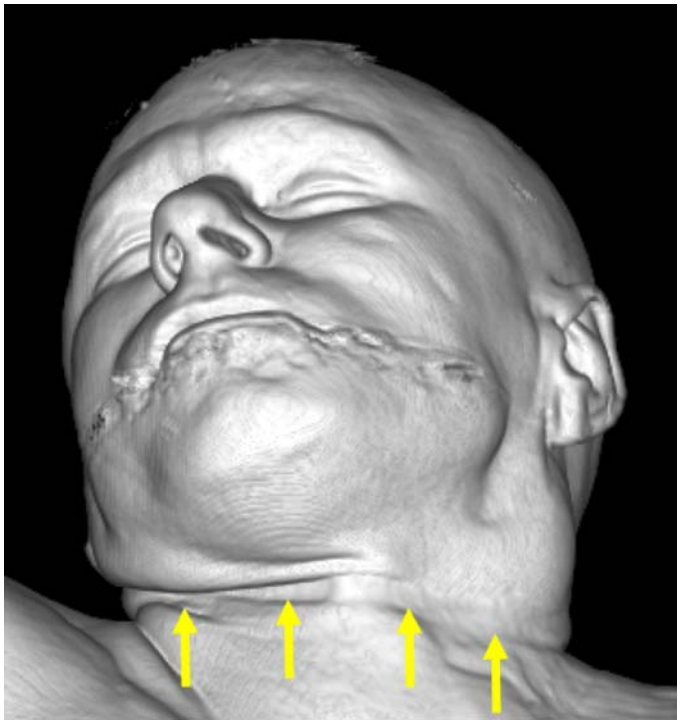

FIG. 5—*MSCT 3D-Reconstruction surface rendering: the ligature mark is clearly depicted (arrows). Note some MSCT artefacts due to dental work with increased density on the lower lip and both cheeks.*

FIG. 6—*MRI transversal T2 weighted image: Note the intramuscular haemorrhage and the bleeding at the clavicular insertions of the sternocleidomastoid muscles, the haemorrhage in the subcutaneous neck tissue, the platysmal haemorrhage (bold arrows) and the ligature mark (fine arrows).*

FIG. 7—*MRI sagittal T2 weighted image: No osseous bruising of the vertebra, no cervical spine ligament injury, no injury of the cervical cord or soft tissue bleeding above the cervical spine was shown. Note the signal alteration of the subcutaneous neck tissue (bold arrow) due to haemorrhage and the ligature mark (fine arrows).*

conventional radiographs is, that this technique reduces a 3D body information onto a 2D plain film, thus loosing the forensic important 3D spacial resolution. In the past few years, several groups have evaluated and validated postmortem CT and MRI examinations (9–13,17–22,31–34). Although the district attorney requested only an external examination (in Switzerland a so-called legal inspection), we were able to answer further important forensic questions, i.e., whether death occurred due to cerebral hypoxia due to strangulation by hanging or possibly due to a brainstem lesion because of a hangman fracture. The postmortem CT and MRI examination showed no skeletal fractures or damage to the brainstem or hindbrain. Especially, a fracture of the dens could be ruled out. A fracture of the hyoid bone became visible. In contrast to plain postmortem radiographs the MRI examination, which modality specific has a higher resolution of soft-tissues, was able to show haemorrhages into the soft-tissue of the neck, a well known finding in events like this (28,29,34).

We are aware of the possible danger of misinterpretation of postmortem radiological findings, especially when no autopsy, the current gold standard for morphological examinations, is performed. In this presented case, the relevant postmortem radiological findings such as gross bleedings, and negative findings such as intact vertebral bodies, well known from clinical radiology and easy to diagnose, were presented. But we conclude that postmortem imaging by CT and MRI scans may be very useful in the future as a viable compromise between a legal inspection and an autopsy in cases where an autopsy is opposed to due to religious reasons or opposition on behalf of the relatives or refused by the court system practises, to deliver additional relevant findings non-invasively. We believe that postmortem imaging with MSCT and MRI in so-called legal inspections is a useful adjuvant examination technique, and because of 2 and 3D reconstruction possibilities, is superior to classic radiology.

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