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CASE REPORT

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Radiographic magnification in the diagnosis of traumatic lesions of the hyoid-larynx complex

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Abstract This paper proposes the use of radiographic magnification to detect the effects of neck traumas. This technique, both fast and economical, has proved to be particularly useful in all those cases where post mortem examinations failed to detect valid evidence of lesions of the hyoid-larynx complex. This is the case with corpses in an advanced stage of putrefaction where death occurred as a result of pressure or when a soft object is placed between the victim's neck and the assailant's hands. The radiological study was performed "on site" on four cases of medicolegal interest and its potential was confirmed.

Key words Direct magnification · Radiographic magnification · Traumatic lesions of the neck · Hyoid-larynx complex

Introduction

In medicolegal terms, the diagnosis of manual or ligature strangulation or airway occlusion is established both on the grounds of traumatic lesions at the skin of the neck – abrasions, bruising, petechiae, scratches, etc – and on the histological study of the superficial and deep structures of the neck, so that signs of haemorrhagic infiltration, interpretable as the body's response to the exertion of external forces, may be detected [1, 2].

However, this kind of study cannot be performed in a number of cases. In corpses with advanced stages of putrefaction, for example, it is rarely possible to distinguish specific lesions from transformative processes. Similarly, death occurring immediately after exertion of pressure where death is immediate – as is the case with a commando-punch or a karate-chop – does not give rise to evident vital reactions [3]. Furthermore, it is well known that death by asphyxia preceded by agony or convulsion may cause haemorrhages in the laryngeal muscles and in the loose tissues of the neck, which creates a somewhat ambiguous macroscopic situation [4].

In these cases, the use of radiological evidence can be very helpful to formulate or exclude the diagnosis of strangulation or airway occlusion or direct and indirect traumas. Analogously the radiological evidence was used also to display gunshot wounds [5] or foreign particle in the skin [6].

Among the most recent work on the subject we would like to draw attention to the paper by Kunnen et al. [7], which describes the use of semi-microradiography of the larynx in a case of death in a road accident with fracture of the cervical spine at the level of C6 and in two cases of hanging, one suicide and one homicide. In all these cases, the radiographic examination revealed extensive fractures of the hyoid-larynx complex. Gordon et al. [8], using a plain radiographic examination detected fractures of the hyoid bone and of the thyroid cartilage and additionally a case of post-mortem hyoid bone fracture which had occurred during autopsy.

Radiographic investigation using a new-generation mammographer proved to be essential for understanding the four cases reported in our study.

Case reports

Case 1

On 13/04/96 the corpse of a 35-year-old woman was found in her flat. The woman had last been seen by her family 3 days earlier. The corpse had reached a stage of chromatic putrefaction, which extended to the face, the thorax and upper limbs. In the laryngeal region, there was a small, 5 cm uninterrupted groove, which affected only the left side. The state of putrefaction and the initial shredding of

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the skin made it impossible to detect other lesions. The post mortem examination of the neck structures failed to reveal any signs of violence since putrefaction had altered the colour of the skin and muscles.

Case 2

On 15/09/96 a police patrol was called to a private home. Neighbours had called the police because of the noxious smell emanating from a flat. Inside, a corpse in an advanced state of putrefaction of a 37-year-old woman was found lying face down on a bed. The victim's brother, who suffered from mental disorders and who also lived in the flat, declared that he had not seen his sister go out for about 54 days. In an armchair in the bedroom where the corpse was found, there was a bottle of rum and some antidepressants. The deceased suffered from depressive states. At first the brother was suspected, because of his failure to notice the death despite living in the same flat. The post mortem did not enable us to establish or rule out the use of violence and toxicological examinations revealed the presence of high levels of alcohol and barbiturates in the stomach contents.

Case 3

On 25/11/96 a Maltese ship, which had reported having a deceased member of the crew on board, arrived in the port of Trieste. The Captain had declared that a 35-year-old Philippine sailor had disappeared at 7:00 on 25/11/96. He had last been seen by another member of the crew at 6:30. At 8:40 a merchantship had spotted a man in the sea, but all efforts to resuscitate him were vain, as he was already dead. A life-boat brought him aboard the Maltese ship, which had in the meantime changed its route and was sailing towards the merchant ship. The autopsy revealed signs of asphyxia from drowning. However, a small haemorrhagic infiltration in the neck region was also noted, which could give rise to suspicion of some kind of violence.

Case 4

On 03/01/97 a Police patrol was called to a private home where they found the corpse of a 49-year-old man lying on a bed in the flat. The caller had said that he had murdered the man and had also described the position of the corpse. However, he later denied everything. On-site examination of the corpse revealed a small purplish bruise immediately below the external corner of the right eye; there were no petechiae under the conjunctivae, there were minute abrasions and bruises on the nose, but no notable evidence of fractures. A dark purple bruise was noted on the left upper lip mucosa, near the corner of the mouth and there were multiple dark purple bruises on the medial surface of the left arm. The autopsy revealed only very slight bruising of the neck muscles. The high fluidity of the blood indicated possible death by asphyxia.

Materials and methods

Our study is based on four cases examined over a 6-month period; where two of the victims were female and two male and the ages ranged from 34 to 49 years. In all four cases, the tongue and the hyoid-larynx complex were excised at autopsy using Gordon's technique as follows: after mobilisation of the tongue, the pharyngeal tissues were dissected from behind, forwards and laterally and then carried distally without exerting any traction whatsoever on the structures of the hyoid-larynx complex. The tongue and the hyoid-larynx complex were then cut free by separating the tongue from its attachments to the soft palate and by cutting across the trachea below the cricoid cartilage. With sharp-pointed scissors, the remnants of the pharynx and the oesophagus were dissected from the dorsal wall of the hyoid-larynx complex. The structures were fixed in 10% formalin for about 12 h, and then placed on a cloth laid over the mammographer magnifier.

We agree with Gordon on the necessity of following this procedure for isolating the hyoid-larynx complex since in situ radiographic examination of the neck does not allow identification of the cartilage structures of the larynx or the hyoid bone because these are obscured by the greater radio-opacity of the cervical vertebrae.

The anatomical specimen was examined radiographically with dedicated mammographic equipment: a mammographer with 0.1 mm microfocal spot (Senographe DMR-GE Medical Systems Italia), Trimax T2 M cassettes with a single rare-earth intensifying screen 5 (3M) combined with single-emulsion mammographic film HM2 (3M) and dedicated film processor Trimatic M Plus (3M). Direct magnification was then performed with a $\times 1.8$ magnification ratio and a focus-film distance of 65 cm. Exposure was set manually with exposures ranging bewteen 23 and 25 Kv and between 25 and 45 mAs, depending on the state of fixation and the thickness of the anatomical specimen. Orthogonal and, in some cases, oblique views were taken.

Fig. 1 Evident fracture of the right lamina of the thyroid cartilage, with a moderate diastasis (A-P view)

Results

Case 1: evident fracture of the right lamina of the thyroid cartilage, with a moderate diastasis (Fig. 1). Finding compatible with a traumatic lesion to the neck.

Case 2: mild calcification of the thyroid cartilages. Anomalous calcification of the left sternohyoid muscle (Fig. 2).

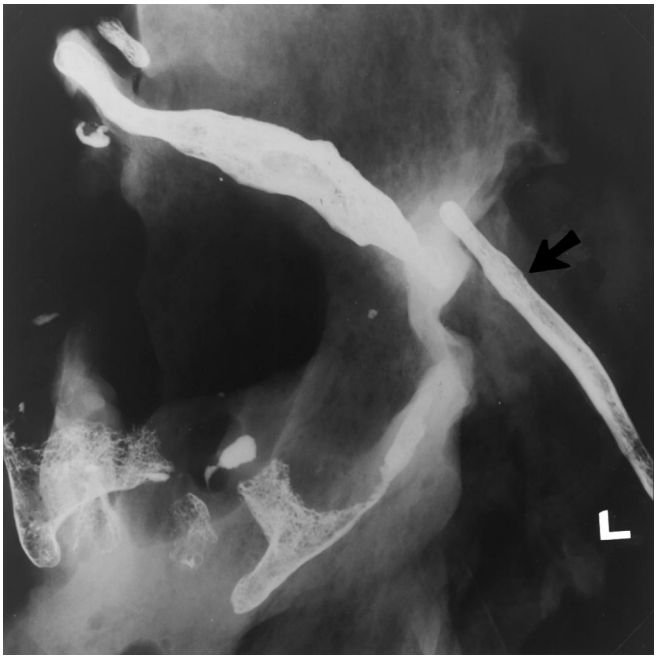

Fig. 2 Mild calcification of the thyroid cartilages, anomalous calcification of left stylo-hyoideus ligamentum (A-P view)

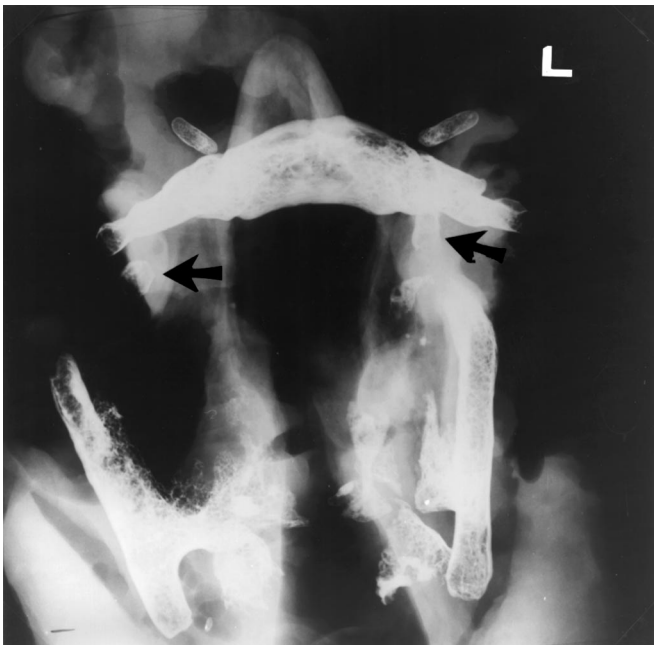

Fig. 3 No evident fractures, evident calcifications of the cartilago triticea (A-P view)

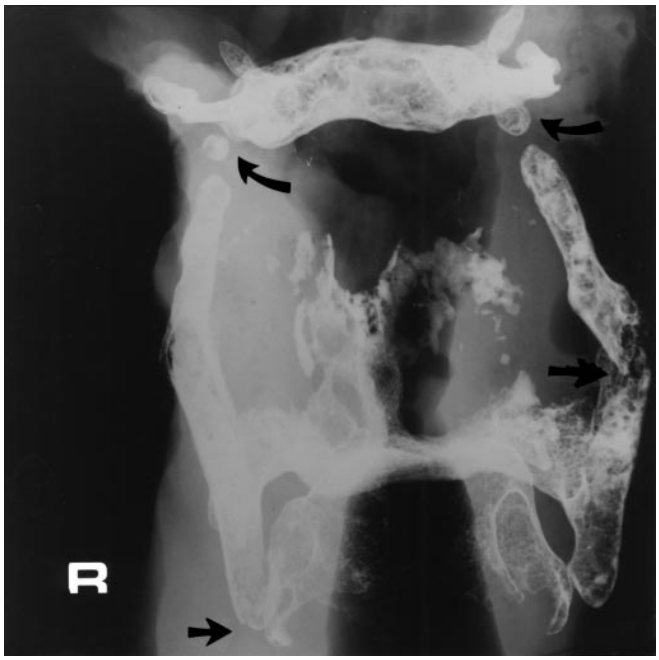

Fig. 4 Fracture of the left superior thyroid cartilage horn (arrow). Infraction of the tip of the right thyroid cartilage horn (small arrow). Evident calcifications of the cartilago triticea (curved arrows) (A-P view)

Case 3: no evident fractures. Evident calcifications of the cartilago triticea (Fig. 3).

Case 4: fracture of the left superior thyroid cartilage horn. Infraction of the tip of the right thyroid cartilage horn. Evident calcifications of the cartilago triticea (Fig. 4). Finding compatible with a traumatic lesion to the neck. The murderer later confessed he had suffocated the man, who was drunk, by pressing a cushion against his face. This explains the scarseness of marks on the neck.

Discussion

Caudalwards from the cranium, the hyoid-larynx complex is made up of the hyoid bone, thyrohyoid membrane, thyroid cartilage, cricothyroid membrane and cricoid cartilage. The two horns of the thyroid cartilage and those of the hyoid bone are the most delicate areas of the hyoid-larynx complex; fractures of the wings of the thryoid cartilage and of the cricoid cartilages are less frequent [9]. Neck traumas, such as strangulation, in subjects with calcified thyroid and cricoid cartilages result more frequently in fracture of the horns of the thyroid cartilage and less frequently in fracture of the hyoid bone horns. This phenomenon was noted by Simpson [10] when he examined 25 cases of strangulation and found that 20 had fractures of thyroid cartilage horns and only one had fractured the hyoid bone horns. Young subjects are not generally prone to fractures of the thyroid cartilage since it has not yet calcified and is therefore more elastic [11].

The larynx has a relatively low radiographic contrast which may, however, be enhanced by examining the anatomical specimen using a mammographer with low energy radiation, as this ensures good visualisation of small thin objects with low radio-opacity. The advantages of magnification are well known in mammography and pertain mostly to the quality of the images i.e. an increase in contrast and definition, and noise reduction. These factors make for a better perception of the finer details, which means that the information content of the images is maximised and the accuracy of the diagnosis improved. Therefore, apart from showing the hyoid bone, this technique offers a good radiographic visualisation of the laryngeal cartilages and allows detection of any traumatic alterations of these structures.

Direct magnification, performed as described, proved to be very useful in two cases where the state of putrefaction made it impossible to rule out or confirm the presence of traumatic lesions to the neck. In the third case it has been able to exclude, in the presence of only slight infiltrations in the neck muscles but in the absence of cutaneous lesions, that the death was due to traumatic lesions to the neck following assault by another person. The cause of these slight lesions can be accounted for the fall in the sea from the upper deck of the oil-tanker. In the fourth case it demonstrated the fracture of the thyroid cartilage horn, even though there were only very slight marks on the neck tissues.

It should be stressed that this radiological examination is very easy to perform. The procedure is the same as normally used for mammographic examinations and is very fast (no more than 10 min elapsed between taking of the X-ray and reading it) and economical (it costs no more than a mammogram).

It is also important to note that our examinations only required equipment which is nowadays commonly found in any centre where mammography is performed, therefore the widespread presence of mammographers makes it possible to examine cases of medicolegal interest basically anywhere.

The films, as well as the anatomical specimen – intact and properly fixed – can then be preserved for any length of time. This implies that each film may be re-examined by a panel of experts, for instance at the various stages of a legal proceeding, or that the specimen can be X-rayed again with new-generation machines, for example in the event that the mammographic equipment previously used has become old-fashioned or obsolete.

The technique used for excising the hyoid-larynx complex is particularly important, especially when it is impossible to detect traces of macroscopic haemorrhagic infiltration or other signs indicating, to some degree of probability, that the lesion was caused by an external force. This the case, for example, with corpses in advanced state of putrefaction, where post mortem lesions are difficult to distinguish from ante mortem lesions.

We must emphasise that radiological examination must be correlated to the anatomical specimen and to the corpse by indicating precisely the anatomical site of the lesion and comparing the radiographic observations with the autopsy findings and with circumstantial data. In terms of differential diagnosis, when reading an X-ray of the hyoid-larynx complex, one should always bear in mind the phenomenon of senile calcification. Calcification of the thyroid cartilage and of the synchondrosis between the greater horn and the body of the hyoid bone may easily resemble a fracture. However, the experience of the examiner, who should be a radiologist with a good knowledge of medico-legal issues, and the absence of trauma to the skin of the neck should lead to rule out violence. In this light, the time when the cartilages calcified is of great importance. We would like to draw attention to Gamsu's work [12]. Using CT, he showed that the thyroid cartilage is calcified in most adults over the age of 30, although symmetry of the calcification may vary considerably. Anson, on the other hand, states that calcification of the thyroid and cricoid cartilages and of most of the arytenoid cartilages begins at the age of 20 [13]. In elderly people, as Gamsu showed by using CT on living subjects, the cartilages are completely calcified. Finally, according to Keen and Wainwright the cricoid cartilage starts a slow process of calcification from the age of 20 which is completed by the age of 61 [14].

Other accessory cartilages have also been described, namely cartilago triticea – 'triticea' means 'wheat' and this cartilage resembles a grain of wheat – which, as suggested by Gordon et al. [8], frequently occurs in each of the lateral thyrohyoid ligaments which form the posterior borders of the thyrohyoid membrane, and connect the tips of the superior cornua of the thyroid cartilage to the posterior ends of the greater cornua of the hyoid bone. The cartilages may undergo calcification or ossification and may simulate fractures of the upper ends of the superior cornua of the thyroid cartilage.

It must again be emphasized that the experience of those reading the radiological examination is of great importance. Because these calcifications are very frequent in adults, we believe that non-conservative examinations, such as microdissection of the hyoid-larynx complex, should be avoided: in the case of asymmetrical or accessory calcifications, dissection makes the data very difficult to interpret. Furthermore, it would be impossible to reconstruct the anatomical relationship formed by the cartilages, and any future radiological examination would become useless. This is all the more true if we consider the scarse diagnostic value of a microfracture, which would in any case be clearly detected by radiological examination. It must be stressed that, apart from not providing any decisive elements in the case of anomalous cartilages, inopportune dissection would make it impossible to repeat the examination. In agreement with Knight [2], we wish to recall that "bleeding is therefore a 'one-way' criterion: if there is no haemorrhage, the fracture must be post-mortem, but is there is a small bleed, then the lesion can be either ante-mortem or post-mortem. On the other hand, it must again be emphasised that the solitary finding of a fractured laryngeal horn even with slight associated bleeding, is not in itself sufficient evidence of ante-mortem trauma to the neck".

In conclusion the Authors believe that in cases where the corpse is at an advanced state of putrefaction or where there is circumstantial evidence indicating death from direct or indirect traumatic lesions to the neck, the technique of direct radiographic magnification of the hyoid-larynx complex using mammographic equipment may prove very useful for medicolegal investigations. In the case of suspicious lesions on the neck, radiological examination may constitute a useful addition to the usual post mortem examinations, and sometimes even provide decisive elements.

This radiological examination is fast, easy to perform, inexpensive, reproducible and potentially highly informative, all features which make it an excellent tool for investigation which should always, however, be used in combination with the more conventional post-mortem procedures.

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