Int J Legal Med (2003) 117 : 10–13
DOI 10.1007/s00414-002-0300-4

ORIGINAL ARTICLE

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Intracartilaginous haemorrhagic lesions in strangulation?

Received: 17 October 2001 / Accepted: 24 January 2002 / Published online: 3 December 2002

Abstract This case control study was designed to investigate if laryngeal haemorrhages occur in cases of strangulation and whether these lesions are specific to strangulation. In the study 30 larynxes from victims of fatal strangulation were examined (7 cases of manual strangulation, 12 cases of ligature strangulation, 11 cases of combined manual and ligature strangulation). The control group comprised 40 cases of death without any neck injuries and another group consisted of 5 cases of death caused by trauma with findings of non-strangulation neck injuries. In all the groups, only four solitary haemorrhages (two cases, one control, one non-strangulation neck injury) were observed that did not occur in the proximity of areas of blood accumulation. The results of our investigation suggest that histological evidence of blood accumulation or of haemorrhages in thyroid cartilage is not a reliable criterion to distinguish between haemorrhagic lesions due to strangulation and other types of blood accumulation or artefacts.

Keywords Strangulation · Pressure on the neck · Intracartilaginous laryngeal haemorrhages · Larynx

Introduction

In some cases autopsy findings are insufficient for a diagnosis of death by strangulation [15]. Therefore, additional examinations are used to detect specific morphological changes in lung tissue, neck soft tissues, larynx, and hyoid bone [5, 9, 10, 20, 21]. Macroscopic hyoid or laryngeal fractures are common with older victims of strangulation but with younger victims, especially females, these lesions are less frequent due to the resilience of the cartilage tissues. Pollanen and McAuliffe reported, however, that out of 12 cases of female strangulation (mean age 27±10 years, range 20–46 years) 75% had microscopic intracartilaginous laryngeal haemorrhages without any laryngeal microfractures having been observed [16]. A further investigation [14] described intracartilaginous haemorrhages that were consistantly associated with other laryngeal haemorrhagic lesions. Intracartilaginous laryngeal haemorrhages were assumed to have been caused by the disruption of blood vessels in the cartilage due to elastic deformation of the larynx and were localised inside the thyroid at the point of intersection of the superior cornu and the lamina approximately on a level with the superior tubercle.

Since no control group had been included in the investigation of Pollanen and McAuliffe [16], the present control case study was designed to investigate the specificity of these haemorrhages for strangulation.

Materials and methods

In this study, larynges from 30 cases of strangulation (mean age 38±20 years, range 7–89 years) were examined, and twothirds of the cases were female (20 individuals). Laryngeal fractures were found in 47% of cases in this group and 9 of these cases were equivalent in age and sex to the group investigated by Pollanen and McAuliffe [16]. These 9 cases were women (mean age 25±7 years, range 15–41 years) who had died of manual or ligature strangulation and none of these cases had laryngeal microfractures. The control group comprised 40 individuals (mean age 44.8±20 years, range 3–90 years). An exclusion criterion for this group was the diagnosis that death had resulted from violent application of pressure on the neck. Neither laryngeal cartilage fractures nor hyoid fractures were detected in any of these controls. The causes of death in the control group were cardiac failure (n=7), drug overdose (n=5), alcohol withdrawal delirium (n=4), myocardial infarction (n=4), sepsis (n=4), carbon monoxide and smoke inhalation (n=3), drowning (n=2), aspiration (n=2), lung disease (n=2), convulsion (n=2), exsanguination (n=1), fulminant liver failure (n=1), hypothermia (n=1), subarachnoid haemorrhage (n=1) and blunt force to the chest (n=1). In addition, a group of 5 controls of death caused by trauma with findings of non-strangulation neck injuries (mean age 29.8±9.7 years, range 19–45 years) was included. Of this group two controls had laryngeal fractures, three other controls revealed only injuries to the soft tissues of the neck.

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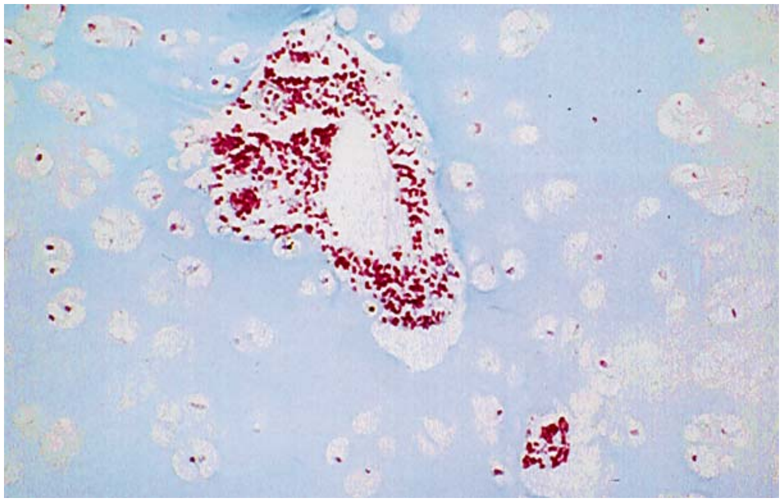

Fig. 1 Perivascular erythrocytes in cartilage canals (Masson-Goldner, 50×)

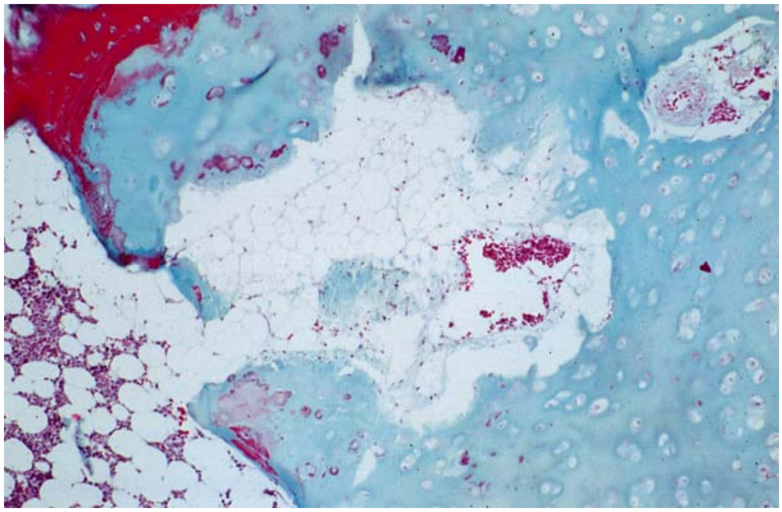

Fig. 2 Bone marrow *(left)* that has grown into the adjacent cartilage resorption cavity with a blood sinusoid *(middle)* near a blood vessel in a cartilage canal with perivascular localized erythrocytes *(right)* (Masson-Goldner, 25×)

All larynges were fixed for at least 24 h in buffered formalin and dissected according to the technique of Maxeiner and Dietz [13]. After removal of muscle tissue as well as fatty and connective tissues, the cartilages were ultrasonically incubated with 10% formic acid for 17 h. After washing for more than 24 h, the specimens were embedded in paraffin and cut into 4 -μm thick sections. The superior cornua was sectioned along the long axis as in the investigation of Pollanen and McAuliffe [16]. Since the point where the superior cornu of the larynx meets the lamina of the thyroid cartilage is highly vulnerable to fracture due to mineralisation of the larynx, the most intense effects of mechanical forces are to be expected here. The sections were stained with hematoxylin-eosin as well as with the Masson-Goldner staining methods.

Results

The total accumulations of blood in the 3 groups were 22 (73%) in the case group, 30 (75%) in the control group and 3 (60%) in the group of non-strangulation neck injuries. Perivascular haemorrhages were observed in only a few cases of our study (six cases, one control, two non-strangulation neck injuries) (Fig. 1). The haemorrhages were found at the point of intersection of the superior cornu of the larynx and the lamina of the thyroid cartilage. Histological examination revealed that these lesions were located in the perivascular space deep inside the cartilage and did not communicate with the perichondrium. Bone marrow sites were also observed in cartilages of younger victims of strangulation. Furthermore, some of the haemorrhages were localised close to the bone marrow blood sinusoids (Figs. 2 and 3). No microfractures or other lesions were detected microscopically near the bone marrow blood sinusoids. On this basis, Table 1 separates perivascular haemorrhages into solitary haemorrhages and haemorrhages with adjacent blood formation areas (bone marrow), i.e. haemorrhages and blood formation areas or blood sinusoids in the same visual field with a magnification of at least ×80 (Table 1, rows 1 and 2, respectively). Table 1 also shows the frequency of blood accumulations in bone marrow sinusoids without additional perivascular haemorrhages in the investigated groups (Table 1, row 3).

In Table 2, those cases are presented that are equivalent in sex (female) and age (max. 46 years old) to the cases in the group examined by Pollanen and McAuliffe [16].

Fig. 3 Longitudinal section of the bony canal that communicates with bone marrow. A taut blood-filled sinusoid is observed inside the canal (Masson-Goldner, 25×)

Table 1 Types of blood accumulation observed at the point of intersection of superior cornu of larynx and lamina of thyroid cartilage (*CC* cartilage canal)

Type of blood accumulation	Cases *n*=30	Controls *n*=40	Non-strangulation neck injuries *n*=5
Solitary perivascular haemorrhage in CC	2	1	1
Bone marrow with perivascular haemorrhage	4	0	1
Bone marrow with adjacent blood sinusoid without perivascular haemorrhage	16	29	1
Total	22 (73%)	30 (75%)	3 (60%)

Table 2 Types of blood accumulations at the point of intersection of superior cornu of larynx and lamina of thyroid cartilage in the group comparable to the investigation group of Pollanen and McAuliffe regarding sex and age

Types of blood accumulation	Cases *n*=9	Controls *n*=9	Non-strangulation neck injuries *n*=1
Solitary perivascular haemorrhage in CC	1	1	1
Bone marrow with perivascular haemorrhage	1	0	0
Bone marrow with adjacent blood sinusoid without perivascular haemorrhage	1	4	0
Total	3 (33%)	5 (55%)	1 (20%)

Discussion

Cases of homicidal strangulation are relatively frequent in Germany. A study of forensic autopsies at the Institut für Rechtsmedizin, Medizinische Hochschule Hannover, reported the diagnosis of death by strangulation in 29.5% of all homicidal deaths [6] and strangulation was diagnosed in 4.6% of all autopsies. The autopsy study at the Institut für Rechtsmedizin, Freie Universität Berlin, reported the diagnosis of death by strangulation in 5% of all autopsies [19]. Another study described homicides with signs of violent application of pressure on the neck in 11% of all examined autopsies [11]. In manual and ligature strangulation, the pressure of the thyroid cartilage on the lamina is particularly intense at the point of intersection of the superior cornu and the lamina. This explains the fact that fractures of the mineralised superior cornua commonly occur in cases of strangulation [1, 7, 8, 12, 17]. Even assuming that laryngeal fractures are not specific to strangulation, as a rule they point directly and causally to an accidental injury. However, in a study on laryngeal lesions caused by resuscitation attempts, no cases of fractures were observed [18]. It seems likely that no macroscopic lesions occur with younger victims of strangulation where the larynx is still flexible.

In our study, perivascular laryngeal haemorrhages were found in six strangulation cases (20%). The frequency reported by Pollanen and McAuliffe (75%) [16] can only be confirmed by taking solitary perivascular haemorrhages, perivascular haemorrhages with adjacent blood formation areas and blood formation areas without additional haemorrhages into consideration. It was necessary to distinguish between these categories because blood formation areas without additional haemorrhages are physiological artefacts. In addition, it seems necessary to us to differentiate between solitary perivascular haemorrhages (two cases) and perivascular haemorrhages located close to bone marrow formation areas and their sinusoids (four cases) since it cannot be distinguished with certainty whether perivascular haemorrhages are caused by a traumatic rupture of blood vessels due to strangulation or whether they appear as artefactual extravasations of blood that communicate with a blood sinusoid opened during the autopsy preparation. Moreover, the thin endothelium of blood sinusoids cannot always be clearly recognised and can possibly be confused with haemorrhages. Even solitary perivascular haemorrhages could not be assigned to a traumatic cause with certainty since a solitary perivascular haemorrhage was found in one control. In our study, bone marrow sites in the cartilage and numerous blood vessels in thyroid cartilage tissues were also observed in larynges which were still flexible to a great extent with initial or no signs of ossification (younger victims, especially women) (Figs. 2 and 3). Endochondral ossification starts with the formation of cartilage resorption cavities, so-called cartilage canals [2, 3, 4], due to apoptosis of various chondrocytes in adolescent thyroid cartilage. About the end of the second decade of life, blood vessels grow into the preformed cavities. Mesenchymal cells, that later develop into various stem cells including marrow cells, are also involved in this process. In this phase, ossification sets in and proceeds as individually as the in-growth of blood vessels and the process of extension of the blood vessel network. This explains the fact that persons of the same sex and age show great differences in the degree and extension of ossification [3]. Cartilage mineralisation and ossification begins at the dorsal border of the thyroid cartilage in the caudal region and proceeds to the cranial region. At the upper and lower borders of thyroid cartilage, mineralisation develops from the dorsal to the ventral area [3] and the process of ossification shows sex-related differences. While the male thyroid cartilage is mineralised almost completely by the end of the seventh decade, the ventral half of the female thyroid cartilage laminae remains unmineralised [3]. The point of origin of the superior cornu from the lamina of thyroid cartilage is mineralised early in both sexes.

In order to prevent discrepancy in the results due to differences in study materials, a study group was formed that was directly comparable to the group investigated by Pollanen and McAuliffe [16] (Table 2). Intracartilaginous haemorrhages were discovered only in two of the nine cases (one solitary haemorrhage, one accumulation of blood associated with bone marrow) in this group. Therefore, the discrepancy in the results cannot be explained by differences between the study groups.

Solitary perivascular and intracartilaginous haemorrhages located close to blood formation areas were found not only in six cases but also in one control without neck injuries and two controls of death caused by trauma with non-strangulation neck injuries. On this basis, the specificity of intracartilaginous haemorrhages for strangulation could not be confirmed. Bone marrow formation areas were often found in cases and controls.

In summary, the occurrence of intracartilaginous perivascular haemorrhages in a flexible larynx (Fig. 1) is possible from the physiological aspect (capillary vascularisation by ossification) as well as from the physical point of view (mechanical forces on the basis of the superior cornua in strangulation). However, these haemorrhages are not specific to strangulation and artefactual haemorrhages can occur as a result of opening of the sinusoid during the postmortem preparation. This is possible even in an uninjured thyroid cartilage if vascularisation of the cartilage is strongly developed due to bone marrow formation.

Acknowledgements We would like to thank Mrs. K. Bardowicks, Mrs. M. Busch and Ms. O. Korotkova for excellent technical assistance.

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