Forensic value of soft tissue detachments from the hyoid bone in death due to strangulation asphyxia

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Abstract

Background. There are no unequivocal histopathological findings for the diagnosis of fatal asphyxia due to neck compression. From the observation of a series of asphyxiation cases, we noted, during microscopic analysis, a high frequency of "detachment" of soft tissues from the hyoid bone. This specifically refers to the presence of an optical space between the surface of the hyoid bone and soft tissues.

Objectives. We aimed to evaluate the detachment of soft tissues from the hyoid bone as specific histological evidence of death due to strangulation asphyxia.

Materials and methods. Ten blocks were taken from deaths due to external mechanical compression of the neck (strangulation asphyxia, group A), 22 blocks were taken from deaths for other causes without trauma to the neck (group B), and 38 blocks were obtained from living subjects that have undergone laryngectomies (group C). The presence/absence of detachments were compared between the 3 groups (A, B and C) using Fisher's exact test.

Results. The detachment of soft tissues from the hyoid bone was observed in 5 cases (50%) in group A, 6 cases (27.2%) in group B, and 17 cases (44.3%) in group C. The sensitivity and specificity of the presence of the detachment in group A were 0.5 (95% confidence interval (95% CI): 0.38–0.62) and 0.57 (95% CI: 0.45–0.69), respectively. The comparison between the 3 groups and the presence/absence of soft tissue detachment showed no statistically significant differences between the groups ($p = 0.329$), clarifying that soft tissue detachment is a nonspecific variable for all 3 situations.

Conclusions. Detachment of soft tissues has poor value as a single element to favor the diagnosis of asphyxia due to violent compression of the neck and should be interpreted as an artifactual finding, unrelated to the neck injury or injury vitality.

Key words: histology, autopsy, strangulation, artifact, detachment of soft tissue from hyoid bone

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Background

Asphyxia due to external compression of the neck (i.e., strangulation asphyxia) is a common issue in forensic pathology and can be seen in homicides, suicides, and, rarely, in accidental cases.[1] Compression can be caused by different mechanisms and can be classified as hanging, ligature strangulation and manual strangulation, depending on the means used to compress the neck (ligature vs hands) and the application of forces (assailant force vs gravity).[2] Ligature and manual strangulation are typically seen in homicides, whereas hanging is often encountered in suicide cases. Homicide by hanging and suicide by ligature strangulation is rare.[3,4]

Macroscopic and microscopic signs of strangulation have been broadly studied, and their specificity is well known for hanging[5,6] as well as manual and ligature strangulation.[7,8] Histological analysis of deaths due to strangulation is usually performed to identify signs of injuries of the skin and internal structures of the neck,[9–11] such as fractures with hemorrhages of the surrounding soft tissues. However, when there are no known hallmarks of asphyxia due to external forces, the cause of death determination can be challenging. In such cases, there are, as a rule, no (or only uncharacteristic) morphological macroscopic or microscopic findings, namely conjunctival petechiae and other findings during the histological examination of the lung, the so-called "hemorrhagic-dysphoric syndrome".[12] Nevertheless, none of the signs of asphyxia in internal organs is conclusive for asphyxia: the diagnosis of asphyxiation is typically made by collecting all relevant internal and external findings, expressing a different level of support for the hypothesis of asphyxia over other hypotheses, such as fatal drug intoxication or sudden death.

In recent years, the ultra-specialized research in legal medicine[13,14] on this topic has focused on studying signs of asphyxia and developing new techniques that can support the diagnosis.[15–17] A series of autopsy cases revealed a high frequency of soft tissue "detachment" from the hyoid bone during microscopic analysis.. This specifically refers to the presence of an optical space between the surface of the hyoid bone and soft tissues.

Objectives

Hypothesizing that the microscopic identification during light microscopy of soft tissue detachment from the hyoid bone could contribute to the challenging diagnosis of asphyxia resulting from neck compression, the objective of this study was to determine, through a retrospective case-control analysis, whether this finding is more frequent in cases of asphyxia or if it is an artifact resulting from sample processing. The findings in our casework will be compared to existing literature on mechanical asphyxia.

Materials and methods

We performed a retrospective study on whole neck blocks (including the tongue, hyoid bone, larynx, and the first tracheal ring) collected during forensic autopsies between 2019 and 2021 in the Section of Forensic Pathology of the University Hospital of Verona (Italy), which represents one of the main referral centers for forensic pathology in northeast Italy. Seventy whole neck blocks were available for the purposes of the study, including 10 blocks taken from deaths due to strangulation (group A), 22 blocks taken from deaths for other causes without inner cervical injuries (group B), and 38 blocks obtained from living subjects that had undergone laryngectomies for infiltrative squamous carcinoma (group C), as reported in Table 1 (groups A and B) and Table 2 (group C).

In group A, the cause and manner of death were determined after a comprehensive medico-legal evaluation, based on circumstantial data, external examination, autopsy, and, when needed, ancillary tests (i.e., histologic and toxicologic analyses). Group C specimens were selected after a review of the anatomy of the specimens following primary gross sampling for oncologic primary diagnosis and staging at the Pathology Department of the University Hospital of Verona. In group C, the invasion of the soft tissue directly surrounding the examined hyoid bone horn was an exclusion criterion. Tumors did invade the soft tissue and/or adjacent bones and were staged as pT3 in 13 cases and pT4 in 4 cases. All hyoid-larynx complexes included in the study were fixed in a 10% buffered formalin solution immediately after sampling/extraction. After formalin fixation, the histologic analysis was performed within 2 weeks for all cases.

Neck blocks from asphyxiation deaths were used as cases, while neck blocks from other deaths or laryngectomies in living patients were used as negative controls. The dissection techniques applied were identical, according to The National Association of Medical Examiners (NAME) recommendations.[18] Neck structures were dissected using a layer-by-layer technique following vascular decompression of the neck by removal of cephalic and thoracic organs to minimize the risk of misinterpretations. During neck dissection, each layer was contextually examined to search for any macroscopic lesions of the soft tissues. The hyoid-larynx complex collected during autopsies was obtained by incision of the oral floor and subsequent gentle dissection of the esophagus and anterior neck structures from the anterior aspect of the cervical spine. During the procedure, a layer of 0.5 cm of soft tissue adjacent to the hyoid bone (the greater hyoid bone horns) was preserved intact for histological analysis. The sampling for histological analysis was performed on surgical laryngectomies as samples according to the College of American Pathologists (CAP) protocol. All complexes were referred to the Section of Pathology of the University

Table 1. Detachment of soft tissue from hyoid bone in asphyxia deaths due to neck compression compared to other circumstances

ID	Sex	Age	Group	External injuries	Internal injuries	Cause of death	Manner of death	Presence of detachment/number of samples^	Maximum extent of the detachment	Near to hemorrhage	Near to fracture	PMI
1	M	58	A	petechial hemorrhages and skin sulcus	none	ligature strangulation	suicide	8/9 blocks	1250 µm	–	–	2
2	F	34	A	skin sulcus	fracture of the left greater cornu of hyoid bone, hemorrhages	hanging	suicide	4/4 blocks	1820 µm	no	no	2
3	F	68	A	skin discoloration	tongue hemorrhages	ligature strangulation*	homicide	4/4 blocks	230 µm	–	–	3
4	F	11	A	petechial hemorrhages and gum bruises	bilateral fracture of hyoid bone and hemorrhages	smothering and manual strangulation	homicide	4/4 blocks	510 µm	yes	no	3
5	F	43	A	skin sulcus	none	hanging	suicide	3/4 blocks	630 µm	–	–	4
6	M	64	A	brownish discoloration of the skin	brownish discoloration of soft tissues	ligature strangulation*	homicide	0/12 blocks	no	–	–	6
7	F	49	A	fingernail abrasions	hemorrhages	manual strangulation	homicide	0/8 blocks	no	no	–	4
8	M	37	A	irregular abrasions	hemorrhages in the left superior horn of thyroid cartilage	hanging	suicide	0/2 blocks	no	no	–	2
9	M	91	A	none	fracture of the superior horn of the thyroid cartilage, hemorrhages	smothering and manual strangulation	homicide	0/1 blocks	no	–	no	3
10	M	40	A	linear abrasion	none	hanging	suicide	0/2 blocks	no	–	–	2
11	M	89	B	none	none	sepsis*	natural death	1/4 blocks	480 µm	–	–	2
12	F	55	B	none	none	thoracic trauma	accident	0/3 blocks	no	–	–	2
13	M	69	B	none	none	drowning	suicide	0/2 blocks	no	–	–	3
14	M	34	B	none	none	gunshot	homicide	1/3 blocks	580 µm	–	–	4
15	M	62	B	none	none	cardiac death	natural death	0/1 blocks	no	–	–	3
16	F	26	B	none	none	drug overdose	accident	0/1 blocks	no	–	–	5
17	F	52	B	laceration	hemorrhages	choking	suicide	1/1 blocks	2110 µm	–	–	2
18	M	35	B	none	hemorrhages	polytrauma	accident	0/1 blocks	no	–	–	5
19	M	32	B	none	none	drug overdose	accident	0/1 blocks	no	–	–	2
20	F	77	B	none	none	cardiac death	natural death	1/3 blocks	1920 µm	–	–	3
21	M	58	B	none	none	head trauma	homicide	0/3 blocks	no	–	–	2

Table 1. Detachment of soft tissue from hyoid bone in asphyxia deaths due to neck compression vs other circumstances – cont.

ID	Sex	Age	Group	External injuries	Internal injuries	Cause of death	Manner of death	Presence of detachment/number of samples^	Maximum extent of the detachment	Near to hemorrhage	Near to fracture	PMI
22	F	49	B	none	none	polytrauma	suicide	0/2 blocks	no	–	–	3
23	M	29	B	none	none	CO poisoning	accident	0/3 blocks	no	–	–	4
24	M	38	B	none	none	cardiac death*	natural death	0/2 blocks	no	–	–	4
25	M	42	B	none	none	sepsis	natural death	0/4 blocks	no	–	–	3
26	M	79	B	none	none	polytrauma	accident	1/5 blocks	1110 µm	–	–	2
27	M	79	B	none	none	silicosis	natural death	0/3 blocks	no	–	–	2
28	M	66	B	none	none	gunshot	accident	0/4 blocks	no	–	–	3
29	F	51	B	abrasions, bruises	perihyoid tissue hemorrhages	polytrauma	homicide	0/3 blocks	no	–	–	4
30	F	27	B	petechial hemorrhages, mucosal contusion on the lips	none	smothering	homicide	0/2 blocks	no	–	–	3
31	F	52	B	none	none	pulmonary embolism	natural death	1/1 blocks	990 µm	–	–	2
32	F	3	B	petechial hemorrhages and abrasions	none	smothering	homicide	0/3 blocks	no	–	–	2

* advanced post-mortem decomposition stage; group A – deaths due to violent external compression of the neck; group B – deaths of other causes without trauma of the neck; Near to hemorrhage – the reported maximum extent of the detachment was reported on the slide where the horn fracture was present; Near to fracture – the reported maximum extent of the detachment was reported on the slide where the soft-tissue hemorrhage was present; PMI – post-mortem interval; M – male; F – female; CO – carbon monoxide.

Hospital of Verona and placed in a slow decalcifying solution. Serial withdrawals of the hyoid bone and adjacent soft tissue were obtained from each sample. A minimum of 3 and a maximum of 12 withdrawals for each autopsy were obtained and were dehydrated in an increasing ethanol ladder, diaphonized in xylene substitute, and embedded in a high fusion point paraffin (60°), resulting in a mean of 4.6 paraffin blocks per case. From each block, a single slice 3–5 µm-thick was cut using a microtome and stained with hematoxylin and eosin (H&E). Each slide was examined using a standard morphologic method, represented by vision with an Olympus BX microscope (Olympus Corp., Tokyo, Japan) performed by an expert pathologist, and a digital method by which the slides were scanned and digitalized using a Grundium Ocus scanner (Grundium/Nikon, Tampere, Finland). An expert pathologist analyzed the slides and digital images, focusing on the identification of detachment of the soft tissues from the hyoid bone (presence of an angular empty space in between soft tissue and bone on H&E staining), as well as any incidental microscopic findings, such as hemorrhages in cartilages, soft tissues and muscles, or microfractures of the hyoid bone and thyroid cartilage.

Statistical analyses

The following data were collected for each case: sex, presence of detachment, the number of blocks in which the detachment was observed, and the maximum extent of the detachment. Only for autopsy cases, external and internal injuries and the cause and the manner of death were included. Logistic regression is a statistical method allowing for the testing of models designed to predict binary outcomes, such as the presence or absence of detachment. In a single model, the independent predictor variable is categorical and pertains to 3 medico-legal/clinical settings, namely, groups A, B and C. To run a logistic regression, some assumptions regarding the sample size, multicollinearity and outliers were preliminarily checked. Since we only had 1 independent variable, we deemed the minimum sample size to be adequate (group A; n = 10). Additionally, we did not find any outliers. Statistical tests were performed using the IBM Statistical Package for the Social Sciences (SPSS) v. 29.0 (IBM Corp., Armonk, USA). Values were presented as absolute number of cases, frequency and, when appropriate, median and ranges. The presence/absence of detachment in cases

Table 2. Detachment of soft tissue from the hyoid bone in asphyxia deaths due to neck compression compared to other circumstances in group C – blocks obtained from living subjects that had undergone laryngectomies for infiltrative squamous carcinoma

ID	Sex	Age	Presence of detachment/ number of samples^	Maximum extent of the detachment
1	F	61	0/4 blocks	no
2	M	66	1/2 blocks	1210 µm
3	F	71	2/3 blocks	230 µm
4	F	77	0/1 blocks	no
5	M	67	0/4 blocks	no
6	F	75	0/1 blocks	no
7	F	67	1/3 blocks	1920 µm
8	F	66	0/4 blocks	no
9	M	66	0/4 blocks	no
10	M	78	0/4 blocks	no
11	F	87	0/4 blocks	no
12	F	78	1/3 blocks	230 µm
13	F	77	1/3 blocks	460 µm
14	F	75	0/2 blocks	no
15	F	66	1/3 blocks	1200 µm
16	F	64	0/4 blocks	no
17	F	59	1/3 blocks	580 µm
18	F	55	0/2 blocks	no
19	M	56	0/2 blocks	no
20	M	57	0/2 blocks	no
21	M	81	2/3 blocks	580 µm
22	M	67	1/2 blocks	613 µm
23	F	58	1/2 blocks	713 µm
24	M	60	1/2 blocks	619 µm
25	M	80	0/1 blocks	no
26	M	80	2/3 blocks	1920 µm
27	M	81	2/3 blocks	1821 µm
28	M	78	1/3 blocks	1218 µm
29	F	65	1/3 blocks	415 µm
30	F	78	1/3 blocks	1754 µm
31	F	67	0/1 blocks	no
32	M	56	0/1 blocks	no
33	M	65	0/4 blocks	no
34	F	67	0/1 blocks	no
35	F	56	0/1 blocks	no
36	M	69	2/3 blocks	2230 µm
37	M	80	0/4 blocks	no
38	F	81	0/4 blocks	no

*advanced post-mortem decomposition stage. External injuries not applicable in all cases; M – male; F – female

and controls was also compared within the 3 groups (A, B and C), using Fisher's exact test (level of significance < 0.05). The sensitivity and specificity of the tests were provided.

Results

In group A (asphyxia deaths due to the compression of the neck), the median age was 46 years (range: 11–91 years), and the male-to-female ratio was 1:1. In group B (deaths for other causes), the median age of the group was 51.5 years (range: 3–89 years), while the female-to-male ratio was 1.6:1. In group C (neck blocks from laryngectomies), the median age was 67 years (range: 61–87). The age of group C was significantly higher than the age of the other groups.

Table 1,2 report all the details of the study cohort. All hanging cases were suicidal "short-drop hangings" or "hangings without the drop", with the knot located behind the occiput, whereas manual strangulation cases were homicides. Internal injuries were totally absent in 2 hanging cases, while the other 2 cases presented hemorrhage alone and fracture of the left greater cornu of the hyoid bone with concomitant hemorrhage, respectively.

Detachments were identified in 6/22 (27.2%) autopsy specimens due to other causes than asphyxia and in 17/38 (44.7%) surgical laryngectomies. Representative images were captured in Fig. 1,2. Both hanging cases, which revealed the detachment of soft tissues from the hyoid bone, were associated with the skin sulcus to the neck, whereas only 1 of them was associated with injuries to the inner structures of the neck. Both ligature strangulation cases, in which the detachment of the soft tissues from the hyoid bone was found to be associated with internal injury, were homicides. This finding was associated with a fracture of the hyoid bone in a single case of manual strangulation with detachment of the soft tissues from the hyoid bone. A bar chart of the presence/absence of detachment is presented in Fig. 3.

Statistical analyses results

A direct logistic regression analysis was conducted to determine whether the likelihood of detecting a detachment of soft tissues from the hyoid bone was impacted by the medico-legal setting. The model featured a single independent variable, namely the medico-legal setting. However, the full model, which included the predictor, was statistically not significant (χ^2 (2, n = 70) = 2.319, p = 0.314). This indicates that the model was unable to differentiate between medico-legal settings that reported detecting a detachment of soft tissues from the hyoid bone and those that did not. As a result, there was no need for additional post hoc analyses with pairwise comparisons between groups, or for sensitivity and specificity analyses. A contingency table is provided in Table 3.

Finally, the comparison between the 3 groups and the presence/absence of soft tissue detachment showed no statistically significant differences between groups (p = 0.329), clarifying that soft tissue detachment is a non-specific variable for all 3 situations. In other words, it has no role in identifying any of these different situations.

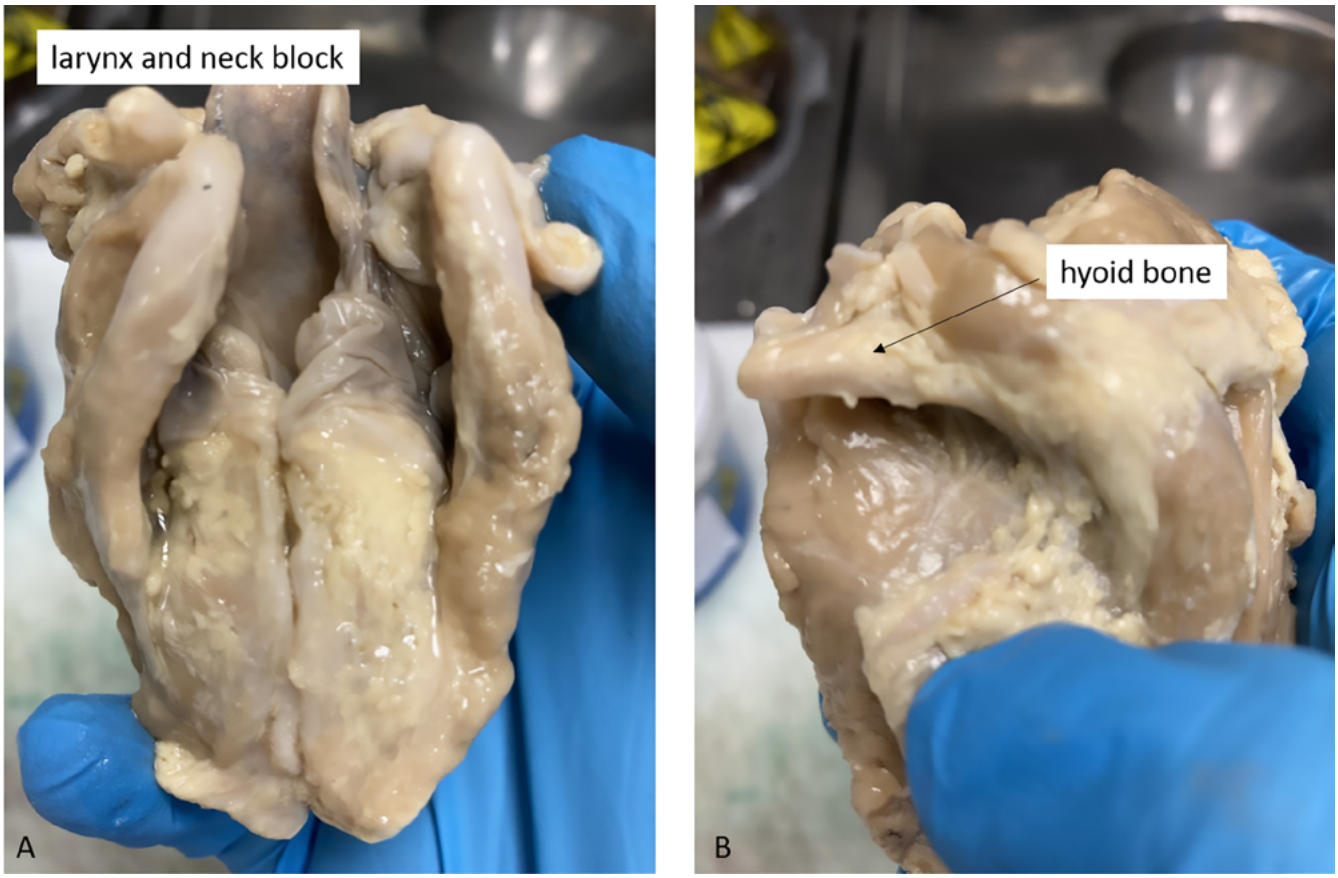

Fig.1. A. Hyoid-larynx complex, posterior view; B. Hyoid-larynx complex, lateral view with signature to the hyoid

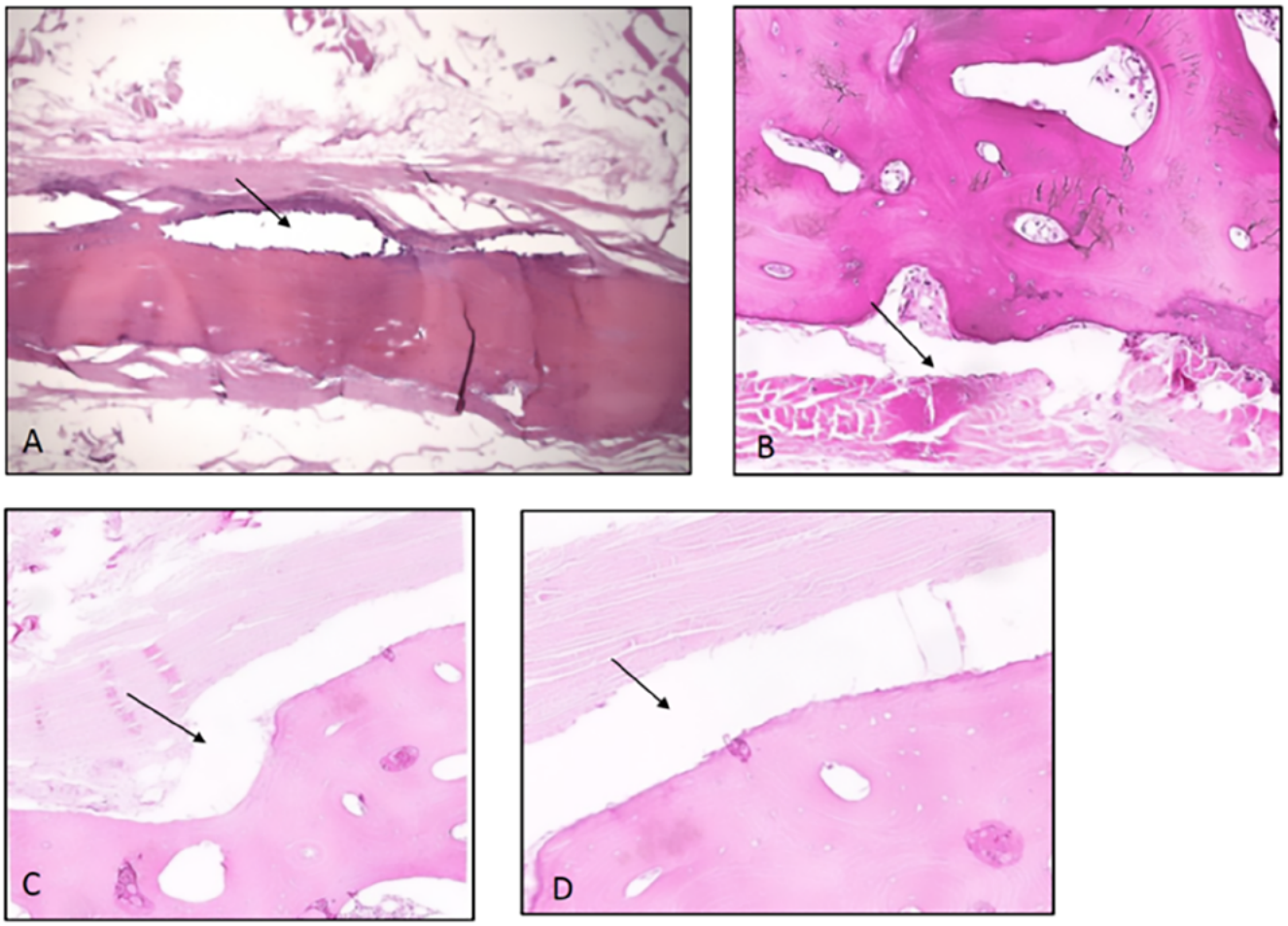

Fig. 2. Soft tissue detachment from the hyoid bone in a specimen obtained by: A. Legal autopsy case that occurred from a violent compression to the neck (study cohort); B. Surgical laryngectomy; C,D. Legal autopsy case in which no compression occurred to the neck (control cohort). Hematoxylin & eosin (H&E) staining (×10 magnification)

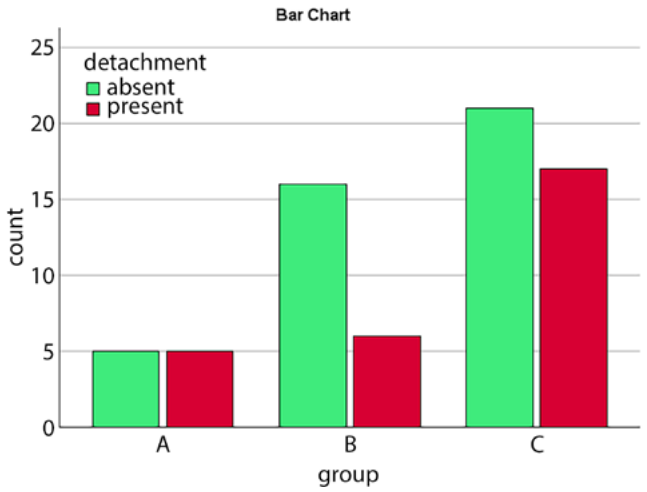

Fig. 3. Bar chart reporting the presence/absence of detachment in the 3 groups

Table 3. Contingency table

Group		Detachment		Total
		Absent	Present	
Group	A	5	5	10
	B	16	6	22
	C	21	17	38
Total		42	28	70

Group A – deaths due to violent external compression of the neck; group B – deaths for other causes without a trauma of the neck; group C – blocks obtained from living subjects that had undergone to laryngectomies for infiltrative squamous carcinoma.

Discussion

Histopathologic findings in relation to death due to strangulation asphyxia are poor, and literature mostly refers to the hemorrhagic infiltration of skin injuries produced by the mean used to cause asphyxia or other signs, such as a transverse laceration of the intimal layer of carotid arteries described in cases of hanging (Amussat's sign).[19,20] The NAME Forensic Autopsies Performance Standards released in 2006 (updated in 2020) detailed that muscles, soft tissues, airways, and vascular structures of the anterior neck must be examined to identify signs of disease and/or injury; thus, a layer-by-layer dissection is necessary for proper evaluation of trauma to the anterior neck. Removal and ex situ dissection of the upper airway, pharynx and upper esophagus is mandatory, and the dissection of the posterior neck is also necessary when an occult neck injury is suspected. The forensic pathologist shall examine in situ muscles and soft tissues of the anterior neck, ensure proper removal of neck organs and airways, examine neck organs and airways, dissect the posterior neck in cases of suspected occult neck injury, and perform anterior neck dissection in neck trauma cases.[18] All steps are usually performed during autopsies, and less frequently the anatomical whole neck regions are analyzed after the formalin-fixed process and after paraffin embedding. It is well known in any anatomic pathology and/or forensic laboratory that there is a chance to produce artifactual tissues when dealing with fixation and tissue sectioning. Therefore, when mechanical asphyxia is suspected as the cause of death, and forensics are requested to analyze the neck region after formalin-fixation, the artifacts must be known to avoid misinterpretation of final gross and histopathological morphological signs. Hemorrhages, soft tissue edematous congestion or bone fractures are the morphological details to search for. Some autopsy cases without pathognomonic external and internal macroscopic findings fail provide an effective element to allow expert anatomical or forensic pathologists to correctly diagnose the cause and manner of death with a high level of confidence.[21] This is due to the relatively low specificity of some of the common findings in asphyxia cases, which can be revealed in people who died due to causes other than strangulation asphyxia.[22,23]

Detachment of soft tissues from the hyoid bone can be easily examined by microscopy, and, to date, little was known about the value of this finding, which was observed with a high frequency in our casework. In fact, to our knowledge, no study on the diagnostic value of this finding has been published thus far. We observed a low sensitivity and specificity of the evidence of soft tissue detachments from the hyoid bone as a unique interpretation of the cause of death, particularly in the differentiation between mechanical strangulation asphyxia and death by other causes. The relatively high rate of soft tissue detachment from the hyoid bone in deaths due to other causes than asphyxia, as well as in group C, showed the non-specificity of the detachment, probably being an artifact occurring during the preparation of the sample. Again, this issue is supported by the relatively high rate of detachment found in the surgical laryngectomy group, where any sort of external compression to the neck was ruled out.

The detachment of soft tissues from the hyoid bone can be caused by several mechanisms. First, the dissection technique and an excessively rough extraction of the hyoid-larynx complex can lead to detachment of soft tissues, as well as other artificial findings such as fractures of the bone and cartilage.[24] Second, the complex processing of autopsy samples implies the use of aggressive chemicals, frequent manipulation and cutting forces with a scalpel, with the risk of artificially producing detachment of soft tissues from the hyoid bone.[25] The use of a slow decalcifying solution may help to reduce possible artifacts owing to its lower chemical aggressiveness compared to other strong decalcifying solutions. Moreover, the transition point from the dense structure of the hyoid bone to the lower density of the nearby soft tissues may represent a point of resistance that prevents easy running through the microtome blade. This resistance may artificially induce the detachment of soft tissues from the hyoid

bone.[26] As a consequence, the detachment of soft tissue from bones is not an uncommon finding during the technical histopathological processes after decalcification and tissue sectioning at the microtome. Bones are usually decalcified, and the process, although gently performed by using slow decalcifiers, usually shows detachments such as those observed in our study, even more in older patients. All technical processes are part of the pre-analytical standard operative procedures in an anatomic pathology and/or forensic laboratory.

With regard to the manner of death, our study is consistent with the results provided by other authors who found a clear prevalence of suicide in hanging cases and homicide in deaths due to strangulation.[9,27] Our single case of suicide by ligature strangulation showed no internal injuries, in contrast to other cases of ligature and manual strangulation, since internal injuries were found in all cases. This finding is consistent with Maxeiner et al.[28] and may be a consequence of the different forces involved in homicide and self-inflicted strangulation.

Taking into consideration the occurrence of fractures of the hyoid bone and thyroid cartilage, we found 2 fractures of the hyoid bone in a case of hanging and in a case of manual strangulation, whereas only 1 case of fracture of the thyroid cartilage occurred in a 91-year-old man who was a victim of manual strangulation. The occurrence of fractures of hyoid bones in asphyxia deaths is not uncommon. According to the literature, the prevalence of hyoid bone fractures in victims of hanging varies between 2% and 21%,[5,29] while the same injury can be found in approx. 35% of manual strangulation cases.[30] This difference is related to the major amount of energy applied by the hands of the assailant in contrast to the energy and the direction of the force provided by the ligature used in suicide by hanging.[30] The fracture of thyroid cartilage appears to be as frequent as that of the hyoid bone in hanging cases, ranging from 5% to 32%,[31,32] and it is more frequent in manual strangulation cases.[32] At the same time, it is well known that fractures of the thyroid cartilage are related to the age of the victim. The rate of fracture of the thyroid cartilage increases with age because of the ossification process of the cartilage as people age.[32,33] For this reason, the frequency and distribution of fractures of neck structures are commonly utilized to assist in interpreting the manner of death.[34,35]

In our study, we observed that the detachment of soft tissues has poor value as a single element to support the diagnosis of asphyxia due to violent compression of the neck. Moreover, the procedures regarding glass slide sectioning at a microtome and the decalcification process of the neck-hyoid blocks can justify the artifactual detachment of soft tissue from the hyoid bone. The design of this study seems appropriate for its purposes, having 2 independent control groups, 1 comprising deaths from other causes and the other consisting of samples taken from living individuals. The main limitation of the study is represented by the size and heterogeneity of group A compared to the other 2 groups. The exclusion criteria for group C, namely the absence of tumor invasion into the tissue near the hyoid bone, are also important to avoid sampling bias and improve the reproducibility of the study.

Limitations

The primary limitation of this study is the heterogeneity of mechanical asphyxia cases (group A), both in terms of the age of the subjects and the mode of death. It is possible that detachment may be more pronounced when greater force is applied to the neck. Additionally, the small number of cases in group A does not allow for quantitative considerations regarding a potential association between the extent of detachment and the cause of death.

Conclusions

Ongoing research for markers of strangulation asphyxia is necessary to achieve an adequate level of evidence in a judicial context. The exclusion of possible markers is also useful to avoid judicial errors. This observational retrospective study demonstrates that the detachment of soft tissues from the hyoid bone does not support the diagnosis of strangulation asphyxia in forensic autopsies and should be considered an artifact due to technical reasons. Therefore, in the absence of alterations to the structures of the neck, as is often the case in asphyxiation with soft means, the differential diagnosis must rely on the integrated assessment of all elements gathered during the forensic medical examination and autopsy. The forensic pathologist will then provide their evaluation, expressing support for the asphyxia cause, when requested. Further studies are required to draw more reliable conclusions on this forensic topic. Specifically, prospective studies, expanding the number of cases of asphyxia deaths, and improving the homogeneity of groups are needed to assess the nature and occurrence of the detachment of soft tissues from the hyoid bone.

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