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Neck Injuries Caused by Being Run Over by a Motor Vehicle*

ABSTRACT: We report a homicide involving the use of a motor vehicle and simulating a traffic accident. This observation was the reason for a retrospective analysis of neck injuries in victims of traffic accidents, in which a person has been run over (RO) by a motor vehicle. The autopsy material of two institutes from 1990–1996 was used. The following findings were obtained in 63 victims: laryngo-hyoid fractures (LH-fx): 10 cases (16%) with a clear difference between the institutes (22% versus 7%). This resulted from examination with special regard to such injuries in many cases at one of the institutes, whereas only autopsy reports were taken retrospectively from the other institute. Five of these cases had suffered only minor LH-fx (as seen frequently in strangulation), although extensive run over (RO) injuries of the other cervical tissues were present. All LH-fx were caused by direct compression of the neck; in eight of the cases they were combined with mandibular fractures. Petechial hemorrhages (petH) at the eye lids/conjunctivae were seen in 19 cases (30%); 16 of these were related to thorax RO injuries, three to abdominal RO only. Four cases involved LH-fx, petH as well as cervical skin lesions and additional cervical soft tissue hemorrhages. Interpretation can be extremely difficult with this combination of findings if the character of the event cannot be established as accidental beyond doubt on the basis of the circumstances.

KEYWORDS: forensic science, forensic pathology, automobile accident, running over, simulated accident, strangulation, neck injuries

Fractures of the hyoid bone and the larynx (LH-fx) may be caused by direct neck compression or indirectly, resulting from violent hyperflexion or hyperextension of the neck (1–4). Although these fractures are non-specific, they occur most frequently as a result of strangulation in forensically important fatalities (1,4,5).

Neck injuries due to road traffic accidents are clinically well known; predominantly they refer to motor vehicle passengers who hit their neck against inner car structures or to cervical impact injuries in motor cycle riders (6–11). In the forensic literature, laryngeal injuries are only rarely described in the context of traffic accidents (1–3,12–14), although 20–25% of those injured or killed in traffic accidents have some form of neck injury (1). In an earlier analysis of our own, we found laryngeal injuries in 4.2% of 665 traffic accident fatalities (8).

Forensic problems can arise in rare cases, where general trauma may explain the neck injuries, but a previous homicidal attack on the neck must be considered. However, in victims of traffic acci-

dents, this special aspect is only sporadically discussed in the surveyed literature (12). Earlier studies (73 cases, Ref. 15; 54 cases, Ref. 16) of RO cases make little or no mention of these lesions.

An extraordinary case involving an attempt to cover up a homicide by simulating a traffic accident required differentiation between neck injuries caused by strangulation and those due to a blunt trauma. An analysis of the occurence and types of neck injuries in a series of victims killed by RO in traffic accidents was done to obtain data that could not be found in the literature.

Case Report

The corpse of a 49-year-old woman was found beside her badly damaged bicycle at a remote crossroads. The situation was at first regarded as a routine accident, but soon appeared suspicious because of the evidence obtained at the accident site and the circumstances involved. The victim had been run over by a Fiat Ducato, resulting in massive blunt trauma from the severely injured face (with a fracture of the mandible) to the pelvis. Injuries clearly indicating a primary impact of a vehicle prior to a secondary RO were not present. The findings of special interest here were: bleedings and abrasions of the skin of the neck (Fig. 1); some petechial bleedings in the conjunctivae; hemorrhages in the anterior neck muscles and laryngo-hyoid trauma. This included: fractures of the right greater horn of the hyoid bone, both upper thyroid horns, thyroid cartilage (midline fracture), and cricoid cartilage (Fig. 2). Gross bleedings of the laryngeal mucosa and extensive hemorrhages of the vocal folds were also present. The histological examination was not indicative of survival following these laryngeal injuries.

According to the results of the criminal and scene investigation, it was concluded that the victim had been killed, or made unconscious, then brought to the scene in the involved car, and run over to simulate an accident. Because no other injury from a homicidal attack could be found at autopsy, and no intoxication was present, a neck compression prior to the RO-event was supposed. However, a tire had obviously rolled over the face, neck and shoulder region, so that this mechanism could also explain the neck injuries.

Analysis of 63 RO Accidents

Autopsy Material

The autopsy material of all the deaths between 1990–1996 at the Institute of Forensic Medicine of the Free University of Berlin and the Heinrich-Heine University at Düsseldorf were reviewed for cases of RO in victims of traffic accidents (the authors thank Prof. Dr. Bonte for allowing them to include the cases from Düsseldorf). In Berlin, special attention has been given to congestion bleedings and laryngo-hyoid fractures in all autopsy cases for many years
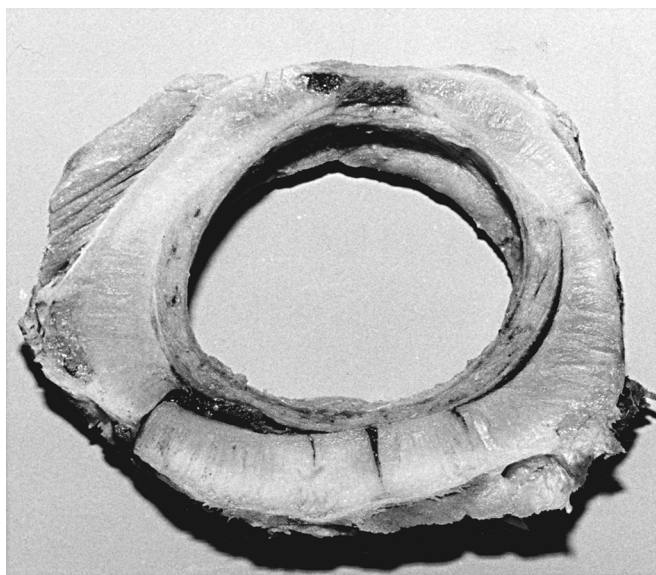
FIG. 1 and 2—*49-year-old woman (see case report) with RO-injuries of the right upper arm (open fracture), face, neck and both shoulders. Bleedings, small scratches and extensive abrasions of the cervical skin (Fig. 1). A horizontal incision through the cricoid cartilage (Fig. 2) shows several complete and incomplete fractures, predominantly of the posterior part of the cartilage.*

TABLE 1—*Victims, vehicles, accident mechanisms, and laryngo-hyoid fractures in 63 cases of run over in road traffic accidents.*

	Berlin		Düsseldorf		Total	
	Cases	fx	Cases	fx	Cases	fx
All	36	8 (22%)	27	2 (7%)	63	10 (16%)
Victims						
Pedestrians	27	5 (19%)	23	2 (9%)	50	7 (14%)
Bicyclists	9	3 (33%)	4	0	13	3 (23%)
Vehicles involved						
Trucks	25	7 (28%)	16	1	41	8 (20%)
Cars	8	0	7	0	15	0
Others	3	1	4	1	7	2 (29%)
Type of accident						
Secondary RO	31	8 (26%)	17	2 (12%)	48	10 (21%)
Primary RO	5	0	10	0	15	0

NOTE: Fx = fractures. Secondary RO = impact of the vehicle against an upright person followed by running over. Primary RO = running over a lying person without a previous impact.

TABLE 2—*Regions of RO-injuries and laryngo-hyoid fractures in 63 victims which were run over in traffic accidents.*

	Berlin		Düsseldorf		Total	
	Cases	fx	Cases	fx	Cases	fx
I. Head	3 (1)	1 (1)	0	0	3 (1)	1 (1)
II. Head and trunk	15 (6)	6 (5)	10 (2)	2 (1)	25 (8)	8 (6)
III. Trunk without head	18 (4)	1 (1)	17 (1)	0	35 (5)	1 (1)
I.–III.	36 (11)	8 (7)	27 (3)	2 (1)	63 (14)	10 (8)

NOTE: fx = laryngo-hyoid fractures. The numbers in () indicate the number of cases with at least partial run over of the neck.

(see Ref. 5). Cases with long-term survival and RO cases involving the extremities were omitted. There were 42 male and 21 female victims; the mean ages were 47 years and 58 years, respectively. Table 1 shows the types of traffic accidents and the vehicles in these accidents. The most frequent type (28 cases) were pedestrians being run over by a truck, followed by 14 automobile-pedestrian RO and 13 truck-two-wheeled vehicle RO events (12 bicycles, 1 motorcycle).

RO Patterns (Table 2)

As far as possible, the most important injuries were classified as the effects of "run over" and "impact by the vehicle;" only run over injuries are included in Table 2 and subsequently analyzed. Exact information on the exact RO direction was usually not available in the retrospective cases, but this detail did not seem imperative for the present investigation.

The regions injured by RO were: head, 28 cases, neck, 14 cases, thorax, 48 cases, abdomen, 43 cases, and extremities, 31 cases. The injury patterns were classified according to a simple scheme which only included RO findings for the localizations "head," "neck," "thorax," and "abdomen." Concomitant RO findings of the extremities were omitted (Table 2).

Laryngeal and Hyoid Injuries (See Table 3)

LH-fxs were found in 10 cases, half of them caused by head to abdomen RO, 2 by head and thorax RO and 1 each by: a) head and abdomen, b) chest only, c) head only. Nine of the 28 victims with head RO had LH-fx (32%) compared to a single case (3%) in 35 victims without head RO. The direction of RO in the 10 LH-fx cases could be determined as: nearly at right angles to the vertical axis of the victim (5), nearly in the vertical direction (1) and in oblique direction (2) or could not be determined (2). The following LH-fxs were observed: hyoid bone: 6 cases; cricoid cartilage: 4 cases; thyroid cartilage: 8 cases, including 6 cases with superior horn fractures, 3 cases with inferior horn fractures and 3 cases with lamina fractures. Five of the 10 fracture cases exhibited only minor injuries (fractures of hyoid horns or superior thyroid horns), although 3 of these cases had other RO injuries at the neck structures. In four cases (all with neck RO), severe laryngeal injuries were found. Two of these cases had a completely "unusual" form of a LH-fx: a widely depressed fx of the cricoid cartilage (Fig. 4) and a transverse fx through the thyroid notch (Fig. 3). In two cases, the larynx was completely crushed.

TABLE 3—*Characteristics of 10 cases with laryngo-hyoid fractures.*

No., Age, Sex, Type, Speed	Regions Injured by RO, Neck RO, fx of Mandible	Pet	Skin	Laryngo-Hyoid Fractures
B1, 29,f, 1-b*’ 1†	II‡ n+ m+	−	he.	cr., ri.th.u.h., b.th.1.h.
B2, 37,m, 1-b, 1	II n+ m+	+	he.	ri.th.u.h., th.lam.
B3, 46,m, 1-p, h	II n+ m−	−	ab.	cr., le.th.u.h., b.h.h.
B4, 67,m, 1-b, 1	I n+ m+	−	ab.	ri.th.u.h., ri.h.h.
B5, 74,m, 1-p, 1	II n+ m+	−	ab.	multiple fx and deformation
B6, 52,f, 1-b, 1	III n+ m−	+	ab.	le.th.u.h.
B7, 59,m, 3-p, h	II n− m+	+	−	le.h.h.
B8, 50,m, 1-p, h	II n+ m+	−	−	cr., le.th.l.h.
D1, 23,m, 1-p, 1	II n+ m+	+	−	th.lam., le.h.h.
D2, 53,m, 3-p, 1	II n− m+	−	−	ri.h.h.

NOTE: B, D = case from the Berlin/Düsseldorf material; *m* = male, *f* = female, n+/n−: neck RO present/not present; m+/m−: mandibular fracture present/not present; Pet +/−: petechial bleedings of the eyelids/conjunctivae present/not present; skin = injuries of the skin of the neck: ab. = extensive abrasions; he: extensive hematoma. Laryngohyoid fractures: ri./le./b. = right/left/both; th.u.h./th.l.h. = upper/lower horn of thyroid cartilage; th.lam. = thyroid lamina; h.h. = greater hyoid horn; cr. = cricoid cartilage.
* Type of vehicle: 1 = truck, 2 = car, 3 = others, and the involvement of the victim: p = pedestrian, b = cyclist.
† Collision speed of the vehicle: 1 = "low" speed, h = "high" speed (more than appr. 30 km/h).
‡ Body regions injured by run over: I: head only; II: head and trunk; III: trunk without head.
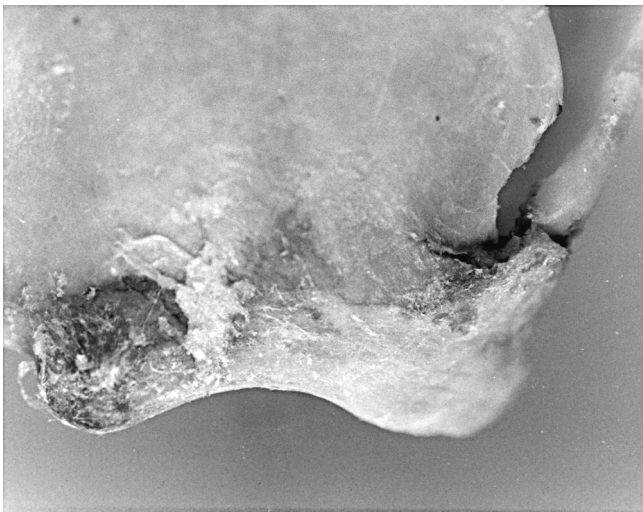

FIG. 3—*37-year-old man, RO by a truck, case "B2" in Table 3. The thyroid cartilage after removal of soft tissues is shown from the right frontal side. Both laminae are broken above the thyroid notch in a horizontal plane and displaced backwards; the lower part of the thyroid junction remained intact. The victim had extensive decollements of the right shoulder and lower right cervical region; an extensive hematoma of the complete anterior cervical tissues was present.*

Cervical Muscle Hemorrhages

Cervical soft tissue hemorrhages were found in 20 cases. The most common finding was strip-like hemorrhage in the lower part of the sternomastoid muscles down to the clavicular periosteum (13 cases); they occurred predominantly in cases without neck RO and were caused by straining of the muscles (9 cases; including 2 with

muscle ruptures). Extensive contusions and muscle ruptures were described in 6 cases; laryngeal injuries being severe in 3 of these, mild in 2 and absent in one. Hemorrhages of the strap muscles were only observed in association with extensive ruptures or contusions of the neck structures. In 3 cases of neck RO, the anterior neck compartment was completely torn from the cervical spine (Fig. 5);

FIG. 4 and 5—*29-year-old woman, RO by a truck, case "B1" in Table 3. Multiple facial fractures, destruction of the chest. Fig. 4: Horizontal incision through the cricoid cartilage: the anterior part of the ring is broken threefold and widely displaced to the back. Fig. 5: Posterior aspect of the cervical structures, which were widely torn off from the cervical spine and entirely hemorrhaged.*

in 2 of these cases, only minimal laryngo-hyoid injuries were present.

Cervical Skin Injuries

Twelve of the victims had skin injuries of the neck: extensive subcutaneous hemorrhages (3), abrasions (6) or a combination of both findings (3). The neck had been directly run over in 10 of these. Open wounds or characteristic marks corresponding to a tire imprint were not observed.

Petechial Facial Hemorrhages (See Tables 4 and 5)

Nineteen victims had petechial hemorrhages (petH), with little difference between the institutes (33–26%). Sixteen of the 48 cases with RO of the chest had petH; if the vehicle was a truck, the rate was 35%, in RO by a car, the rate was 27%. The 3 cases with petH and without chest RO had suffered abdominal RO.

Combinations of These Findings

Four cases presented a combination of LH-fx and petH, including one case with cervical skin lesions and cervical muscle hemorrhages, 2 cases with muscle hemorrhages and no cervical skin lesions, and one case with cervical skin lesions and no muscle hemorrhages. LH-fx and neck muscle hemorrhages were found in 5 cases without petH, 4 of these with concomitant cervical skin lesions.

Discussion

In the forensic literature, little information of laryngo-hyoid fractures in victims of traffic accidents (especially in RO cases) is available. The minor significance of these injuries concerning the cause of death and accident reconstruction may explain the paucity of reported data. Even a previous extensive forensic examination of such deaths (15) contained no details on neck injuries, although criminal aspects were mentioned (one simulated accident).

A case in which a victim's neck had been run over by a vehicle,

TABLE 4—*Petechial bleedings: vehicles and accident mechanisms (for abbreviations see Table 1).*

	Berlin		Düsseldorf		Total	
	Cases	Pet	Cases	Pet	Cases	Pet
All cases	36	12 (33%)	27	7 (26%)	63	19 (30%)
Vehicles involved						
Truck	25	9 (36%)	16	4 (25%)	41	13 (32%)
Car	7	1	7	2 (29%)	14	3 (21%)
Others	4	2 (50%)	4	1	8	3 (37%)
Type of accident						
Secondary RO	31	11 (32%)	17	3 (18%)	48	14 (29%)
Primary RO	5	1	10	4 (40%)	15	5 (33%)

TABLE 5—*Petechial bleedings (pet) and body regions injured by run over (RO).*

Body Region Injured by RO	Berlin		Düsseldorf		Total	
	Cases	Pet	Cases	Pet	Cases	Pet
Head only	3	0	0		3	0
Head and chest	15	4 (27%)	10	3 (30%)	25	7 (28%)
Trunk without head	18	8 (44%)	17	4 (24%)	35	12 (34%)

but a criminal neck compression prior to this event had to be strongly considered, was the reason for us to investigate the occurrence and types of neck injuries in RO accidents. The autopsy material from two institutes was evaluated. The 27 cases from the institute in Düsseldorf were retrospectively recorded on the basis of the autopsy protocols. The findings of the institute in Berlin were completely or in part (laryngohyoid complex) recorded by one of the authors (H.M.) in about half of the cases. Furthermore, laryngeal injuries have been extensively examined and collected for more than 10 years by this institute (5). The different incidences of LH-fx (22%:7%, see Table 2) are clearly a result of this.

All 10 LH-fx in this study belong to the group of secondary RO, i.e., the pedestrian or cyclist is hit by a motor vehicle and subsequently run over. Nine of the vehicles involved were trucks, buses or other heavy motor vehicles. The victim in the last case was apparently run over by several (not identified) motor vehicles.

Eight of the 14 cases (57%) with involvement of the neck in RO suffered laryngeal or hyoid fractures. Two of the fracture patterns had not yet been observed with strangulations in our own autopsy material (Figs. 3 and 4). The two fracture cases without neck RO (B7, D2) had only a hyoid fracture, associated with a mandibular fracture. A direct compression was therefore also responsible for these fractures. The relation between mandibular fractures and LH-fx underlines the role of neck compression: the mandible was fractured in 14 cases, 8 of the 10 cases with LH-fx were found in this group. An additional indication of direct fracturing was a relatively low collision speed (crossroads accident: a starting and turning truck runs over a pedestrian or cyclist; see Table 3). In only two cases, indirect fracturing (by straining of the neck; cases B3, B8) had to be considered on the basis of the accident mechanism but could be rejected due to the morphology of the neck injuries.

These findings lead to the conclusion that LH-fxs in a RO victim with no evidence of severe direct trauma of the neck and the absence of a mandibular fracture can be considered as suspicious and potentially criminal finding.

The relation between chest compression and petechial hemorrhages located in the face is well known. Therefore, the high rate of petechiae (about 1/3 of the cases) is not difficult to explain, but an important differential diagnosis has to be considered in such cases. Small intracutaneous bleedings are also known to result from severe compression of the skin. In 3 of our 19 petechial cases, such compression bleedings of the midface were present, but the pattern of the injuries of the face combined with the distribution of the petechial bleedings allowed us to interpret the bleedings (at least in part) as the congestion type.

In the initially described criminal case, the victim's neck had been run over. On the basis of the evaluation, the laryngeal injury could have been caused by this trauma. The characteristics of this LH-fx can be detailed as follows: despite fractures of all structural components, there was no crushing deformation of the larynx. In the absence of further comparative material a criminal attack to the neck (strangulation) rather than considerable RO injuries caused by a motor vehicle might have been assumed. However, a similar injury pattern was also observed in one case from the accidental RO group despite a complete anterior neck RO. Five of the 10 laryngeal injuries were minor, 3 of these being due to a direct neck RO. This may be due to both the larynx and cervical soft tissue having been pressed to the side and therefore not crushed. This was directly observable in 3 recent cases in which the severely torn and hemorrhaged anterior cervical soft tissue and the larynx had been detached from the cervical spine (Fig. 5).

On the other hand, the victim in our described crime had exten-

sive vocal fold hemorrhages as well as symmetrical extravasations of laryngeal mucosa. These types of findings could not be obtained in the RO-related laryngeal injuries examined by the authors, but were quite often evident after homicidal neck compression (5,17,18). Histological findings (18,19) which might support an assumption of a two-stage event (short survival after a primary strangulation) were not detectable; in a similar case (strangulation and subsequent RO by a train (20)), a homicide was discovered in this manner.

In summary, a homicidal neck compression prior to the running over could not be proven without a doubt, but was more likely than not. The victim's husband was found guilty of murder; and although the actual sequence of the murder could not be reconstructed, the court was convinced of a homicide and the husband's involvement, on the basis of all the circumstances and evidence.

Conclusions

- LH-fx can be found in up to one-third of traffic accident fatalities if head and chest RO have occurred.
- In our autopsy material, all 10 LH-fx resulted from the tire, directly compressing either the neck (8 cases) or the lower face (2 cases).
- Despite a neck RO, not only severe laryngeal traumas were observed but in 5 cases only minor injuries were present, comparable to those found in strangulation cases.
- PetH at the eye lids and/or conjunctivae were seen in about $\frac{1}{3}$ of all cases. The majority resulted from massive thoracic compression.
- A complete strangulation-like pattern of findings (neck injuries, congestive bleedings of the face) can be produced by RO events.
- Homicides in which a RO situation by a motor vehicle is of importance are extremely rare. If however, such a possibility must be seriously considered in a case under investigation, massive difficulties may arise in the classification of findings. Exhaustive efforts must be made by the investigating authorities, as well as a very extensive and subtle medical examination by the forensic pathologist. The presence of a LH-fx without a direct neck RO and without a mandibular fracture as well as the presence of extensive hemorrhages of the laryngeal muscles should arouse suspicion.

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