



## Study of endolaryngeal structures by videolaryngoscopy after hanging: A new approach to understanding the physiopathogenesis

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### ABSTRACT

**Purpose:** To evaluate laryngoscopic findings in hanging cases and to compare them with magnetic resonance imaging (MRI) and forensic autopsy results.

**Materials and methods:** Postmortem nasolaryngofibroscopy and MRI of five people who died from hanging were performed. Three people who died from other causes than hanging were also examined with a flexible laryngofibroscope. The results were compared with injuries discovered during forensic autopsy.

**Results:** In all five hanging cases, laryngofibroscopic investigation showed a vocal fold position in complete adduction confirmed by MRI. This position did not seem to be influenced by the intensity of the forces applied to neck or postmortem delay and cadaveric phenomena. The vocal cords of the three non-hanging deceased were found in the intermediate position. These findings could suggest that pressure applied to the cervical nervous and cartilaginous structures or their elongation during hanging could lead to closure of the glottis with vocal cord adduction maintained after death.

**Conclusion:** Laryngofibroscopic examination in hanging cases could be very useful in confirming the vital character of the hanging and understanding asphyxial phenomena in incomplete suspension without laryngeal crush.

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## 1. Introduction

Because there is no pathognomonic sign of hanging, its diagnosis is difficult to categorically establish and is always based on several arguments but can sometimes be uncertain if vital injuries are absent or invisible. Although in current forensic practice, such injuries as soft-tissue cervical hemorrhages or vital fractures of laryngeal skeleton are systematically researched and regularly published [1–3], the appearance of the endolarynx is never highlighted.

Furthermore, the diagnosis of vital signs depends on the techniques used [4]. Several authors currently affirm that multislice spiral computed tomography (MSCT) and magnetic resonance imaging (MRI) offer great potential for the detection of these injuries [5–7]. In the following, magnetic resonance imaging, videolaryngo-

fibroscopy and autopsy findings of five asphyxia fatalities by hanging are analyzed and compared with three non-hanging deceased. The aim of this study was to evaluate the appearance of the endolarynx and the benefit of laryngofibroscopic examination as possible diagnostic tools of hanging in postmortem situations.

## 2. Materials and methods

### 2.1. Subjects

The responsible justice department approved the present study. Five cases of suicidal hanging described in Table 1 (five males, mean age = 51 years, age range = 33–83) were examined using postmortem pre-autopsy MRI and videolaryngofibroscopy. One case (case 6, male, 25 years), for which autopsy was not required, was only investigated by two successive laryngofibroscopy examinations at 48-h intervals. Three non-hanging deceased (cases 7–9, males, mean age = 54 years) were only investigated by laryngofibroscopy within 24 and 48 h after death (no data being available in the literature) for comparison. All of the corpses were undressed and examined externally prior to scanning and autopsy by a forensic pathologist. The body mass index (BMI), the type of hanging and the link used were recorded. The time since death was evaluated using current standard methods of body temperature, degree of rigor mortis and investigation data. The time of suspension was approximated from the time since death and police and detailed interviews of the relatives of the deceased. The results of the external examination were recorded, e.g. conjunctival congestion or bleeding, cyanosis, visible neck

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**Table 1**

Characteristics of subjects and hangings of study.

Case	Age (years)	BMI	Link	Type of hanging	Characteristics of cervical compression			Suspension time (h)
					Type of knot	Anatomical position of loop	Anatomical position of knot	
1	48	22.9	Rope	Atypical incomplete	Slip knot	Above thyroid cartilage prominence	Regarding left mastoid	4 ± 1
2	33	23.7	Girths	Atypical incomplete	Slip knot	Above thyroid cartilage prominence	Regarding left mastoid	12 ± 2
3	33	22.3	Electric extension	Typical complete	Fixed knot	Above thyroid cartilage prominence	No visible print	7 ± 1
4	83	28.4	Rope	Atypical unknown	Slip knot	Above thyroid cartilage prominence	Behind left mandibular angle	43 ± 4
5	58	23.4	Girths	Atypical incomplete	Fixed knot	Above thyroid cartilage prominence	No visible print	8 ± 1
6	25	19.9	Rope	Atypical complete	Fixed knot	Above thyroid cartilage prominence	No visible print	5 ± 1
7	29	20.8	–	–	–	–	–	–
8	59	26.3	–	–	–	–	–	–
9	75	23.2	–	–	–	–	–	–

injuries, etc. The bodies were preserved at a temperature of 4 °C after their admission to the forensic department and prior to the different examinations.

### 2.2. Postmortem MRI and videolaryngofibroscope

The teleryngoscopy examinations were conducted using a flexible nasolaryngofibroscope Olympus ENF type P4 and conventional video system with microcamera Storz tricam. Images were digitalized using image capturing program E-capture (Metris).

For MRI, the bodies were wrapped in artifact-free body bags to prevent contamination of materials. All MR examinations were performed with a 1.5-T system (Intera Achieva 1.5 T; Phillips) and consisted in T1, T2 fast spin-echo (FSE) and short-tau inversion recovery (STIR) sequences with an antneck coil (Neurovascular 8 channel Array head-neck).

The mean times between estimated death, laryngofibroscope examination and imaging were 27 and 38 h, respectively.

### 2.3. Forensic autopsy

A standard autopsy was performed according to current guidelines at an average time of 9 h after imaging. The layer by layer neck dissection was undertaken after evisceration of the other organs following the protocol of Prinsloo and Gordon [8] and the cervical spine was extracted and examined after removal of vertebral body. In all the autopsied cases, samples of each major organ and injured tissue were histologically analyzed after formalin fixation, embedding in paraffin and hematoxylin–eosin–safron staining. After macroscopic examination, when a fracture was present, the laryngeal skeleton conserving the surrounding adherent soft tissue was decalcified with a 10% HNO<sub>3</sub> solution and microscopically examined.

### 2.4. Data analysis

A direct comparison of the imaging, videolaryngofibroscope, autopsy and histology findings was carried out taking the autopsy and histology data as reference.

## 3. Results

### 3.1. Subject and hanging characteristics

The main subject and hanging characteristics are summarized in Table 1. In all the hanging cases, the ligature mark on the neck was always above the thyroid cartilage prominence. The causes of death revealed by autopsy and toxicological analysis of blood, urine and gastric content samples of the last three subjects (cases 7–9) were opioid intoxication, myocardial infarct and ballistic intracranial trauma, respectively.

### 3.2. Comparison of autopsy and imaging findings in hanging cases

The results of comparison between autopsy and imaging findings concerning neck structures except for buccal and endolaryngeal elements are shown in Table 2.

**Table 2**

Cervical findings by MRI and autopsy (N=5, and the number of the observations is indicated in brackets).

Findings	MRI	Autopsy
Subcutaneous hemorrhage	3 [1,3,4]	4 [1,3–5]
Intramuscular hemorrhage	4 [1,3–5]	4 [1,3–5]
Perivascular hemorrhage	1 [4]	1 [4]; Fig. 1A
Fracture of hyoid bone	0	1 [2]; Fig. 1B
Fracture of laryngeal cartilages	0	0
Sinusal lymph node congestion	3 [2,3,5]	3 [2,3,5]
Epidural cervical spinal hemorrhage	1 [3]	1 [3]

In all cases, the autopsy suggested the asphyxial nature of death and the histological aspect of the lungs were similar and consisted in emphysema (Fig. 1C). In these five observations, hanging was due to suicide attempt.

### 3.3. Comparison of buccal and endolaryngeal findings on autopsy, laryngoscopy and imaging in hanging cases

The results of correlation of laryngofibroscope, MRI and autopsy findings concerning the endobuccal and endolaryngeal structures are summarized in Table 3.

The abundance of secretions found during nasolaryngofibroscope (performed in all cases before MRI) above the glottic plane required an aspiration system to progress into the laryngeal tract. The posterior placement of the root of the tongue observed in two cases was responsible for complete obstruction of the oropharynx in the median plane (Fig. 2A). The base of tongue congestion (Fig. 2B) gave a cyanic pseudo-ecchymotic aspect to this anatomical region with laryngoscopic examination and hyper-signal in T2-weighted MRI. In all cases, vocal cord adduction in the median plane was observed with contact between the vocal processes of arytenoid cartilages (Fig. 3).

**Table 3**

Endolaryngeal findings at laryngoscopy and imaging examinations and autopsy (N=5).

Findings	Laryngoscopy	MRI	Autopsy
Abundant secretions	5	0	0
Posterior lingual fall	2 [3,5]	2 [3,5]	0
Base of tongue congestion	2 [1,4]	2 [1,4]	2 [1,4]
Adduction of vocal cords	5	5	0

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