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Assessment of laryngeal tube placement on post mortem computed tomography scans

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A B S T R A C T

Background: Laryngeal tubes (LT) as opposed to endotracheal tubes (ET) appear to be relatively rare in the medico-legal caseload of the Institute of Forensic Medicine of the University of Zürich(IFMZ). They contain possible relevance for medicolegal casework: they significantly differ from ET in that a LT's lower end correctly resides in the upper esophagus, and despite being designed to specifically facilitate fast and easy correct placement particularly in emergency situations they might not always live up to expectations. This study documents the computed tomography (CT) post mortem appearance of an LT as well as three cases with such a device in place. *Method and material*: One LT device and all three bodies admitted to the IFMZ so far that were found to contain an LT in situ underwent CT scanning. *Results*: Of three cases, one was found to contain an LT that was both in correct position and patent. A second case contained an LT that was blocked by food. In a third case the LT was positioned too low relative to anatomical landmarks. Only the case with correctly placed and patent LT featured an inflated and ventilated appearance of the lungs. *Conclusions*: LT position and patency should be examined and reported not just by radiologists but also by forensic pathologists. No conventional autopsy technique has been published so far to exhibit the relevant details in relation to LT usage.

1. Introduction

Laryngeal tubes (from hereon abbreviated as LT) are relatively new devices used for emergency mechanical ventilation [1]. The LT (Fig. 1) is a multiple use silicon tube. It contains a connector to attach a manual or machine ventilator (CN, Fig. 1), an oropharyngeal cuff (OC, Fig. 1), a ventilation outlet (VO, Fig. 1) and an esophageal cuff (EC, Fig. 1) [1].

Optimal placement of an LT (normal anatomy, see Fig. 2, A1 and A3) is shown in Fig. 2 A2: the connector (CN, Fig. 2) remains outside the mouth, whereas the oropharyngeal cuff (OC, Fig. 2) resides cranial to the hyoid bone (H, Fig. 2). As result, the ventilation outlet (VO, Fig. 2) opens into the tracheal laryngeal inlet. The esophageal cuff (EC, Fig. 2) impedes air from entering the stomach and serves to block gastric contents from getting aspirated into the airways. With that, the targeted optimal position in the esophagus significantly differs from the expected position of a conventional endotracheal tube.

>LTs are reported to be fast (average of 21 s) and easy to place correctly [1]. Failed ventilation seems to occur rarely, according to one study only in 2 out of 35 patients (6%, [2]). Compared to that, laryngeal mask airways (39 s, +85% compared to LTs) and endotracheal intubation (average of 201 s, +857% relative to LTs) take considerably longer to install [3]. Wrong initial placement of ETs appears to be considerably more frequent with ET placement in up to 51% [4,5]. The LTs also have drawbacks though. Incidence of laryngo-pharyngeal discomfort after laryngeal mask airway placement can be as high as twice compared to endotracheal intubation [6]. Tissue congestion with lymphatic and venous congestion has been mentioned in context of LTs, particularly under hypotension that may systematically accompany general anesthesia [7]. One thus might assume that LTs as well as laryngeal airway masks tend to be used more often in emergency situations than in elective intubation.

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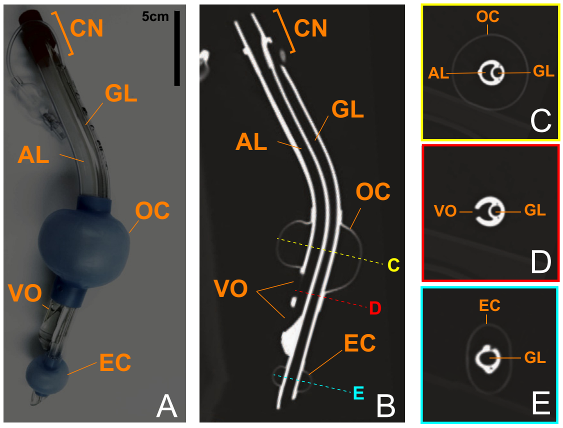

Fig. 1. Photograph (A, bar 5 cm) and CT morphology (B–E) of a larnyx tube. In detail, a lengthwise CT section (B) exhibits the connector (CN), lumen to ventilate air (AL, cross sectioned on C, and air lumen opening into ventilation opening in image D), lumen for gastric tube (GL, cross sectioned in C), oropharyngeal cuff (OC, see also C), ventilation openings (VO, cross sectioned in D) and the esophageal cuff (EC, also in E). Cross section images C–E are referenced in image B. (For interpretation of the references to color in this figure caption, the reader is referred to the web version of this article.)

Forensic pathologists are in a privileged position also to document specific pathology after resuscitation attempts failed [8,9]. Despite that, post mortem issues related to LTs do not appear to be documented well throughout medicolegal literature; also, coverage in authoritative text books is minimal at best (e.g. [10–12]). A survey of our own casework did not yield more than three autopsy cases (detailed below).

A number of reasons may explain why that device appears to be seen relatively rarely by forensic pathologists. When paramedics go out on an emergency, they might be licensed to place an LT but as it turns out, they usually will not actually use LTs. In the region of Greater Zürich, medical doctors are the professional group that is trained to perform endotracheal intubation. Typically, on location usually fast enough, and their preference appears to be to place an ET rather than LTs. Also, LTs are designed for multiple use [1]. While there appears to be no jurisdiction in Switzerland explicitly requesting paramedics to leave tubes in place, one-way use still seems to be practiced for most resuscitations that are performed out of hospital.

This study documents CT (computed tomography) appearance of an LT as such. Furthermore, its CT appearance *in situ* is demonstrated as seen in three cases at the IFMZ so far. Forensic pathologists encounter different end points than anesthetists, not only with regard to lethal outcome but also with regard to LT placement. So these observations could be of particular interest to anesthetists and pathologists alike.

2. Methods and material

2.1. Laryngeal tube

LT models found to be present in the bodies matched appearance of a King LTS–D™ (King Systems, Noblesville, Indiana, USA) which also was the model documented separately (Fig. 1).

2.2. Cases

All IFMZ autopsy cases containing an LT were included in this study. All three cases were examined with authorization by the respective local investigative authorities.

*Case*1: A 53 year old man was found unconscious in the stairway of the house he was living in. His scalp exhibited superficial lacerations and his right incisive tooth (1.1) was fractured. Resuscitation attempts were unsuccessful. Body length, 182 cm; weight, 55.6 kg; and BMI, 16.8.

*Case*2: A 42 year old man with mental retardation suffering from epilepsy was found unconscious by a warden of his residential home. Choked up food of his last meal were found to block his throat. Resuscitation attempts were unsuccessful. Body length, 175 cm; weight, 71 kg; and BMI (body mass index), 23.2.

*Case*3: A 51 year old man suffered sudden onset of severe dyspnea and muscle cramps with foam exuding from his mouth about 1 h after starting soccer team training. He collapsed. Resuscitation attempts were unsuccessful. Body length, 177 cm; weight, 87.5 kg; and BMI, 27.9.

2.3. CT scanner and data visualization

A 128-slice dual source CT scanner (Somatom Definition Flash, Siemens, Erlangen, Germany) was used. Scans were obtained at 120 kV, 350–1000 mAs and 128 x 0.6 mm collimation. Multiplanar and axial slice images were obtained at arbitrarily chosen windowing levels and widths using standard workstation equipment ("Somaris/7 syngo 2011A" software; hardware: "Leonardo" workstation, Siemens, Erlangen, Germany). Volumes of lungs consistent with ventilation – CT density −650 to −1000 Hounsfield units (HU) – were estimated using standard thresholding software ("syngo MMMWP VE36A" software; hardware: "Leonardo" workstation, Siemens, Erlangen, Germany).

3. Results

3.1. Computed tomography appearance of laryngeal tubes in situ

CT appearance of the LT as such: There are two lumina, one to contain a gastric tube (GL, Fig. 1), the other one to ventilate air or gas (AL, Fig. 1) into the laryngeal inlet of the trachea. Cross sections of the tube at different levels (C, D and E, Fig. 1; location of C, D and E cross sections indicated in B as colored marks) show the cuffs and ventilation outlet.

Correct position, patent lumen: Only in one case (case 1, Fig. 2 B1–B3), the LT was both patent and featured a position of the oropharyngeal cuff (OC) cranial to the hyoid bone (H) (Fig. 2 B1). The lungs contained a low density and thus appeared relatively well inflated (B2) while the stomach contained only little gas (B3). CT-based estimation of ventilated lung volume was 1412 cm^3.

Blocked lumen: The LT's ventilation outlet in case 2 (Fig. 2, C1–C3) is mostly blocked by the CT-correlate of food content with a similar appearance to that found in the stomach (C3). CT-based estimation of ventilated lung volume was 70 cm^3.

Low position: In contrast, the LT installed in case 3 (Fig. 2, D1–D3) exhibited a significantly more caudal position of the oropharyngeal cuff (OC) with most of that device's part below the hyoid bone (H). Volume rendering (Fig. 3) shows that one of the ventilatory openings' position possibly allows air to ventilate the lungs. The stomach has a partly air- or gas-filled appearance (D3). CT-based estimation of ventilated lung volume was 279 cm^3.

With a mostly blocked LT (case 2) and rather low position (case 3), lungs in axial views of both of these cases (C2, D2) contained considerably higher CT densities and thus appeared to be less distended or inflated compared to case 1 (B2). CT based estimation of ventilated lung volumes (thresholding tool set to capture volume between −650 and −1000 HU) yielded markedly reduced volumes for cases 2 (blocked tube: 70 cm^3) and 3 (downwardly