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Effective Use of Video Laryngoscopy in Emergencies

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The importance of a successful first attempt in endotracheal intubation is demonstrated in several studies. In addition to excellent training and routined skills of the performers, a standardized procedure in the team with extensive pre-oxygenation and optimal patient positioning as well as a sufficiently deep anesthesia including muscle relaxation, and finally the use of a video laryngoscope with the first attempt may contribute to a high first-pass-success. This article describes the possibilities of video laryngoscopy in out-of-hospital emergency medicine.

ABBREVIATIONS

CPR	Cardiopulmonary Resuscitation
DGAI	German Society of Anesthesia & Intensive Medicine
DL	Direct Laryngoscopy
EOLM	External Optimal Larynx Manipulation
FPS	First-Pass Success (successful placement [of the endotrachel tube] in the first pass)
HWS	cervical spine
ROSC	Return of spontaneous Circulation
VL	Video Laryngoscopy

Introduction

In various indications, patients already benefit from a secured airway and hence guaranteed oxygenation and ventilation in prehospital care [1–5]. Despite all the developments of alternative airway devices in recent decades, endotracheal intubation under laryngoscopic view remains the gold standard in airway management. Particularly in emergency situations, however, laryngoscopy can be unexpectedly difficult even for experienced users [6–8]. This results in repeated intubation attempts that can lead to oral, pharyngeal, and laryngeal injuries, bleeding, or mucosal swelling and – due to the delayed oxygenation – to dramatic drops in arterial oxygen saturation [9–14]. Furthermore, experience shows that each further intubation attempt is more difficult than the preceding one – due to both the previously incurred injuries and the strain on the intubating professional. Correspondingly, various studies prove a rise in complications (e.g., desaturation, faulty intubation, aspiration, dental trauma, or hypotension) as the number of intubation attempts necessary for securing a definitive airway increases [15–19]. Among 1,828 laryngoscopic intubation procedures performed by emergency physicians at an emergency room, Sakles et al. describe such complications in 14% of cases when the first intubation attempt was successful, but in 47% of cases when a second intubation attempt was necessary [15]. Clearly, successful airway management also affects the results of cardiopulmonary reanimation (CPR). Kim et al., for example, show that multiple endotracheal intubation attempts performed as part of CPR were associated with a considerably lower probability of return of spontaneous circulation (ROSC): The ROSC rate following successful 1st intubation attempt vs. multiple intubation attempts was 60% vs. 43% (p = 0.006) [19].

OVERVIEW

Possible complications though multiple intubation attempts

- Desaturation
- Gastric Intubation
- Aspiration
- Teeth Damage
- Hypotension

Note

With this knowledge, one must aim for a "first-pass success" (FPS)- successful placement of the endotracheal tube in the first attempt especially while securing airways in emergencies [10, 15].

With this in mind, it is important to strive to achieve maximum first-pass success (FPS) – that is, successful placement of the endotracheal tube on the first attempt – particularly in airway management in emergency situa-

tions [10, 15]. Many aspects can contribute to high FPS, including excellent training and regular practice of intubating professionals as well as a standardized procedure in the team with extensive pre-oxygenation, optimal patient positioning, and sufficiently deep anesthesia including muscle relaxation [20, 21].

In recent years, a growing number of studies have shown that FPS can be improved in a clinically relevant manner by the primary use of video laryngoscopy (VL). For instance, a study by Sakles et al., which was also conducted in the ER, showed an FPS of 90 % for VL compared to 73 % for direct laryngoscopy (DL) [22]. Promising results have now been published for the prehospital setting as well: In a prospective observational study conducted at a German air rescue base, prehospital airway management was successfully performed in 227 of 228 patients when a video laryngoscope with Macintosh-like blade was used in the first intubation attempt as a standard measure (overall success rate: 99.6 %); a supraglottic airway was needed only in one trapped patient [23]. In 57 of these patients, who received prehospital care by anesthesiologists experienced in VL, VL improved the view of the glottis from grade III/IV according to Cormack/Lehane [24] (under direct laryngoscopy) to I/II under VL ($p < 0.001$). Similar positive results of the use of VL were found by a retrospective data analysis of intubations performed by paramedics in the US. In this case, use of VL ($n = 195$) was associated with a higher FPS of 95 % than DL at 75 % ($n = 593$) ($p < 0.001$) [24].

Video laryngoscopes for use by emergency physicians are currently being purchased by a growing number of facilities. However, many of them keep video laryngoscopes only as a backup solution for the difficult airway. This concept has drawbacks: While rare use exclusively for the difficult airway limits costs (particularly in case of devices with single-use blades), exclusively using them in situations where conventional intubation attempts under DL have already failed means that intubating professionals gain less experience with the video laryngoscope.

In addition, the exclusive use of video laryngoscopes as an alternative after failed direct laryngoscopy only extends the algorithm until a definitive airway is secured and hence increases the risk of hypoxia. With this in mind, video laryngoscopes for emergency use should not be kept only as an alternative for the unexpected difficult airway but be generally used as first-line devices in first intubation attempts as well [23]. Doing so does not change the general procedure or the known airway algorithms (e.g., the DGAI recommendation for prehospital airway management [24]): The preparation, positioning, and pre-oxygenation of the patient as well as the alternative airway management techniques remain the same; only the laryngoscope is replaced by a video laryngoscope – thereby replacing DL by VL in the first intubation attempt [25] (▶ **Fig. 1**).

PRACTICAL ADVICE

Principles

Currently increasingly more bases are procuring video laryngoscopes for emergency medical services. However, on many bases, video laryngoscopes are only kept available as a backup-solution for difficult airways.

This concept should be viewed critical:

- In fact, through rare use only on difficult airways, costs (especially when using devices with single-use blades) can be kept low. However, the necessary routine in the use of the video laryngoscope would lack if only used in situations, in which conventional intubation attempts with direct laryngoscopy failed.
- Additionally, the solely use of video laryngoscopes as an alternative after failed direct laryngoscopy would only extend the algorithm until definite securing of the airway and with that increase the risk of hypoxia.

With this in mind, video laryngoscopes should not only be hold available as an alternative for unexpected difficult airways, but used always as a "first line device" with the first intubation attempt [23].

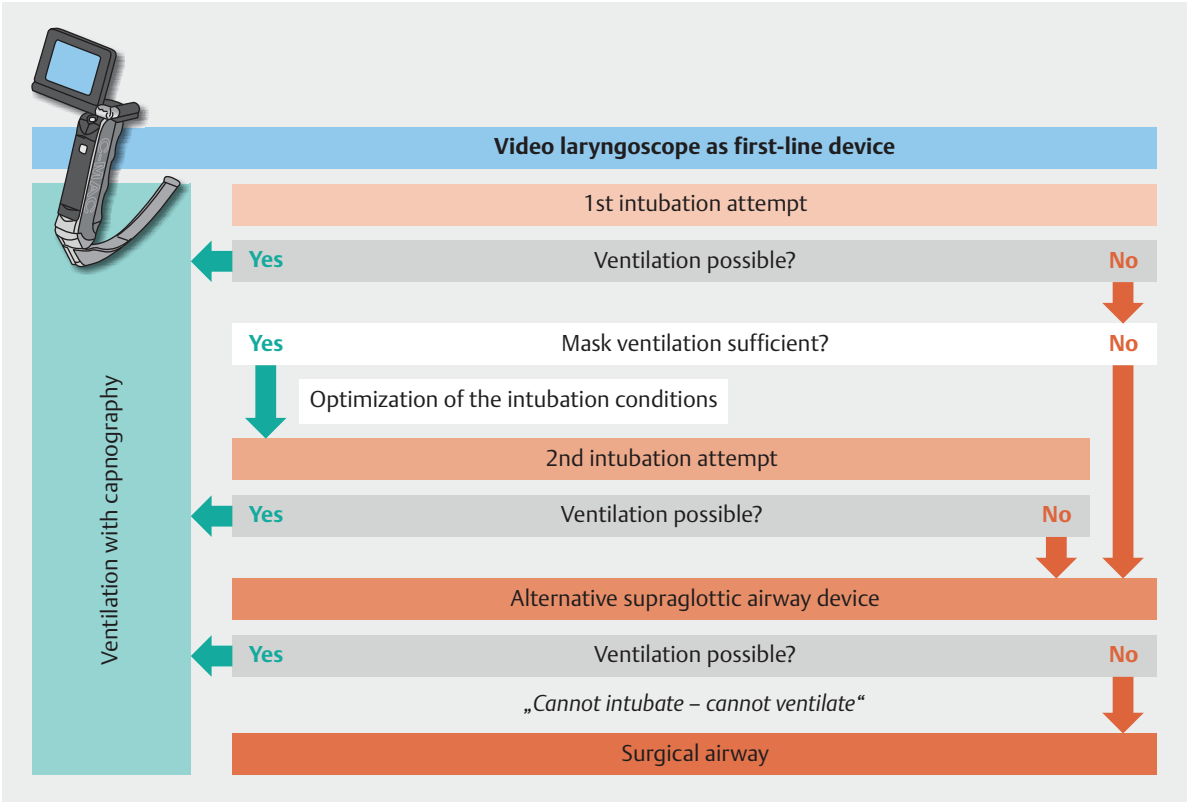
This paper is intended to describe the technique of video laryngoscopy and to support users in airway management.

Technique

All video laryngoscopes feature a camera next to the light source at the blade tip. The image captured in this manner is transmitted to a small monitor at the handle of the video laryngoscope or to a larger external monitor. Unlike conventional DL, which provides only the intubating professional with a view of the glottal level, the monitor image offers the entire rescue team an impression of the intubation site. This makes it easier for paramedics or nurses to support the emergency physician in performing laryngoscopy (e.g., through Optimal External Laryngeal Manipulation, OELM).

Note

Video laryngoscopy provides the intubating professional with a better view of the glottis and improves assistance options since the entire team can view the monitor image of the intubation.



▶ **Fig. 1** Airway algorithm with primary use of video laryngoscopy (modified acc. to [24]).

▶ **Fig. 2** Comparison of a Macintosh blade (top) with a hyperangulated blade (in this case, the D-BLADE, bottom) using the example of the C-MAC®, KARL STORZ, Tuttlingen.

Various Blade Shapes

It is difficult to comprehensively present all available systems, but a classification by blade shape is possible. Video laryngoscopes with hyperangulated blades (e.g. GlideScope Ranger, Verathon Medical Ltd, Birmingham, UK) are distinguished from those with "classic" Macintosh blades or Macintosh-like blades (e.g., C-MAC®, KARL STORZ, Tuttlingen, D) (▶ **Fig. 2**).

Hyperangulated blades

Hyperangulated blades are advanced medially over the tongue and allow "looking around the corner" – meaning that the monitor image is the only possible laryngoscopic view – DL via the eye-larynx axis is impossible with these systems (▶ **Fig. 3**). If the blade tip with the camera is immersed in blood, saliva, or vomit or becomes smudged or fogged, no view of the glottal level is available at all. For the emergency room, Sakles et al. report moderate problems due to the smudged camera of the video laryngoscope in 12.2% and severe problems in 13.3% of cases [28]. Intubation under visual control using a hyperangulated blade is much more difficult and virtually impossible in such cases.

Note

The monitor image is the only possible laryngoscopic view, if hyperangulated blades are used – a DL through the eye-larynx-axis is impossible with these systems (▶ Fig. 3).

Cave

If the distal tip of the blade immerges in blood, secretions or vomit, the camera get smeared or fogged, no view on the vocal cord area is possible, if hyperangulated blades are used.

Provided with a clean camera, a clear image is relatively easy to achieve in indirect laryngoscopy. However, since the blade is hyperangulated, the tube must be able to follow this angulation. Some manufacturers offer special guide rods (stylets) for this purpose, while others have equipped the blade with a guide channel to slide the tube into the field of view in a guided manner. Despite optimal visualization of the vocal cords, in indirect video laryngoscopy using a hyperangulated blade, it is virtually impossible to place the tube endotracheally in a classic manual manner without additional aids.

Use of intubation catheters

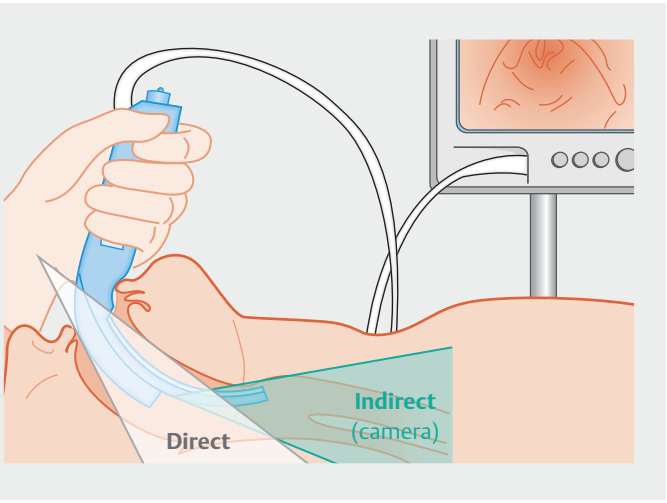
An elegant alternative is the use of intubation catheters (e.g. FROVA, Cook, Bloomington, USA or S-Guide, VBM, Sulz am Neckar, D). These "rods" can be pre-bent to match the angulation of the blade and placed endotracheally under video laryngoscopic guidance. Afterwards, the tube is railroaded over this intubation catheter using the Seldinger technique under continued VL, endotracheally positioned and secured in place. The authors recommend this procedure particularly when using video laryngoscopes with hyperangulated blades.

Note

The availability and use of suitable stylets, guide rods, or intubation catheters are an absolute necessity for safe tube placement with hyperangulated video laryngoscope blades.

Video laryngoscopes with Macintosh (-like) blades

Video laryngoscopes with Macintosh or Macintosh-like blades do not allow "peeking around the corner" with a camera at the blade tip but still achieve a better view than DL of the glottal level according to Cormack and Lehane [26]. In addition, these blade systems permit a direct view of the glottis at all times in parallel with (indirect) VL. For this purpose, however, video laryngoscopes with Macintosh blades are not advanced medially over the tongue, but are inserted in the right side of the mouth as in conventional laryngoscopy, and the tongue is swept to the left. This allows an optimal axis of view to the laryngeal inlet.



▶ **Fig. 3** Viewing axes of direct and indirect laryngoscopy (source: Kill C, Dersch W., Jerrentrup A. Videolaryngoskopie. Notfallmedizin up2date 2012;7: 5–8).

If VL is impaired by soiling of the camera, a switch from (indirect) VL to DL is possible at any time without changing the laryngoscope, and the tube can be placed under direct view. Furthermore, the use of a hyperangulated blade was required only in rare exceptions in a set of prehospital emergency patients [23]. Some manufacturers offer alternative blades to exchange for this purpose.

Note

Video laryngoscopes with Macintosh blades provide a better video laryngoscopic view and still permit direct laryngoscopy at any time, e.g., in case of a soiled camera.

Video laryngoscopy in patients with cervical spine immobilization

Particularly for the subgroup of 483 patients with immobilized cervical spine, another study on video laryngoscopic intubation of trauma patients in the trauma room shows a much higher FPS for VL, at 87 % vs. 80 % under DL ($p = 0.03$) [27].

PRACTICAL ADVICE

That is why the ventral opening of the immobilization collar together with manual in-line-stabilization is advised with laryngoscopy. This enables an improved mouth opening during laryngoscopy and intubation without risking the stabilization of the cervical spine.

Under cervical spine immobilization, laryngoscopy can be far more difficult, especially since the available cervical

▶ **Fig. 4** Manual in-line stabilization performed by an assistant since the cervical collar is ventrally opened for video laryngoscopy.

collars not only prevent head reclination, but their design also significantly restricts the patient's mouth opening. For laryngoscopy, it is recommended to ventrally open the cervical collar and ensure manual in-line stabilization. This permits a better mouth opening during laryngoscopy and intubation without endangering the stability of the cervical spine. Of 116 trauma patients, 98 patients (84.5%) were cervically immobilized as appropriate for the type of accident [29]. To facilitate laryngoscopy, the employed cervical collar was ventrally opened in 81 cases, and the cervical spine was manually in-line stabilized by a paramedic. Not all of the 17 video laryngoscopic intubations that were performed using a VL with Macintosh blade (C-MAC®) with a closed cervical collar were successful upon the first attempt [27]. To achieve a high FPS, the collar should therefore be ventrally opened under manual in-line stabilization of the cervical spine for VL as well. (▶ **Fig. 4**)

PRACTICAL ADVICE

For a high FPS, the immobilization should be opened ventrally additional to video laryngoscopy as well as the cervical spine should be stabilized in-line (▶ **Fig. 4**).

Note

Cervical spine-immobilization-collars not only limit the reclination, but also the mouth opening of the patient, therefore securing the airway with manual in-line stabilization also under video laryngoscopy should be done with ventral opened immobilization collar!

Problems and limitations

In video laryngoscopy, the blade is often inserted too far. As a result, the camera is positioned directly at the glottis, and the image quality seems high. However, the advanced tube then enters the field of view late or not at all, and intubation may fail. In these cases, it can help to carefully retract the blade by 1–2 cm; the field of view will become wider and the tube tip will appear in the image at an earlier time, thereby facilitating manipulation and placement.

Note

If the video laryngoscope blades are inserted too deep, the camera will be too close to the vocal cords area, and the passage of the tube will not be visible; in such cases it helps, to carefully pull back the blade!

Studies also describe other limitations of VL: reduced contrast on the monitor due to bright light or soiling of the objective lens by blood or secretions or fogging of the lens, particularly in cold temperatures, have been repeatedly described. However, light conditions can be a problem in DL as well since the intubating professional's eye cannot easily adjust to the comparatively dim light of the laryngoscope, particularly in case of very bright ambient light (e.g., when the sun is low in the sky). An umbrella or a blanket can help to create some shade (▶ **Fig. 5**).

PRACTICAL ADVICE

In difficult light conditions, a screen or a blanket helps to provide shade (▶ **Fig. 5**).

Fogging of the camera seems to be more common with the use of single-use blades since a small space in which moist air can condense is created between the single-use blade and the camera. A similar phenomenon can arise when the video laryngoscope is introduced into the patient's pharynx immediately after being switched on

("moist breath"). In these cases, it can help to switch on the video laryngoscope during pre-oxygenation since the light source warms up the camera or to apply an anti-fogging agent as used in endoscopy. The soiling of the lens, however, particularly presents a problem in indirect video laryngoscopes with hyperangulated blades; considering this aspect, the authors recommend using VL blades that permit indirect VL as well as DL without requiring a switch to another instrument (Macintosh-like blades) [23]. For cases with a particularly difficult airway, a hyperangulated laryngoscope blade that exclusively allows indirect laryngoscopy by VL (e.g., D-Blade) may be included as well.

PRACTICAL ADVICE

In order to avoid fogging of the camera, it can be helpful to switch on the video laryngoscope during the pre-oxygenation already, to let the light source heat up the optics, or use anti-fog solution, as known from endoscopy.

Conclusions

The primary use of video laryngoscopy permits much higher first pass success rates in emergency airway management. In addition to this new technique, however, this also requires training and experience in the use of these video laryngoscopes [30, 31].

KEY MESSAGES

- The importance of a successful first intubation attempt in securing airways has been demonstrated in several studies.
- The following contributes for a successful first intubation attempt:
  - good education and regular training of the operators.
  - standardized team approach
  - ample pre-oxygenation
  - optimal positioning of the patient
  - ample deep anesthesia
  - use of muscle relaxanzes
  - use of a video laryngoscope
- Video laryngoscopy enables a higher success rate of the first intubation attempt in the emergency situation.
- Video laryngoscopy enables a better visible monitor view on the vocal cords area for the person intubating.
- Video laryngoscopy improves the possibility for assistance through a visible monitor view for the complete rescue team.

▶ **Fig. 5** Assistants hold up a blanket (top right) to create some shade. In both VL and DL (picture), very bright ambient light can complicate laryngoscopy.

Conflict of Interest

B. Hossfeld got travel expenses refunded by from the company KARL STORZ, Tuttlingen. M. Kulla: German interdisciplinary society of Intensive and emergency medicine (DIVI): travel and hotel expenses and financial support for an open-access publication; Federal Ministry of Defense – support code SoFO 34K3–17 1515 (DigiPen): Research funds for the development of a medical registry for the military forces; Federal Ministry of education and research – support code 01KX1319A (AKTIN): Applicant – no financial or other support; Federal Ministry of Defense – support code SoFO 37K3-S-20 1618 (HappiER): Patientenzufriedenheit in der Notaufnahme. M. Bernhard, J. Knapp and M. Helm indicate no conflict of interest.

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