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Review

Update on video laryngoscopy in the emergency environment: The most important publications of the last 12 months

Jochen Hinkelbein [a,*], Fabrizio Cirillo [a,b], Edoardo De Robertis [b], Oliver Spelten [a]

[a] *Department of Anaesthesiology and Intensive Care Medicine, University Hospital Cologne, Kerpener Str. 62, 50937, Cologne, Germany*
[b] *Department of Neurosciences, Reproductive and Odontostomatological Sciences, University of Naples "Federico II", Via S. Pansini, 5, 80131, Napoli, Italy*

A R T I C L E I N F O

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1. Introduction

The use of video laryngoscopes has increased over the last years significantly for many pre-hospital and in-hospital emergency situations. Whereas their use was limited to elective intubations, especially for the anticipated difficult airway, they are used today for a broad spectrum of indications. In general, it seems that the learning curve for video laryngoscopes is very steep and especially beginners may benefit from their use. However, both experienced anaesthesiologists and beginners have usually a high success rate for tracheal intubation when using video laryngoscopes.

This review presents and analyses recent publications and gives an oversight on published data on video laryngoscopes use in emergency environment. Identification of articles with a focus on video laryngoscopy for emergency situations was made in the MEDLINE database (http://www.pubmed.org) from August 1st, 2014 to August 1st, 2015. Articles were then independently screened and rated by each author for further analysis and, after consensus selected for inclusion.

2. Faster and more successful

Tracheal intubation is considered gold standard for securing the airway during cardiopulmonary resuscitation (CPR) or after the return of spontaneous circulation (ROSC) [1,2]. It is also considered the optimal method [3] and was associated with better outcomes in

* Corresponding author. Department for Anaesthesiology and Intensive Care Medicine, University Hospital Cologne, Kerpener Str. 62, 50937, Cologne, Germany.
E-mail address: jochen.hinkelbein@uk-koeln.de (J. Hinkelbein).

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some recent CPR studies [4]. However, tracheal intubation during CPR is a high-risk procedure [5] and has a lower success rate [3] as compared with in-hospital tracheal intubation for anaesthesia which may be caused by adverse environmental factors [1,6]. Additionally, repetitive and prolonged tracheal intubation attempts by direct laryngoscopy may reduce CPR quality and prolong no-flow time [3] and, therefore, may be associated with poor outcomes for cardiac arrest victims [7]. Recent studies showed a higher success rate and faster intubation attempts when using video laryngoscopes in emergency medicine patients instead of conventional, direct laryngoscopy [6,8]. This effect might even be more significant with less training in tracheal intubation [9].

To analyse video laryngoscopy as compared with direct laryngoscopy during CPR, Park et al. [3] performed a historically controlled clinical study in a tertiary training hospital in Seoul to analyse the improvement of tracheal intubation performance during CPR in novice physicians. Eight first-year residents, with no clinical experience of tracheal intubation beforehand, participated in the study, which consisted of two different time-frames (May, 2011, to April, 2012, and May, 2012, to April, 2013). The success rate of the first attempt tracheal intubation was chosen as the primary outcome parameter. The authors analysed a total of 305 adult victims with out-of-hospital cardiac arrest (OHCA) during the two-year study period in which 83 tracheal intubations (34 vs. 49) were performed by direct laryngoscopy or GlideScope video laryngoscopy (Verathon, Bothell, WA, USA).

The overall success rate of the first tracheal intubation attempt was significantly higher in the video laryngoscopy group (91.8%) as compared with direct laryngoscopy (55.9%; $p < 0.001$). Congruently, the time to place the tracheal tube was significantly shorter when using a video laryngoscope (37 vs. 62 s; $p < 0.001$) and the number of oesophageal intubations was lower in the video laryngoscopy group (0 vs. 6). Concerning the quality of CPR, the use of a video laryngoscope resulted in significantly less interruptions of chest compressions (0 vs. 7; $p < 0.001$).

This study by Park et al. [3] is the first analysing several different quality parameters of tracheal intubation by direct laryngoscopy as compared with video laryngoscopy. The results of this study clearly show that using video laryngoscopy for ETI during CPR results in faster and more secure tracheal tube placement and a higher quality of CPR in novice physicians. Fastening tracheal intubation with a higher success rate is of utmost experience especially in less trained physicians and seems to be feasible when using video laryngoscopes. In contrast to conventional laryngoscopy, where 100–150 tracheal intubations are required to reach a success rate of >95% [9], the learning curve of video laryngoscopy is steeper. Additionally, video laryngoscopy has shown to facilitate tracheal intubation during frontal intubation [8] or in inconvenient intubating conditions [6]. Since the number of participants in the study was very low, future studies should focus on this aspect and validate the findings in both a larger cohort of patients and more skilled physicians.

3. In-hospital intubation success rate

Supplementary, Lee and colleagues [5] investigated the efficacy of video laryngoscopy for in-hospital tracheal intubation during CPR and, therefore, used a comparable approach to this topic.

Between January, 2011, and December, 2013, the authors prospectively collected data from 229 CPR patients for retrospective analysis. In their study, the initial laryngoscopy method was video laryngoscopy in 121 patients (52.8%) and direct laryngoscopy in 108 patients (47.2%) [5]. Video laryngoscopy was performed through GlideScope or Airway scope (Pentax Corporation, Tokyo, Japan), depending on the availability at the moment, but the precise type of video laryngoscopy was not recorded. The rate of successful tracheal intubation at the first attempt was significantly higher with video laryngoscopy (71.9%) as compared with direct laryngoscopy (52.8%; $P = 0.003$). For experienced physicians, the rate of success at the first attempt was higher (73.0%) than for inexperienced operators, including residents (52.6%; $P = 0.001$). However, mortality at day 28 after CPR was not significantly different between patients with successful tracheal intubation at the first attempt and without (68.1% [98/144] vs. 67.1% [57/85]; $P = 0.876$).

In a multivariate logistic regression analysis, a predicted difficult airway (odds ratio, OR, [95% CI] = 0.22 [0.10–0.49]; $P < 0.001$), intubation by an experienced operator (2.63 [1.42–4.87]; $p = 0.002$), and the use of video laryngoscopy rather than direct laryngoscopy (2.42 [1.30–4.45]; $P = 0.005$) were independently associated with a successful tracheal intubation at the first attempt.

The present study [5], although not analysing OHCA but IHCA patients, found comparable results to the study by Park and colleagues [3]. Congruently, both studies found that the use of video laryngoscopy during CPR from in-hospital or out-of-hospital cardiac arrest was independently associated with successful tracheal intubation at the first attempt. Moreover, time to successful tracheal intubation was shorter and complications were less when using video laryngoscopy for tracheal intubation during cardiac arrest and CPR.

Although the authors found these relevant results for tracheal intubation, the study failed to demonstrate any difference in mortality when using either direct or video laryngoscopy. Since CPR quality may be directly associated with the outcome of patients it is curious why the study failed to show any benefit in mortality when using video laryngoscopes. The reason may be the retrospective approach to the data and concealed effects. Therefore, it seems to be desirable to analyse these effects by a randomized controlled trial in the future.

4. Video laryngoscopy for non-CPR cases

Besides advances in tracheal intubation during CPR by video laryngoscopes, analysis of their use in different emergency medical settings is required for a complete assessment. From recent studies, it is well known that out-of-hospital tracheal intubation may be associated with life-threatening complications [1] and that the incidence of difficult tracheal intubation in the out-of-hospital setting is higher than that seen in the operating room [10–12]. Data comparing direct and video laryngoscopy views simultaneously in the same patients in an out-of-hospital setting is scarcely being published.

Bjoern Hossfeld and colleagues from Ulm, Germany, analysed the effect of the C-MAC PM video laryngoscope (Karl Storz, Tuttlingen, Germany) in terms of laryngeal view and compared the data with direct laryngoscopy for estimating possible consequences for patient safety. They used an observational, single-centre study design for patients of the Helicopter Emergency Medical Service (HEMS) 'CHRISTOPH 22', Ulm, Germany [13].

Two-hundred and twenty-eight emergency patients were included undergoing airway management in the out-of-hospital emergency setting. Laryngoscopy and tracheal intubation were performed using C-MAC PM video laryngoscope. For all intubations, the HEMS physician used C-MAC PM as the first-line device and performed an initial direct laryngoscopy followed by a video laryngoscopy, without changing the laryngoscope blade. The difference in laryngeal view was recorded as well as the number of intubation attempts along with the success rate and difficulties in airway management. Improvement in glottic visualisation from Cormack and Lehane grade III/IV to I/II was rated as being clinically relevant.

During a 20-month study period, a total of n = 228 out-of-hospital emergency patients requiring tracheal intubation were included in their study. The overall success rate in securing the airway was 100%. For 226 patients (99.1%), tracheal intubation was successful with two or fewer attempts. Of 223 patients, 120 had a glottic view rated as Cormack and Lehane grade II to IV with direct laryngoscopy; in these patients, visualisation of the glottis was significantly improved with the C-MAC PM video laryngoscope ($P < 0.001$). In 56 patients (25.1%), improvement of glottic visualisation was clinically relevant ($P < 0.001$).

Using the C-MAC PM video laryngoscope was associated with improved visualisation of the glottis according to the Cormack and Lehane grading system and an excellent success rate for out-of-hospital tracheal intubation. The authors suggested that these results indicate that the use of C-MAC PM as a first-line device for tracheal intubation by out-of-hospital emergency medical services is a safe procedure. In synopsis with the other studies, the present study also showed for one specific video laryngoscope that tracheal intubation by indirect laryngoscopy facilitated tube placement and reduced the number of attempts as well as improved the success rate.

5. Randomized Controlled Trial (RCT) results

Silverberg and colleagues [14] from the Beth Israel Medical Centre investigated tracheal intubation by direct laryngoscopy in comparison to video laryngoscopy during urgent tracheal intubation. In contrast to the previous study, they used the GlideScope in a single-centre prospectiveRCT. The authors analysed a total of 153 consecutive patients undergoing urgent -tracheal intubation by pulmonary and critical care medicine fellows resulting in 117 tracheal intubations for analysis.

As previous studies before, the primary outcome measure was the rate of first-attempt success. It was achieved in 74% of the GlideScope group as compared to 40% in the direct laryngoscopy group ($p < 0.001$). All unsuccessful direct laryngoscopy patients were successfully intubated consecutively with the GlideScope, 82% even in the first attempt. In congruency with the previous studies, the complication rate was comparable between both groups.

As the C-MAC PM in the previous study by Hossfeld et al. [13], the results of the present study by Silverberg et al. [14] are in congruency. The use of a video laryngoscope improved first-time success rate during tracheal intubation as compared with conventional, direct laryngoscopy.

Additionally to this specific aspect, numbers presented by the authors are in congruency to other published data. Taken together, video laryngoscopy seems to be the optimal technique to secure the airway by tracheal intubation in physicians with low experience in tracheal intubation or if fast tracheal intubation and a high success rate are required to optimize outcome.

6. Use in special environments

Besides these standard situations in anaesthesiology, intensive care medicine, and emergency medicine, video laryngoscopy may even have advantages over direct laryngoscopy in complex environmental situations. However, previous studies demonstrated that frontal ("ice-pick") intubation in simulated trauma victims as well as with an immobilized cervical spine [8,6] may be a challenge with video laryngoscopes and the use of video laryngoscopes is not always facilitating tracheal intubation in patients. However, face-to-face direct laryngoscopy may also be compromised by the environmental setting [15].

Patrik Schober and colleagues [15] analysed 24 trainee anaesthesiologists attempting tracheal intubation in an entrapped airway manikin. Besides direct and indirect laryngoscopy, they also used the McGrath Series 5 video laryngoscope (Aircraft Medical, Edinburgh, UK) for tracheal intubation. The authors found that the success rate did not differ significantly between the methods but tracheal intubation was significantly faster with the AirTraq size #3 (Prodol Meditec, Vizcaya, Spain) (25 s) and Macintosh size #3 direct laryngoscopy (34 s) as compared with the McGrath technique (55 s). Therefore, the authors concluded that the usefulness of the video laryngoscope was limited due to longer intubation duration. Additionally, they concluded that the AirTraq may be a promising alternative for face-to-face intubation.

In view of a previous study by Wetsch et al. [8,6], the results of the present study are not completely new. As before, the success rate during face-to-face tracheal intubation is not always higher when using a video laryngoscope. Indeed, when using a video laryngoscope in the frontal intubation setting, anatomy is vice versa which may result in more skills demanded [16]. Therefore, more experience is needed.

In view of these publications on the use of video laryngoscopy during emergency medical care, most publications demonstrated a clear benefit of using video laryngoscopes in terms of success rate and time to intubation. However, extraordinary settings like face-to-face intubation possibly eliminate these effects and may result in longer times and higher skills required for tracheal intubation.

The use of video laryngoscopy has also been recently tested for tracheal intubation in a simulated environment of a decontamination room [17]. This situation represents a real challenge in practise, since rescuers wear personal protective equipment that may hamper intubation [18] and, in general, airway management [19]. In this randomized crossover study, 21 emergency medicine residents performed tracheal intubation on a mannequin while wearing personal protective equipment [17]. Tracheal intubation was performed through standard fiberoptic laryngoscopy and GlideScope Cobalt AVL video laryngoscope. The primary outcome measure was time to successful tube placement; secondary outcome was the perceived degree of feasibility of video laryngoscopy as compared to direct laryngoscopy. A total of six alternating procedures, three with video laryngoscopy and three with direct laryngoscopy were performed by each participant.

Mean time to tube placement was 10 s in the direct laryngoscopy group and 7.8 s in the video laryngoscopy group ($P = 0.08$). The mean overall time from blade insertion to bag valve mask attachment was 17.4 s for direct laryngoscopy and 15.6 s for video laryngoscopy ($P = 0.30$).

Differences between the two tracheal intubation procedures did not reach statistical significance. After the simulation, a post-intervention questionnaire reported that video laryngoscopy was perceived as the easiest technique whilst wearing personal protective equipment, but also as the less feasible in that environment. Authors argued that video laryngoscopy could increase operator comfort in these situation without a real evidence of benefit [17]. However, in a previous study on the patient population of a trauma centre [20], time for intubation, defined as the time between insertion and removal of the laryngoscope, was significantly prolonged by video laryngoscopy (GlideScope) compared with Macintosh direct laryngoscopy, without any significant improvement on first-attempt success rate.

7. RCT results

Intubation of patients with cervical spine immobilisation is often a difficult and dangerous manoeuvre [21,22]. A recent randomized controlled trial was designed to compare two video laryngoscopes, C-MAC and GlideScope, in performing tracheal intubation in 56 patients undergoing elective surgery for cervical spine pathology [23].

Spine immobilisation was assured by manual in-line stabilisation, in order to prevent any dangerous movement of the neck. Patients were randomized to receive tracheal intubation through C-MAC (n = 26) or GlideScope (n = 30). The authors did not specify the blade of C-MAC, so we assume they used the Macintosh blade; anyway, as GlideScope, it was used as indirect laryngoscope. No differences were found in the Cormack and Lehane grade at first Macintosh direct laryngoscopy.

The total intubation time between C-MAC and GlideScope was not statistically different (respectively 35 s and 23, P = 0.05), but a lower rate of unsuccessful first-attempt intubation was found with GlideScope (7% vs 42% with C-MAC, P = 0.002). These results suggest that for this particular setting, GlideScope seems to be convenient to reduce the rate of failed intubations as compared with the C-MAC.

A typical situation of anticipated difficult intubation is that patients undergo oral and maxillofacial surgery, often suffering anatomical abnormalities that make tracheal intubation difficult, and for which awake intubation is considered the standard [24,25]. A German RCT compared the C-MAC equipped with the 40° curved D-BLADE with flexible intubating endoscope in 100 maxillofacial surgery patients that needed awake nasal intubation for surgery [26]. Patients were randomized to have awake nasal intubation through a video laryngoscope or flexible intubating endoscope.

Anaesthetists who performed intubation, all experienced in both techniques, were blinded to the randomization until local anaesthesia was declared effective. Video laryngoscopy achieved the shortest time for intubation assuring an equal success rate of flexible intubating endoscope. Similarly, satisfaction of the practitioners and of the patients was the same for both the techniques.

One RCT tested the hypothesis of a reduction of dental traumatism during tracheal intubation through video laryngoscopy [27]. Based on the results of a previous study [28], Pieters et al. compared the forces applied on both maxillary incisors and lower teeth by three different video laryngoscopes: McGrath series 5, C-MAC (equipped with Macintosh blade), and GlideScope Cobalt with a Macintosh MAC 3 laryngoscope.

This study involved 150 patients without expected difficult airways who underwent surgery. Patients were randomly assigned to three groups, one for each brand of video laryngoscope. Every patient received a first direct laryngoscopy and the tube placement in front of the glottis. Afterwards, tracheal intubation through the video laryngoscopy assigned was performed. Force on the maxillary incisors was measured in Newton (N) by sensors on the blade of the laryngoscope and constituted the primary outcome of the study. A cut-off value of 2 N was established to consider a registered force as actually applied on the teeth. The frequency of contacts and the level of forces applied to the lower teeth were the secondary outcomes.

Anaesthetists who performed the tracheal intubation were aware of the existence of the sensors and were invited to pay particular attention to the teeth, but were completely blinded to the registration of the forces. Patients did not differ for characteristics and Cormack and Lehane grade. Nine of them were excluded from the analysis because the registration was not available due to technical problems. The results from 141 patients demonstrated that video laryngoscopes allowed a reduction of forces applied on the maxillary incisors when compared with direct laryngoscope. A particular advantage was noted for the C-MAC, that resulted in significantly less trauma (Table 1). Adjusting the results for only the case of real contact with the teeth (N > 2), classic laryngoscope was more traumatic than the video laryngoscopes, with C-MAC as the less traumatic in terms of peak force, but differences amongst the video laryngoscopes were not statistically significant. Otherwise, significant lower number of contacts were found with C-MAC as compared with the others laryngoscopes ($P < 0.001$).

As regards to the lower teeth, the peak forces resulted very low for all the laryngoscopes. McGrath allowed less number of contacts with the teeth amongst the others devices ($P < 0.001$).

The authors found that, amongst the video laryngoscopes, the C-MAC performed the tracheal intubation faster and with a higher number of successful first attempt intubations and less requirement for stylet insertion, resulting therefore in a reduction of risk damage (although this risk is supported only by some case reports [29,30]). It was also proved that, although the number of contacts increased in a directly proportional manner with subsequent attempts following an eventual unsuccessful one, the force on the teeth did not increase significantly. As the study did not include patients with difficult airways, these results cannot be translated for all kind of patients, but the authors strongly recommended the use of video laryngoscopes in patients with poor dentition or other dental problems [27].

8. Use for tube exchange

Video laryngoscopy has been proposed as a helpful device during tube exchange in high risk intensive care patients. An American group compared video laryngoscopy-assisted tube exchange in high risk intensive care patients with a historical control groups of similar high risk intensive care patients [31]. All the procedures (also the historical) were performed with an airway exchange catheter, and patients were included only if their Cormack and Lehane resulted in a grade 3 or 4 at the first direct laryngoscopy assessment.

328 patients from 2006 to 2014 that underwent video laryngoscopy-assisted tube exchange were compared to an historical control group of 337 patients. The video laryngoscope being used was the GlideScope-GVL (2006–2009) and the GlideScope (2009–2014). For patients where mouth opening was limited, the McGrath video laryngoscope was used.

The number of attempts and complications were the primary outcome; the improvement of the glottic view between direct laryngoscopy and video laryngoscopy was the second outcome.

Direct laryngoscopy did not improve glottic visualization in historical controls and were rated grade 3 or 4 on the Cormack and Lehane scale in 83.7% of patients. On the contrary, video laryngoscopy achieved a grade 1 and 2 in 288 of 328 cases (87.8%) [31]. The study also found fewer complications with video laryngoscopy (Table 2) and an increased first attempt success rate.

The authors argued that the main reason for the reduction of complications and the better successful number of tube exchange was due to the improvement in glottic visualization through video laryngoscopy, therefore, they strongly recommend the use of these devices for this procedure in high risk intensive care patients [31]. Furthermore, the usefulness of video laryngoscopy for tube

Table 1
Average forces registered on the maxillary incisors among all the registrations [27].

Classic (n = 141)	McGrath® (n = 48)	C-MAC® (n = 47)	GlideScope® (n = 46)
30.2 ± 33.9 N	16.2 ± 17.4 N	1.18 ± 4.73	9.31 ± 11.3 N

Table 2
Percentage of complications. DL = direct laryngoscopy; VL = video laryngoscopy; RR = relative risk; CI = confidence interval; SpO_2 = pulse oxymeter oxygen saturation (from Ref. [31]).

Complication	DL group (n = 337)	VL group (n = 328)	RR (95% CI) (DL vs VL)	*P* value
$SpO_2 < 90\%$	42 (12.5)	11 (4.9)	2.6 (1.5–4.5)	0.0005
$SpO_2 < 80\%$	41 (12.2)	3 (0.9)	13.3 (4.2–42.5)	0.0001
Esophageal In.	8 (2.4)	0 (0)	0	
Bradycardia	24 (7.1)	2 (0.6)	11.7 (2.8–49.0)	0.0001
Cardiac arrest	5 (1.5)	0 (0)	0	
Rescue devices required	18 (5.3)	2 (0.6)	8.8 (2.0–37.5)	0.0004

exchange was also reported in a case report in which a Direct Coupled Interface (DCI) video laryngoscope (Karl Storz Endoscopy, Inc., Culver City, CA, USA) equipped with Macintosh #4 was successfully used to change a Combitube by an tracheal tube [32]. In another case report, the GlideScope was utilized for changing a nasotracheal with orotracheal tube in an intensive care patient with a known difficult airway [33].

9. Slower and ineffective in trauma

Manual in-line stabilisation is recommended to avoid additional cervical spine injury after trauma due to tracheal intubation. Manual in-line stabilisation itself can complicate intubation [22,34,35] and may therefore increase mortality [36,37]. Different studies have shown contrary results concerning the benefit of video laryngoscopy versus direct laryngoscopy during manual in-line stabilisation in trauma. Ilyas et al. [38] compared conventional direct laryngoscopy with the McGrath Series 5 video laryngoscope for intubation in adult patients with manual in-line stabilisation.

N = 128 adult patients scheduled for elective surgery (age > 18 years, ASA I-III) at the Alfred and the Royal Melbourne Hospital were randomised into one of two groups: Macintosh or McGrath intubation. General anaesthesia was induced according to a precise protocol. While applying manual in-line stabilisation an anaesthesiologist undertook intubation. Intubation time, difficulty, success, and complications were recorded.

The assigned difficulty score was significantly lower in the McGrath group. The laryngoscopic view was better in 67% of all cases when using the McGrath laryngoscope. However, intubation time (50.0 s vs. 82.7 s) was significantly lower in the Macintosh group. Furthermore, five intubations in the McGrath group failed due to difficulties passing the tracheal tube (3) and technical problems (2). This led to a significant lower number of successful intubations in the McGrath group due to no intubation failure in the Macintosh group. The rate of complications and physiological variables during intubation were not different between both groups.

Compared to Taylor et al. [39] who performed a similar comparison of both laryngoscopes, Ilyas et al. [38] showed identical results in time to intubation and laryngoscopic view. The major difference between both studies was the success of intubation itself. This was caused by the inability to introduce the tube into the trachea despite of good visualization and screen failure during intubation. Thus, although providing better intubation difficulty scores, the McGrath Series 5 laryngoscope prolongs intubation time in a manual in-line stabilisation setting and leads to more intubation failures. As the McGrath Series 5, also GlideScope (although approved by Food and Drug Administration for emergency and military setting [40]) failed to show any significant benefit as compared to the Macintosh direct laryngoscope in terms both of fastening the intubation and first-attempt success rate on a trauma population [20]. A similar consideration was argued in a recent meta-analysis focused on patients with cervical spine immobilization [41], in which only the Airtraq device was significantly associated with a reduction of time for successful intubation and an improvement in the first-attempt success rate. Anyway, larger RCT are needed to confirm these results.

10. Increased success on ICU by non-anaesthetists

Urgent tracheal intubation is often necessary on intensive care units, frequently run by non-anaesthesiologists, and related to a higher difficulty and increased rate of complications compared to an elective operating room setting [42–44]. An important question has to be raised, whether a typical fellowship on an intensive care unit results in enough training in direct laryngoscopy to reach an expert skill level as it has to be expected for optimal care. The use of video laryngoscopes could ease intubation and therefore improve patient safety by addressing the potential problem of inadequate training in the use of direct laryngoscopy.

Lakticova et al. [45] compared all urgent tracheal intubations carried out on an 18-bed intensive care unit of a university-related hospital done with direct laryngoscopy (Macintosh laryngoscope, November 2008 to February 2010) and video laryngoscopy (GlideScope GVL, March 2010 to July 2012). All participating residents received specific training in both, direct and indirect laryngoscopy, before in-vivo use on intensive care unit. Complications due to intubation were recorded.

140 intubations were performed using direct laryngoscopy, 252 using video laryngoscopy. The rate of oesophageal intubation (19% vs. 0.4%) and difficult intubation (more than two attempts: 22% vs. 7%) were significantly lower in the video laryngoscopy group.

The rate of most complications was similar to studies performed by anaesthesiologists [46,42,43], whereas the rate of oesophageal intubation and the incidence of difficult intubations using direct laryngoscopy exceeded comparable numbers reported in literature where the primary operator had extensive experience [9,47,44]. The fact, that in 90% of all cases without any opioid or muscle relaxant only propofol was used for intubation and might be one bias for this noticeable difference.

In the present study the use of a video laryngoscope could decrease the complication rate significantly and therefore might be an efficient tool for improving patient safety on non-anaesthesiology intensive care units.

11. Steep learning curve

In an emergency medical environment an expert level in tracheal intubation is mandatory. Bernhard et al. could show that a high number of supervised attempts and the appropriate time are required to reach this standard in direct laryngoscopy [9]. Due to optimized visualization using a video laryngoscope learning curves could be different.

Sakles et al. reported on a retrospective analysis of intubations performed in adults at a single emergency department of an academic hospital (Level 1 trauma centre) from 2007 to 2014 [48]. All intubations were conducted by EM residents completing a three-year residency program, therefore being in year one, two or three. After a mandatory rotation in anaesthesiology with 25 intubations in direct laryngoscopy technique additional training according to a distinct plan using the standard reusable GlideScope video laryngoscope was conducted. For all attempts data on indication, method, drugs, difficulties, and success of intubation were collected.

129 EM residents performed 1613 intubations, 1035 using initial direct laryngoscopy and 578 using GlideScope video laryngoscope with an average of 21 adult intubations during the course of the training for each resident. The first pass success in direct laryngoscopy did not significantly improve with the experience of residents from year one to three (69.9%, 71.7%, 72.9%). However, the performance using the video laryngoscope improved significantly during the time of educational advancement (74.4%, 83.6%, 90.0%). Most intubations were performed as rapid sequence inductions using sedative and paralytic agents.

Major limitations of this study were the missing record of any complication due to intubation and the omission of randomization. Corresponding to other studies, performance in direct laryngoscopy did not improve over a time of three years with an average of only 21 intubations in the present study. However, video laryngoscopy performance notably increased. That suggests a benefit for video laryngoscopy in an environment of less experienced users due to its steep learning curve.

12. Development of expertise

Tracheal intubation as a complex skill [49] should be performed by an expert reliably and to a high standard [50]. By introduction of video laryngoscopes it has become more complex to define and achieve expertise as it is often proposed as a rescue method followed by failed direct laryngoscopy [51]. Due to limited literature on the learning process Cortellazzi et al. [52] performed an in-vivo longitudinal study on how to define and develop expertise in tracheal intubation using a video laryngoscope.

Nine trainees in anaesthesiology from the University of Milan with a basic expertise in direct laryngoscopy were trained to use the GlideScope video laryngoscope. Each attempt during a six-month period was recorded regarding ten possible outcome (e.g. time of intubation, view, lifting force, complications).

N = 890 intubations were recorded during the test period. As major complications one oesophageal intubation occurred, but additional equipment was never requested. 13 times supervisors had to intervene to ensure patients safety. Following the subsequent multivariate analysis only experience, the declared view and a single insertion were significant independent predictors of success. 76 intubations were required before a trainee could be predicted to have a more than 90% probability of performing an optimal video laryngoscopy intubation. At the end of their training outcomes were comparable to the performance of the control group formed by the supervising anaesthetists.

In contrast to previous studies expecting a much faster learning process [53–55], the present study suggests video laryngoscopy to be a complex skill that requires extensive practise even in those, who were trained in direct laryngoscopy. Still, performance might rapidly improve during continuous training compared to the skill of direct laryngoscopy [9].

13. Conclusions

In the present review, the most important publications of the last 12 months from the field of video laryngoscopes in emergency environments are presented. Using a video laryngoscope for urgent, unplanned tracheal intubation seems to result in fewer complications as compared with "standard" direct laryngoscopy.

Furthermore, using a video laryngoscope resulted in a steeper learning curve and shorter times to place the tracheal tube. Novices especially seem to profit from video laryngoscopy. However, there are some very special situations (e.g., frontal, face-to-face intubation) where no advantage can be found when using a video laryngoscope.

Conflicts of interest

None.

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