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THE C-MAC® VIDEOLARYNGOSCOPY SYSTEM IN CLINICAL AND EMERGENCY MEDICINE

2nd Edition

Volker DÖRGES

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Department of Anaesthesiology and Intensive Care Medicine
University Hospital Schleswig-Holstein, Campus Kiel, Germany

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Erol CAVUS
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Thomas A. NICHOLAS IV
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Mary BARAK-BERNHAGEN
W. Bosseau MURRAY
Carin A. HAGBERG
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Correspondence address of the editor-in-chief:

Prof. Dr. med. **Volker Dörges**
Klinik für Anästhesiologie und Operative Intensivmedizin
Universitätsklinikum Schleswig-Holstein, Campus Kiel
Schwanenweg 21, 24105 Kiel, Germany
E-mail: doerges@anaesthesie.uni-kiel.de
www.uni-kiel.de/anaesthesie

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P.O. Box, 78503 Tuttlingen, Germany
Phone: +49 (0) 74 61/1 45 90
Fax: +49 (0) 74 61/708-529
E-mail: Endopress@t-online.de

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[1] Prof. **André van Zundert,** M.D.
Catharina Hospital – Brabant Medical School, Eindhoven, The Netherlands
Department of Anesthesiology, Intensive Care and Pain Therapy

[2] **Götz Serocki,** M.D. and Prof. **Volker Dörges,** M.D.
Department of Anaesthesiology and Intensive Care Medicine,
University Hospital Schleswig-Holstein, Campus Kiel, Germany

1.1 Videolaryngoscopy – The Intubation Technique of the Future!

André van Zundert

One of the major challenges an anesthesiologist is faced with during operative interventions and trauma care is to provide a patent airway. Semi-comatose or comatose patients often show obstruction of the glottic inlet by a relaxed tongue. Straightforward measures can be taken to obtain a patent airway, i.e., chin lift, jaw thrust maneuver or insertion of a Guedel airway (Mayo tube).[1] Nevertheless, the act of providing a definitive airway is to put an airway tube in between the vocal cords to enter the patient's trachea. In order to be able to visualize the entrance of the trachea, a special tool, the laryngoscope, is used to make insertion of the tube easy and effective. However, visualization of the vocal cords and intubation of the trachea cannot always be accomplished easily. Indeed, the difficult airway is the single major cause of intubation-related morbidity and mortality. Especially during induction of surgical anesthesia and in trauma care, valuable time must not be lost. Patients are at risk of dying unless a patent airway is established as soon as possible. Both morbidity and mortality increase in emergency and trauma situations, but this also applies to patients who are in a condition highly prone to difficult intubation.

The first and most urgent priority in trauma care is therefore to provide an open airway. Of the tens of millions of patients undergoing general anesthesia worldwide, a large proportion (90%) of those, tracheal intubation was performed on by using a traditional laryngoscope, with a battery in the handle and a small light bulb near the tip of the blade. In about 10% of patients, flexible fiberoptic intubation is used.

For more than half a century since *Miller* (1941) and *Macintosh* (1942) introduced straight and curved laryngoscope blades, laryngoscopy essentially remained unchanged till the advent of rigid fiberoptic[2–5] endoscopy in the 1990s (Bullard Scope®, Wu Scope®, Upsherscope®) and videolaryngoscopy in the 2000s. It was in 1998, that *Weiss*[6] modified direct laryngoscopy by incorporating a fiberoptic bundle into a Macintosh blade. In 2001, the Canadian surgeon *John Pacey* was the first to embed a miniature videochip into a modified Macintosh laryngoscope,[7–9] followed by *Berci* and *Kaplan,*[10–11] who added the specific DCI® camera head, with distal light and image fibers providing optimal illumination and image acquisition. Several videolaryngoscopes[7–14] are now available on the market such as the GlideScope® (Ranger™ and Cobalt™, GlideScope, Verathon, Canada), KARL STORZ® (V-MAC® and C-MAC®, KARL STORZ Tuttlingen, Germany), McGrath® Videolaryngoscope (McGrath Aircraft Medical, Edinburgh, UK), Airtraq® (Prodol, Spain) and Pentax® (Pentax-AWS, Tokyo, Japan).

Use of the video modality is well established in surgical endoscopic procedures. Only recently, videolaryngoscopy has been introduced in anesthesia where, in most cases, it has shown to produce better viewing conditions, resulting in a lower incidence of difficult airway as compared to those cases, in which the direct vision laryngoscopy method is used. Although there are several brands of videolaryngoscopes available, the one with a blade is most akin to the Macintosh laryngoscope providing the easiest and fastest intubations and virtually eliminating the need for using auxiliary devices, such as a stylet or a gum elastic bougie. The KARL STORZ Berci-Kaplan DCI® Videolaryngoscope (V-MAC®, KARL STORZ, Tuttlingen, Germany) uses the Tele Pack documentation unit, with an integrated endoscopic CCD video system including

1 Training with the portable videolaryngoscope C-MAC® (KARL STORZ Tuttlingen, Germany).

2 Demonstration of coordinated hand-eye movements during videolaryngoscopy (laryngeal structures are shown on the monitor).

a central control unit with IPM (image processing module) and electronic filter to eliminate the Moiré effect when flexible or semi-rigid endoscopes[15–16] are used. The DCI® camera head is attachable to different sizes of blades with distal light and image fibers providing optimal illumination and image acquisition with a 60º field of view, which is wider than the one obtained with a standard laryngoscope blade, since the viewpoint is closer to the glottic entrance. When using the indirect vision videolaryngoscope, less force in comparison to the classic direct vision laryngoscope is needed to visualize the glottic entrance. Well-documented advantages are both naked-eye direct vision and video-assisted indirect vision of the glottic inlet, without the need for excessive angulation of the scope and, accordingly, reduced risk of trauma to the upper teeth.[17–18] The whole intubation procedure can be documented for optional discussion and post-intervention teaching. A videolaryngoscope is also a better teaching tool than the standard "look-over-the-shoulder" method,[11] since others in the room are actually allowed to observe what the intubating physician or anesthesiologist sees (**Figs. 1–3**), so that they can see what the potential problems are, and thus provide more appropriate help. As compared to a standard laryngoscope, a videolaryngoscope offers improved quality of vision, which is enhanced considerably by optimal lighting conditions owing to the use of an LED light source.

A classic laryngoscope uses an in-line method with direct vision of the vocal cords. However, successful visualization and intubation with direct vision encompasses only about 90% of cases, leaving a substantial number of patients with difficulties of visualization and intubation. Often, adjunctive devices must be used, e.g., use of a gum-elastic bougie, a stylet, a different type of laryngoscope, fiberoptic endoscopic intubation, or successful intubation by temporary placement of a supraglottic airway. With standard laryngoscopy, alignment of the oral, pharyngeal, and laryngeal axes has to be realized in order to visualize the cords. Indirect intubation has the benefit that it requires the alignment of the pharyngeal and laryngeal axes only, which are inclined at much more similar angles when compared to the oral axis. By eliminating the oral axis, anterior airways are much easier to intubate. The downsides to indirect intubation are that movements must be controlled based on the two-dimensional screen view instead of the familiar three-dimensional vision, along with the disparity of what one sees and what one does. This hand-eye coordination is easily acquired, especially by those who are used to playing video games. When intubating indirectly by use of a Macintosh blade, the technique is essentially the same as with the standard method, which involves keeping manipulations of the laryngoscope to a minimum. A videolaryngoscope provides indirect vision of the vocal cords on a monitor. The intubating physician or anesthesiologist must undergo a learning process to improve eye-hand coordination required to intubate the patient's trachea. When using a videolaryngoscope, in the majority of cases good vision of the vocal cords is obtained (nearly 100% of patients show a Cormack-Lehane grade I with a videolaryngoscope, whereas with direct laryngoscopy the Cormack-Lehane grades I and II are seen in 75% of the patients. Cormack-Lehane III and IV should be considered as laryngoscopy failure.

Previously, the paradigm for safe intubation has been built on the foundations of adequate preoperative measurement of a patient's airway. A plethora of metrics have been proposed to determine the anticipated intubation difficulty, (i.e. Mallampati score, BMI, mouth opening, dentition, protruding teeth, overbite, retrognathia, short or no neck, restricted neck mobility or stiff neck), which are usually of little value in predicting difficult visualization of the vocal cords and subsequent difficult intubation. Accordingly, preoperative metrics indicating a difficult airway are not necessarily correct, and therefore, patients who are initially considered to have normal airways should not be removed from the list of standby measures usually initiated in the case of an anticipated difficult intubation. The ubiquitous assessment of preoperative metrics of a potentially difficult airway by anesthesiologists is incomplete, at best, perhaps relevant in direct laryngoscopy, but of less relevance in videolaryngoscopy.

As the problem of visualization of the vocal cords no longer persists when videolaryngoscopy is used, subsequent intubation is not always performed with ease.

3

The new videolaryngoscope C-MAC® (KARL STORZ Tuttlingen, Germany) provides a clear image of the glottic inlet, with vocal cords, arytenoids and surrounding area. User-friendly pushbuttons on the monitor allow users to control a multitude of functions, such as video recording, still image capture, automatic white balancing and image focusing, brightness and contrast adjustment.

External laryngeal manipulation often is not required or proves to be useless. Blade geometry and integration of the endotracheal tube in the videolaryngoscope should be the subjects of further study to determine the acuteness of the angle that the blade of the videolaryngoscope should maintain for optimal intubation conditions. Advancements and modifications should address the potentials of these technical features and compare them with those offered by the videolaryngoscopes currently available. Our own studies revealed that a styletted endotracheal tube is not always needed, depending on the videolaryngoscope brand used.[19–21] In the majority of cases, even in a group of patients undergoing bariatric surgery, intubation can be performed successfully with the KARL STORZ videolaryngoscope, without the use of a stylet. Some manufacturers advocate the mandatory use of a stylet during intubation; however, complications of this technique have been reported recently in the literature. We therefore advise against using a stylet, except for those cases in which intubation seems not feasible otherwise. Indeed, since the introduction of direct Macintosh laryngoscopy in 1942, we use an auxiliary device, such as a stylet, only if attempts to accomplish intubation without its use, have proven to be unsuccessful. However, the GlideScope® and McGrath® videolaryngoscope blades are designed with an 60º anteriorly oriented acute blade. With these devices, the larynx is often not visible by direct inspection, and cannot be reached by the endotracheal tube despite an excellent view on the monitor. Their manufacturers advocate to always using a stylet with these videolaryngoscopes.

Even though videolaryngoscopes are suited to provide a high level of light intensity, a shortcoming of all fiberoptics is that blood or secretions can quickly obscure vision. This problem, essentially, can be resolved by placing the lens about one third of the way back from the tip of the blade, keeping it clear from most debris. Obscured vision can still be a problem with patients who have a lot of blood or secretions and when warm respirations fog the lens. The latter can be prevented by applying some antifogging agent, or some body-warm water to the lens. Some videolaryngoscopes are no longer susceptible to fogging (GlideScope®, Airtraq® and C-MAC®).

Videolaryngoscopy is potentially superior, even in the management of easier-to-intubate patients, but clearly shows its superiority in difficult-to-intubate patients (**Table 1**), especially when preoperative metrics do not provide any indication of a difficult airway, and the anesthesiologist is confronted with an unexpectedly difficult airway. As experience increases, many intubations, that were difficult to manage with direct laryngoscopy, will prove to be performed more easily when indirect videolaryngoscopy is used. In the meanwhile, several institutions have included the use of the videolaryngoscope in their standard intubation protocol, both for the normal and the difficult airway. In the author's opinion, modern anesthesiologists should adopt videolaryngoscopy, just as a cardiologist no longer relies solely on a stethoscope to diagnose heart problems, but rather uses ultrasound methods to establish a preliminary diagnosis. The video modality has brought better options for modern patient care in many surgical specialties. Our patients too, who have to undergo an endotracheal intubation, deserve a better outcome, which now has become reality with videolaryngoscopy.

Clinical Airway Management
■ both direct and indirect vision of the glottic entrance is possible with videolaryngoscopy.
■ improved viewing of the area from the entrance to the trachea with complete visualization of vocal cords.
■ viewpoint is closer to the vocal cords.
■ enlarged angle of view.
■ better viewing without need for excessive angulation of laryngoscope blade.
■ improved vision of correct passage of endotracheal tube between vocal cords.
■ improved vision of correct passage of nasogastric tube in the esophagus.
■ improved evaluation of exact insertion depth of the endotracheal tube.
■ reduced risk of dental damage.
■ greater ease of intubation, with fewer attempts and reduced intubation time.
■ need for use of adjunctive devices considerably reduced.
■ usually, no need for external manipulation (BURP maneuver – cricoid pressure).
■ effective intubation tool – in easy and difficult airways, – of choice in morbid obesity patients, – for oropharyngeal and nasopharyngeal routes.
■ effective intubation tool for elective and emergency patients.
■ diagnostic tool: enlarged angle of vision considerably useful in the diagnosis of cysts and tumors.
■ other specialists (e.g. ENT surgeon) can use it as a diagnostic tool.
■ education tool: eliminating the need for "look-over-the-shoulder" intubation.
■ both anesthesiologist and resident can simultaneously view the intubation procedure and address intubation problems.
■ documented monitoring of tracheal intubation (still images).
■ recording of intubation for training or legal purposes (video recording).

Table 1a
Advantages of videolaryngoscopy using the Macintosh blade.

Technical Improvements
■ integrated video display monitor, laryngoscope and cable.
■ LED lighting further enhances viewing of the glottis.
■ anti-fogging.
■ AC power and DC Lithium-ion battery power.
■ Colour LCD display with CMOS chip.
■ sturdiness (made of stainless steel).
■ portable system.
■ still image capture and video recording.
■ automatic white balancing and image focusing.
■ function keys for brightness, contrast adjustment, color saturation, hue, date, time.
■ SD-card for storage of video / image data (MPEG/JPEG).
■ various sizes of blades can be fitted to the videolaryngoscope (adult and pediatric sizes).
■ fiberscope can be fitted to the videolaryngoscope (others can watch bronchoscopy on monitor).
■ reusable (immersible for reprocessing, HDL, Sterris).

Table 1b (continued from page 10).

References

1. VAN ZUNDERT A, KUCZKOWSKI KM, VAN ZUNDERT T, MEEUSEN V. The art of maintaining a patent airway: an old problem – new evidence. Can J Anaesth. 2008 Jun;55(6):380–1.
2. BJORAKER DG. The Bullard intubating laryngoscopes. Anesthesiol Rev. 1990 Sep–Oct;17(5):64–70.
3. CHOU HC, WU TL. Mandibulohyoid distance in difficult laryngoscopy. Br J Anaesth. 1993 Sep;71(3):335–9.
4. FRIDRICH P, FRASS M, KRENN CG, WEINSTABL C, BENUMOF JL, KRAFFT P. The UpsherScope in routine and difficult airway management: a randomized, controlled clinical trial. Anesth Analg. 1997 Dec;85(6):1377–81.
5. PEARCE AC, SHAW S, MACKLIN S. Evaluation of the Upsherscope. A new rigid fibrescope. Anaesthesia. 1996 Jun;51(6):561–4.
6. WEISS M. Video-intuboscopy: a new aid to routine and difficult tracheal intubation. Br J Anaesth. 1998 Apr;80(4):525–7.
7. COOPER RM. Use of a new videolaryngoscope (GlideScope) in the management of a difficult airway. Can J Anaesth. 2003 Jun–Jul;50(6):611–3.
8. COOPER RM, PACEY JA, BISHOP MJ, MCCLUSKEY SA. Early clinical experience with a new videolaryngoscope (GlideScope) in 728 patients. Can J Anaesth. 2005 Feb;52(2):191–8.
9. KAPLAN MB, WARD DS, BERCI G. A new video laryngoscope – an aid to intubation and teaching. J Clin Anesth. 2002 Dec;14(8):620–6.
10. KAPLAN MB, WARD D, HAGBERG CA, BERCI G, HAGIIKE M. Seeing is believing: the importance of video laryngoscopy in teaching and in managing the difficult airway. Surg Endosc. 2006 Apr;20 Suppl 2:S479–83.
11. LOW D, HEALY D, RASBURN N. The use of the BERCI DCI Video Laryngoscope for teaching novices direct laryngoscopy and tracheal intubation. Anaesthesia. 2008 Feb;63(2):195–201.
12. ENOMOTO Y, ASAI T, ARAI T, KAMISHIMA K, OKUDA Y. Pentax-AWS, a new videolaryngoscope, is more effective than the Macintosh laryngoscope for tracheal intubation in patients with restricted neck movements: a randomized comparative study. Br J Anaesth. 2008 Apr;100(4):544–8.
13. JUNGBAUER A, SCHUMANN M, BRUNKHORST V, BORGERS A, GROEBEN H. Expected difficult tracheal intubation: a prospective comparison of direct laryngoscopy and video laryngoscopy in 200 patients. Br J Anaesth. 2009 Apr;102(4):546–50.
14. SHIPPEY B, RAY D, MCKEOWN D. Case series: the McGrath videolaryngoscope – an initial clinical evaluation. Can J Anaesth. 2007 Apr;54(4):307–13.
15. VAN ZUNDERT A, STESSEL B, DE RUITER F, GIEBELEN D, WEBER E. Video-assisted laryngoscopy: a useful adjunct in endotracheal intubation. Acta Anaesthesiol Belg. 2007;58(2):129–31.
16. VAN ZUNDERT AA, MAASSEN RL, HERMANS B, LEE RA. Videolaryngoscopy – making intubation more successful. Acta Anaesthesiol Belg. 2008;59(3):177–8.
17. LEE RA, VAN ZUNDERT AA, MAASSEN RL, WILLEMS RJ, BEEKE LP, SCHAAPER JN, VAN DOBBELSTEEN J, WIERINGA PA. Forces applied to the maxillary incisors during video-assisted intubation. Anesth Analg. 2009 Jan;108(1):187–91.
18. MAASSEN R, LEE R, VAN ZUNDERT A, COOPER R. The videolaryngoscope is less traumatic than the classic laryngoscope for a difficult airway in an obese patient. J Anesth. 2009;23(3):445–8.
19. MAASSEN R, LEE R, HERMANS B, MARCUS M, VAN ZUNDERT A. A comparison of three videolaryngoscopes: the Macintosh laryngoscope blade reduces, but does not replace, routine stylet use for intubation in morbidly obese patients. Anesth Analg. 2009 Nov;109(5):1560–5.
20. VAN ZUNDERT A, MAASSEN R, LEE R, WILLEMS R, TIMMERMAN M, SIEMONSMA M, BUISE M, WIEPKING M. A Macintosh laryngoscope blade for videolaryngoscopy reduces stylet use in patients with normal airways. Anesth Analg. 2009 Sep;109(3):825–31.
21. VAN ZUNDERT AA, LEE RA. Intubation difficulties in obese patients. Anesth Analg. 2009 Mar;108(3):1051; author reply –1052.
22. VERMELIS AM, MATEIJSEN N, GIEBELEN D, MEEUSEN V, WONG DT, VAN ZUNDERT AAJ. Successful Use of Videolaryngoscopy in an Adult Patient with Acute Epiglottitis: A case report. Acta Anaesthesiol Belg. 2010;16, in press.

1.2 History of Videolaryngoscopy

Götz Serocki, Volker Dörges

Background

Since the early days of modern anesthesiology, establishing and maintaining a patent airway has been a key responsibility of the anesthesiologist. The introduction of endotracheal intubation by *MacEwen* in 1878 contributed greatly to the reduction of anesthesia-related mortality. Initially intubation was performed without visual control. The patient was awake, and the intubating physician directed a flexible metal tube into the larynx using the breath sounds as a guide.

The safety and efficacy of intubation were significantly improved by the development of laryngoscopy. An important pioneer was the German physician *Alfred Kirstein,* who in 1895 performed laryngoscopy with a modified rigid esophagoscope called an "autoscope" (**Fig. 1**). Kirstein was the first physician to perform endotracheal intubations under direct laryngoscopic vision.

1

Modified rigid esophagoscope designed by Kirstein (1895).

A great number and variety of laryngoscopes were introduced after that time, but it was not until the 1940s that laryngoscopy became established as a routine clinical procedure. The laryngoscopes designed by *Miller* in 1941 and by *Macintosh* in 1943 have come into widespread use.

This technique remained essentially unchanged for over 60 years and became the mainstay for patient intubation despite two significant drawbacks:

- The technique is demanding and difficult to teach because bystanders cannot closely monitor the intubation process. Laryngoscopy is very difficult to teach by "looking over the shoulder" of an instructor or trainee, and the instructor cannot adequately supervise a trainee attempting to perform an intubation.
- Anatomical constraints in some patients make it difficult to adequately visualize the laryngeal entrance by conventional direct laryngoscopy. Consequently, alternative methods are needed for safely intubating this subset of patients.

During the past 10 years, videolaryngoscopy has emerged as a modality which combines the advantage of relatively simple handling with dramatic improvements in training capabilities and in the management of difficult airways.

Development of Videolaryngoscopy

Seeing is Believing. *Kaplan et al.* (2006) published a work under that title in 2006, detailing the advantages of videolaryngoscopy both for teaching the routine anesthesiologic technique of endotracheal intubation and for managing difficult airways. But anesthesiologists have been slow to recognize these advantages.

Video-assisted techniques have been successfully used for decades in many surgical disciplines and have largely replaced open approaches in a number of areas (e.g., arthroscopy, laparoscopy, pelviscopy, etc.). The magnified and detailed view of the surgical site on one or more monitors makes it easier to coordinate the work of the surgical team and provides a very effective teaching tool for novices. In otorhinolaryngology as well, video-assisted laryngoscopy has long held an established place in the diagnosis of laryngeal diseases.

It appears that anesthesiologists have noted this development with interest without realizing its potential for their own specialty. For years anesthesiologists have applied video technology almost exclusively for imaging in bronchoscopy and for fiberoptic intubation.

The past decade, however, has witnessed some important innovations in the field of video-assisted airway management.

In 1996, *Levitan* introduced a video camera attached to a head ring (AirwayCam™). With this technique, intubation performed with a standard laryngoscope is displayed on a video monitor so that it can be observed by other personnel in the room. The view of the glottis matches the visual field of the intubating physician and does not improve visualization of the glottic plane.

Another principle forms the basis for the development of modern videolaryngoscopes. By integrating optical image guides and video cameras into standard laryngoscopes, a magnified and detailed view can be displayed on an external monitor while conventional direct laryngoscopy is performed.

In 1995, *Henthorn et al.* first reported on the combination of fiberoptics with a conventional laryngoscope. They taped a flexible fiberoptic cable to a standard Miller laryngoscope blade so they were better able to supervise and correct intubation attempts by their students. Both instructors and trainees found this forerunner of modern videolaryngoscopes to be very helpful in identifying the anatomy of the upper airways and successfully performing the intubation.

Thereafter, various authors made an effort to advance this principle. The first commercially available videolaryngoscopes for clinical use became available at the start of this decade, and initial studies on videolaryngoscopy were published.

In 2001, *Weiss et al.* described a Macintosh laryngoscope (Laryflex®) in which a thin fiberoptic cable can be advanced through a guide channel in the laryngoscope handle and blade to a point very close to the blade tip. Adapters can be used to connect the fiberoptic cable to an external video unit, enabling a close-up view of the larynx to be displayed on an external monitor. Another option is to introduce the video scope into the endotracheal tube. There have been no other publications on this device from other users, however, and apparently it has not found wide application.

Ilias of Vienna had a major role in developing one of the first commercially available videolaryngoscopes with an image guide built into the blade and a video camera installed in the handle (Rüsch X-Lite®/KARL STORZ production, 2001). This was the first design to offer various interchangeable blade shapes and sizes that could be connected to the camera handle (**Fig. 2**).

2

X-Lite® videolaryngoscope, 2001 (Rüsch GmbH, D-Kernen / KARL STORZ, Tuttlingen, Germany).

3

Macintosh videolaryngoscope KARL STORZ MVL® (2002).

In 2002, *Kaplan* and *Berci* reported on the successful use of a different Macintosh videolaryngoscope with an integrated camera and connectable blades equipped with a fiberoptic light guide and image guide (KARL STORZ MVL®) (**Fig. 3**). This device is very similar to the Rüsch X-Lite® videolaryngoscope, and also offered various interchangeable blades. The built-in micro-video module (MVM) ensured compatibility with other intubation aids such as the flexible fiberoptic cable on the same video control unit. Additionally, both devices offered greater brightness than conventional laryngoscopes, which is important for the positive identification of anatomic landmarks in the hypopharynx. As **Fig. 3** illustrates, a short segment of the fiberoptic image and light guides formed an external cable that connected the blade to the integrated camera in the handle. As in the Rüsch X-Lite®, two fairly bulky and heavy cables (light and image guides) emerge from the end of the handle. These characteristics made the device more cumbersome than a conventional laryngoscope. They also hampered cleaning and disinfection and made the device less rugged and more susceptible to wear and technical flaws.


4


5

The next generation of KARL STORZ videolaryngoscopes was significantly improved with respect to the above features. The Berci DCI® videolaryngoscope of 2004 (**Figs. 4, 5**), also called the V-MAC® in the literature, is the first such device in which the handle and blade comprise a fixed unit. The DCI® (direct coupled interface) video camera head is inserted into the handle before use. Image sharpness can be adjusted and image acquisition controlled on the camera head. This led to improved handling and cleaning and made it possible to use one camera head with various devices such as laryngoscopes (Macintosh, Dörges and Miller blades), the Bonfils retromolar intubation endoscope (**Fig. 6**), and flexible fiberoptics. This system integration also makes it possible to create an airway management cart equipped with a TelePack video module, a video monitor, an optional DVD unit (KARL STORZ AIDA® DVD), and a variety of devices for airway management (**Fig. 7**). The new TELE PACK X was released in 2011 (**Fig. 8**). Through integrated data management, the device also facilitates the comprehensive video documentation of procedures. Six USB ports and one SD card slot are available for this purpose. Another benefit is the 15" LCD monitor with a rotatable image display. The DVI video output provides brilliant transmission quality with 24 bit color depth for a natural color display.


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The latest generation of KARL STORZ videolaryngoscopes, the C-MAC® videolaryngoscope (**Fig. 9**), features several distinct improvements, including fully digital image processing with a CMOS video chip combined with high-quality optical lenses. The use of high-intensity light-emitting diodes (LEDs) as a light source produces excellent illumination and provides a warming effect that effectively prevents fogging of the lens (which required the use of anti-fogging solution in the previous model).

Various types of blades are available for the C-MAC® videolaryngoscope:

Macintosh blades in sizes 2, 3, and 4 (**Fig. 10**). The blade shape is patterned after the original Macintosh blade. The C-MAC® blades are slightly more curved than current standard Macintosh blades, and the overall height of the blade was reduced to facilitate use in a difficult airway. Optionally available is the Boedeker-Dörges spatula, the design of which involves an extra channel for introducing a suction tube (**Figs. 11, 12**).


13


14


15

A special D-BLADE is also available for use with the C-MAC® system (**Figs. 13, 14**). The greater curvature of this blade is specially designed to facilitate intubation of the difficult airway. Initial unpublished results show markedly improved glottic visualization in cases where the laryngeal inlet cannot be viewed by direct laryngoscopy (**Fig. 15**).

The acquisition of still images and video sequences has been further simplified and can be controlled with buttons on the laryngoscope handle and on the LCD monitor. The use of all-digital technology has significantly reduced the dimensions, weight, and startup time of the videolaryngoscope. This technology also facilitates mobile use outside the operating room and in emergency settings.

Videolaryngoscopy and the Difficult Airway

Because standard Macintosh or Miller laryngoscope blades do not provide an adequate view of the laryngeal inlet in some patients, other blade modifications have been devised such as the McCoy lever-tip laryngoscope and the Dörges universal blade (**Fig. 16**).

For the difficult airway, a number of alternative intubation aids are also available to the anesthesiologist. All are based on the principle of *indirect laryngoscopy* in which fiberoptics or video chips are used to obtain an "around-the-corner" view.

In use for four decades, the flexible fiberoptic cable is recognized as the "gold standard" for expected difficult intubation. This is a demanding procedure that requires long and continual training, however. It is time-consuming, material-intensive, and is susceptible to vision impairment due to blood and secretions. These characteristics limit the use of fiberoptic techniques in patients with an unexpected difficult airway (**Fig. 17**).

Additionally, various types of indirect laryngoscopes have been developed with blade designs that differ markedly from the Macintosh and Miller blades. The curved blades of these devices conform more closely to the natural anatomy of the oropharynx and hypopharynx, making it unnecessary to hyperextend the cervical spine when these instruments are used.

Starting in the late 1980s, patents were filed on several intubation aids employing fiberoptic systems and external monitors, such as the Berci video intubation endoscope (1989), the George fiberoptic intubation endoscope (1993), the Berall laryngoscope (1998), the Kitamura Intubation stylet (1999), the Weiss video-optical intubation stylet (VOIS, 2000), and the Ilias videolaryngoscope (2000).

Some of these devices only have patent applications and have not been investigated in published studies. They have not found their way into routine clinical use, nor have they achieved commercial success.

The Glidescope® and the McGrath Videolaryngoscope® are indirect videolaryngoscopes that are more widely known and studied. A number of publications have documented improved laryngoscopic vision by indirect laryngoscopy with these devices. The newly developed D-BLADE, an indirect laryngoscope blade with increased curvature, now enables this technique to be applied in the C-MAC® videolaryngoscope system (**Fig. 18**).

Several other indirect, rigid laryngoscopes are the WuScope, the UpsherScope™, the Bumm intubation endoscope, and the Bullard laryngoscope (1990, Björaker). Various authors have described these indirect laryngoscopes as helpful in the management of the difficult airway. But because they are more difficult to handle than conventional Macintosh laryngoscopes and require continual, specialized training, they have found relatively limited practical use.

The Bullard fiberoptic laryngoscope is often used in Anglo-American countries and is available in various sizes. A great many papers have been published on this device, including comparisons with new videolaryngoscopes.

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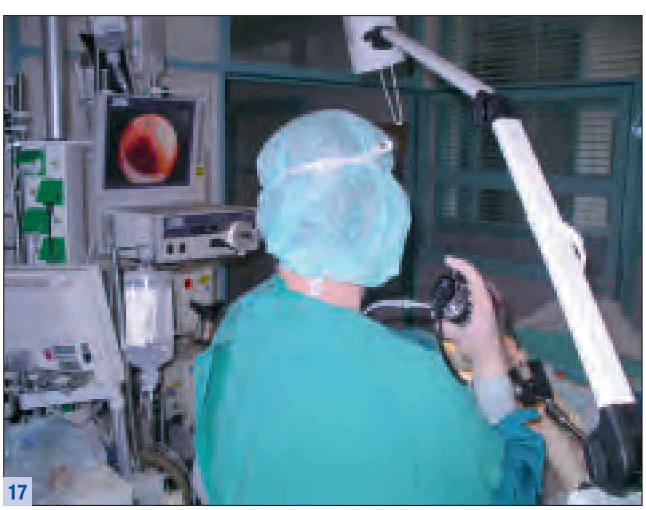

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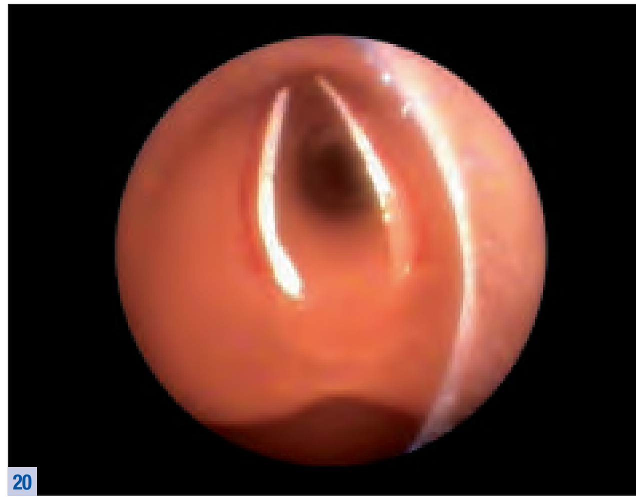
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Actual videolaryngoscopes are distinguished from optical stylets and intubation endoscopes that are introduced into the endotracheal tube and thus require a different intubation technique. Among the best known and most thoroughly investigated devices of this kind is the Bonfils retromolar intubation endoscope (**Figs. 19, 20**).

These devices can be "upgraded" to a kind of videolaryngoscope by connecting an external video camera to the eyepiece of the device, but commercially available videolaryngoscopes like the C-MAC® are considerably easier to handle and provide better image quality.

It is logical to predict that videolaryngoscopy will become increasingly important not just for training and documentation but also in the management of the expected and especially the unexpected difficult airway. Although large multicenter studies have not yet been conducted on its use in the difficult airway, there are a growing number of studies showing that videolaryngoscopy performed with Macintosh blades or with the newer, more curved blades for purely indirect laryngoscopy give improved visualization of the larynx compared with direct laryngoscopy (**Figs. 21, 22**).

Future technical advances will improve handling even further and will contribute to the acceptance of this procedure. More than a few anesthesiologists believe that videolaryngoscopy is destined to become a routine procedure for airway management because…

"Seeing is Believing"


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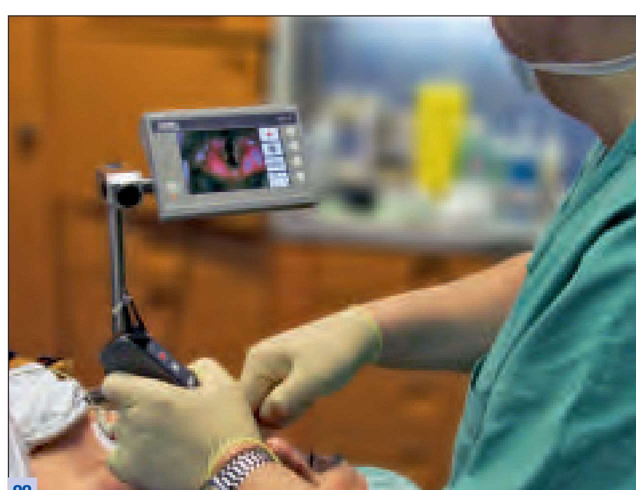
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System Description of the C-MAC® Videolaryngoscope

2.1 Technical Description of the C-MAC® Videolaryngoscope[1]

2.2 Special Features of the C-MAC® Videolaryngoscope[1]

2.3 New Developments in the C-MAC® Videolaryngoscope[2]

2

[1] **Erol Cavus,** M.D.
Department of Anesthesiology and Surgical Intensive Care
Schleswig-Holstein University Medical Center, Kiel Campus, Germany

[2] **Mark Schmelzer**
KARL STORZ GmbH & Co. KG, Tuttlingen, Germany

2.1 Technical Description of the C-MAC® Videolaryngoscope

Erol Cavus

The C-MAC® video laryngoscope can provide a useful alternative both during the routine induction of general anesthesia and in the management of a difficult airway. The C-MAC® is based on a modified Macintosh blade that has the same curvature as the original 1943 version.[1] Unlike the original blade, however, the C-MAC® blade has a flatter profile (maximum of 14 mm) and a beveled shoulder (**Fig. 1**) to reduce the risk of oral and dental injuries while allowing insertion even in patients with a small mouth opening. The blade is available with an optional integrated channel for a suction tube (Ch 14–16), which can optimize visualization during laryngoscopy by removing secretions (**Fig. 2**).

The C-MAC® system is compatible with various types of blade. The electronic module (E-module) fits into the blade handle and allows for the rapid exchange of blade sizes and types (**Fig. 3**).

Currently the system can accommodate Macintosh stainless steel blade sizes 2, 3 and 4, and additional models such as Miller sizes 0 and 1 are available. An addition to the C-MAC® system is the D-BLADE. The greater curvature of this blade improves glottic visualization in patients with a difficult airway (**Fig. 4**).

The combined optical system of the C-MAC® consists of a high-resolution digital camera with a CMOS chip set (320 x 240 pixels) and an optical lens with an aperture angle of 80°. The optical system and a high-intensity LED are mounted in the distal third of the blade (**Fig. 5**). This provides optimum visualization of the glottic plane while also displaying the blade tip at the edge of the image, making it possible to navigate the tip into the vallecula under laryngoscopic vision (**Fig. 6**).


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The system software includes a prewarming algorithm that is designed to prevent fogging of the optical system.

The blade handle with E-module has two pushbuttons that enable the user to capture still frames (in JPEG format) and to start and stop video recordings (in MPEG4 format) of the current screen images.

The handle and monitor were designed to facilitate cleaning and disinfection. The stainless steel blade has a closed contour while the blade, handle, and E-module can withstand manual and mechanical disinfection (up to 60° C) and high-level disinfection (HLD). They are also approved for sterilization in the Steris, Sterrad, and ETO gas systems.

The components can also be cleaned with approved disinfectant wipes with a chlorine dioxide base (e.g., Tristel Wipes System), which have been used for several years in the decontamination of ENT endoscopes and have shown good antimicrobial activity.[2, 3] The growing popularity of single-use blades has prompted the development of the C-MAC® S video laryngoscope. Like the reusable system, the C-MAC® S can accommodate various blade types (Macintosh sizes 3 and 4 plus the D-BLADE). Made of clear plastic, the blades fit over the C-MAC® S imager to form the actual video laryngoscope (**Figs. 8, 9**). The imager has been approved for low-temperature decontamination methods to a maximum of 60° C: manual or machine cleaning and disinfection, sterilization with ETO gas, and high-level disinfection (HLD) according to the US standard.


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C-MAC® Videolaryngoscope, 2008 (KARL STORZ, Tuttlingen, Germany).

Images are displayed on a portable, lightweight, high-resolution LCD color monitor (1280 x 800 pixels, 154 x 93 mm, 7"; monitor weight 1050 g, total system weight approximately 1500 g). The screen is mounted in a shock-resistant ABS plastic housing that features manual white balance control. One pushbutton opens an easy-to-read menu for adjusting the system settings, and the monitor has two additional buttons for capturing still and video images, similar to the buttons on the handle. Image data are stored on standard SD memory cards (4 GB capacity comes with the system).


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The video signal can be sent to an external monitor via an HDMI video output (**Fig. 10**).

The monitor can plug into an electrical outlet or can operate for up to 2 hours on a lithium-ion battery before recharging. A screen icon indicates current battery level, and the unit can charge while operating from the power cord. The video cable connections and power plug are located on the back of the device for safety and are color-coded to eliminate confusion.

The external monitor is dustproof, splashproof, and can be cleaned with disinfectant wipes (IEC standard 60529) – features that are essential for in-hospital and especially prehospital use. The system meets official test standards for electromagnetic interference in rescue aircraft (EC-135, EC-145, and BK 117-B2).

For mobile use, the monitor and blade handle(s) can be packed separately in a rugged, padded, easy-to-clean protective bag, which permits effective use of the C-MAC® system even under difficult ambient conditions (e.g., prehospital settings). The monitor may remain in the bag during operation, and all monitor buttons can be accessed through the bag (**Figs. 11–13**).

The C-MAC® monitor is also compatible with alternative external devices. For example, it can be connected to a Bonfils intubation endoscope or a conventional flexible fiberoptic cable via a C-CAM® adapter (**Fig. 14**), or it can be connected directly to the new FIVE Flexible Intubation Video Endoscope (**Fig. 15**).


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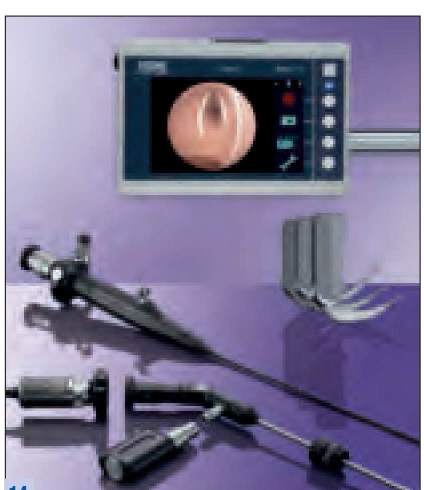
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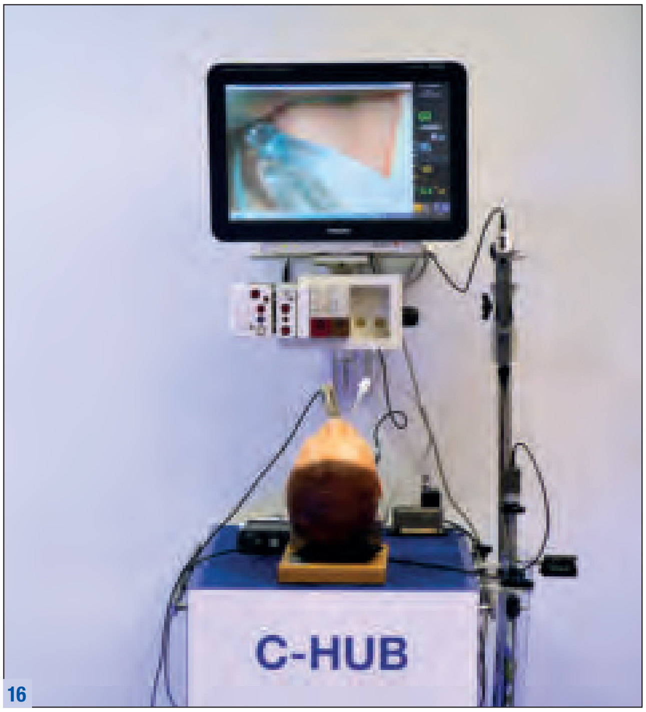

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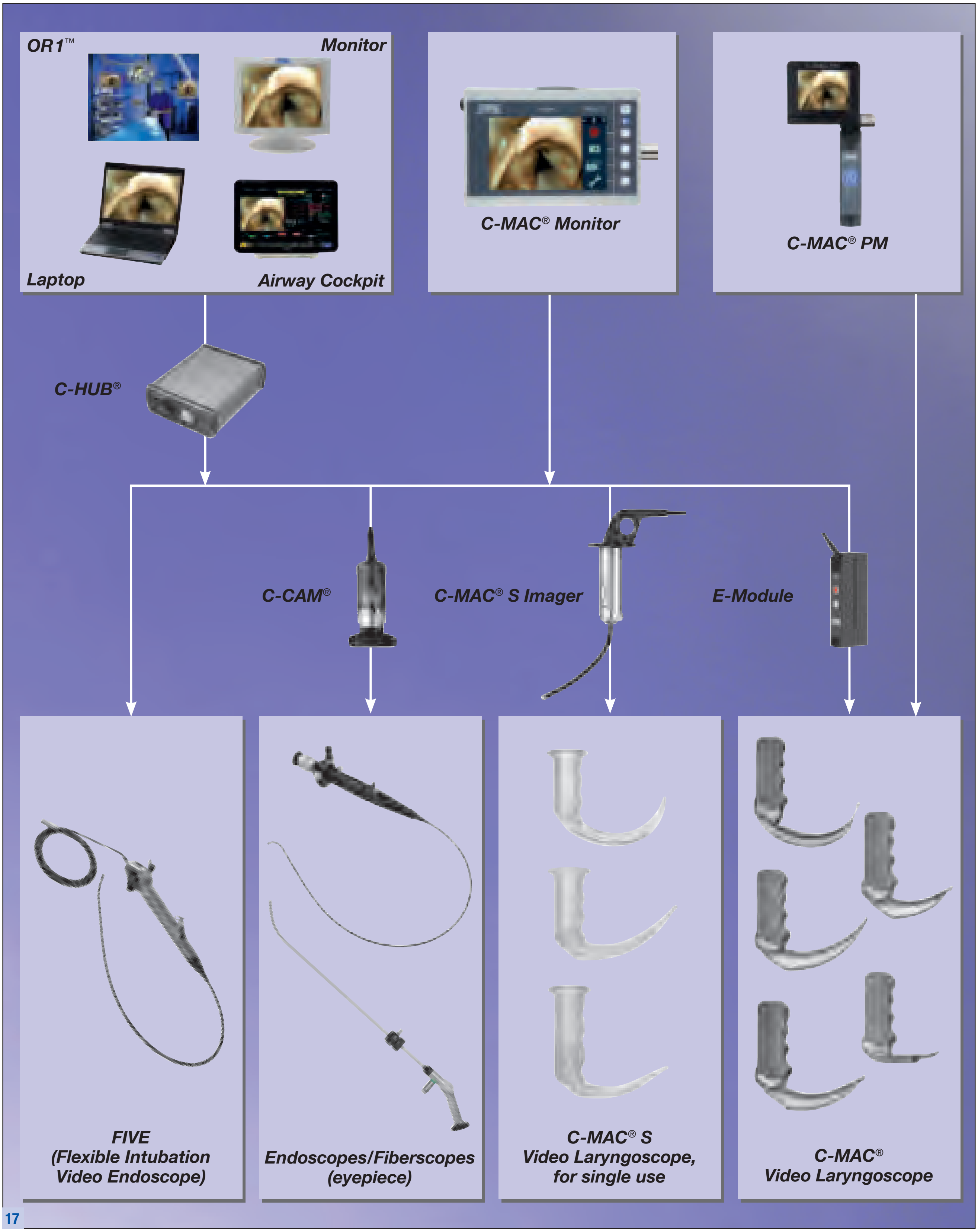
The C-HUB® module provides an interface for connecting additional external monitors or extended data processing on other media (**Fig. 16**). The versatile integration capabilities of the C-MAC® system are illustrated in (see p. 24, **Fig. 17**).



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C-MAC® PM (Pocket Monitor) with a D-BLADE for the difficult airway.

A compact version of the C-MAC® video laryngoscope was developed primarily to achieve maximum portability (e.g., for in-hospital or prehospital emergencies). The C-MAC® PM (Pocket Monitor) consists basically of a small LCD monitor mounted directly on the E-module (2.4" screen, 240 x 320 pixels; open-to-intubate TFT monitor, total system weight 460 g). The E-module of the C-MAC® PM is compatible with all blades in the C-MAC® system. The C-MAC® PM cannot capture still or video images, however, owing to its compact design, and switches and ports for connecting external devices were omitted from the C-MAC® PM to make it as moisture-resistant as possible (IPX8, device is completely immersible in water). The device has a magnetic switch that automatically turns it on when the monitor is opened. The integrated rechargeable lithium-ion battery gives one hour of continuous operation, and the device automatically switches off after 10 minutes' nonuse to conserve power. Current battery level is indicated on the screen (maximum of three bars).

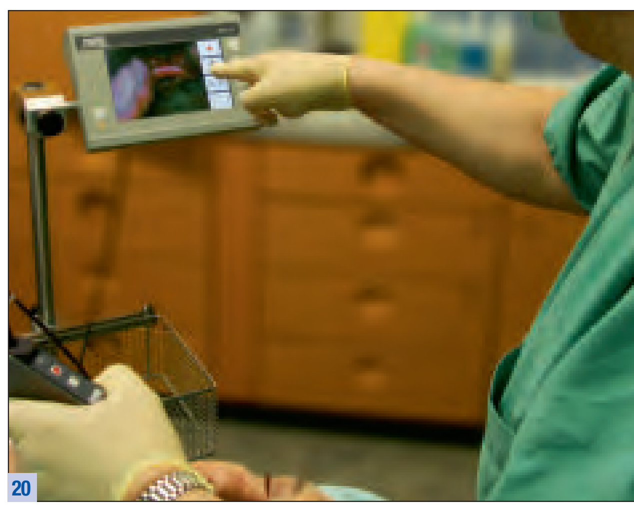
The unit takes 2 hours to recharge when plugged into its charging dock (**Figs. 18, 19**). The closed-case design of the C-MAC® PM makes decontamination fast and easy, since the complete Pocket Monitor unit is immersible in water and cleaning solutions. It is also approved for manual or machine cleaning and disinfection to a maximum temperature of 60° C, or it can be cleaned with disinfectant wipes (e.g., Tristel Wipes System). Owing to its extremely compact design, the C-MAC® PM is particularly useful for emergency intubations under adverse conditions. Time is saved in these situations by using the C-MAC® PM initially with a Macintosh blade, and the user can change quickly to an alternative blade (e.g., the D-BLADE) if the need arises.

2.2 Special Features of the C-MAC® Videolaryngoscope

Erol Cavus

In cases where the glottic plane is poorly visualized by conventional direct laryngoscopy, in which the glottis is viewed directly along the blade (1–9% of all cases)[2, 3], intubation can be successfully accomplished in most cases with the aid of external manipulations such as backward, upward and rightward pressure on the thyroid cartilage (BURP maneuver) or by using a flexible guidewire or even a stylet. Frequent and prolonged intubation attempts are associated with increased airway morbidity, however, especially when the attempts are made "blindly" without visualizing the glottis. It should be noted that airway injuries may occur even with indirect laryngoscopy techniques, including video laryngoscopy, and have been described in the literature[4–8] (**Fig. 20**).

To avoid these injuries, the endotracheal tube must be advanced very carefully into the pharynx until it appears in the visual field of the video laryngoscope. It is helpful if the blade tip is continuously visible on the monitor allowing for accurate tube placement, as is the case with the C-MAC®. The relatively slight curvature of the Macintosh blades of the C-MAC® video laryngoscope allows for direct laryngoscopy in addition to indirect monitor viewing. In contrast to more curved blades, this eliminates the need for a guidewire or stylet, further reducing the risk of injury. This is confirmed by an initial clinical report on anesthesia induction in 60 patients under video laryngoscopic guidance, in which only 8 cases required guidance with an elastic bougie to assist the intubation.[12] Especially in emergency intubations under prehospital or other nonstandard conditions, the capability for direct laryngoscopy provides an essential fallback option in cases where ambient conditions (oropharyngeal secretions, bright ambient light or reflections) hamper or even prevent video-assisted intubation.[13] If the glottis cannot be adequately visualized for anatomic reasons despite use of the C-MAC® video laryngoscope with a Macintosh blade, the operator can change to the more curved C-MAC® D-BLADE with just a few manipulations.[14] It should be noted that the D-BLADE, like all highly curved blades, cannot provide direct glottic visualization (as a fallback solution). Laryngoscopy with this blade is necessarily indirect and requires the use of a guidewire (**Figs. 21, 22**).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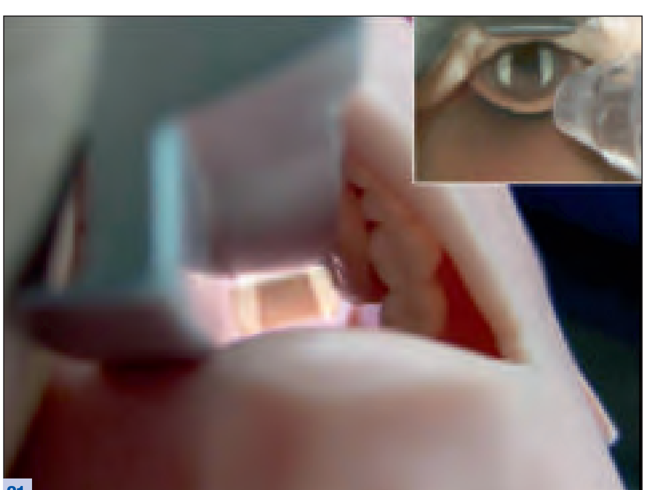
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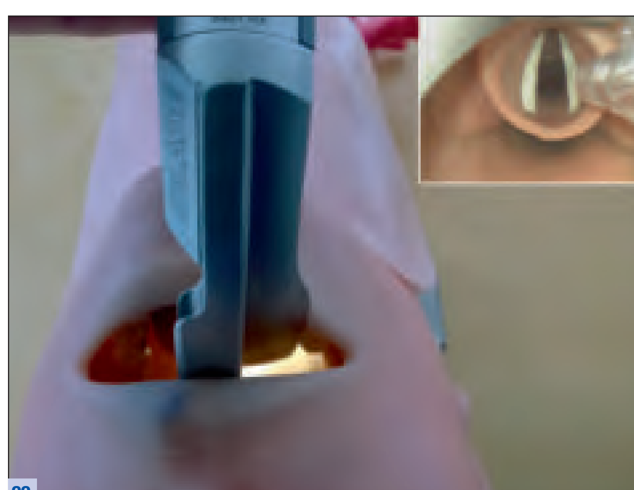
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One of the inherent advantages of video laryngoscopy is that other personnel in the room can observe the intubation process on the monitor and can facilitate the intubation by performing extralaryngeal maneuvers if needed. This feature, plus the capability for direct laryngoscopy, make the C-MAC® an excellent training device. In one possible scenario, the trainee performs a conventional intubation while the instructor watches the monitor and intervenes with help or advice as needed (**Fig. 23**).

The training process is aided by the good optical quality of the system based on the combination of a CMOS video chip and optical lens technology. The still-frame and video memory functions of the C-MAC® are very useful for postprocedure debriefing, as they allow techniques, problems, and instructor interventions to be reviewed and discussed in a calm atmosphere. Since image data can be stored on standard SD memory cards, still images and video sequences can also be viewed on an external PC and can be archived as needed for documentation purposes.

In its present form, the C-MAC® video laryngoscope has been designed not just for difficult intubations but also for routine use. It has been shown that Macintosh-based video laryngoscopy can significantly reduce the intubation forces relative to conventional laryngoscopy with a Macintosh blade, and this can ultimately lower the risk of injuries.[10] Nevertheless, it is also true that unexpected difficult intubations can be successfully managed with the C-MAC® system. This can be accomplished with a C-MAC® Macintosh blade size 4, or else the D-BLADE can be used in an extremely difficult airway (**Fig. 24**).

With the original Macintosh blades, the size 4 blade has a greater curvature than the size 3 blade (**Fig. 25**).

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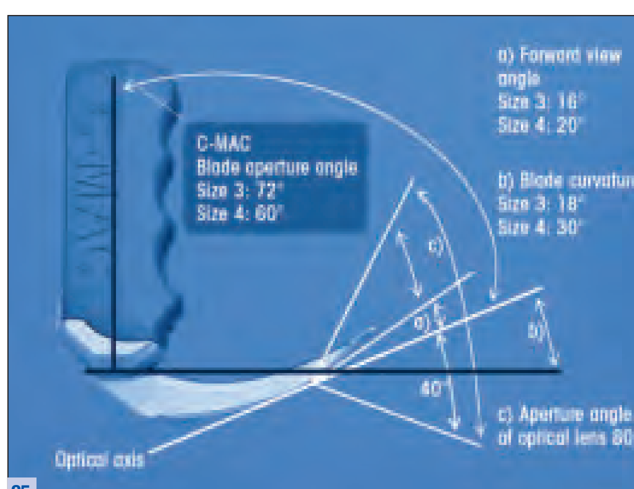

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Laryngoscopic view with a C-MAC® size 4 blade (Cormack-Lehane grade 1) using the Miller technique. The arrow indicates the visible tip of the blade, which has lifted the epiglottis.

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If the epiglottis is also lifted on the laryngoscope as in the classic Miller “straight blade technique,“[11, 12] the Cormack-Lehane grade will be significantly improved, resulting in improved intubation conditions[9] (**Fig. 26**).

The D-BLADE (**Fig. 27**) should be reserved for extremely difficult airways, because its greater curvature does not permit direct laryngoscopy and because it generally requires the use of a guidewire.[13]

The C-MAC® video laryngoscope with the D-BLADE can also be successfully used for careful diagnostic indirect laryngoscopy, as in patients with a presumed foreign body in the larynx (**Fig. 28**). Guided by indirect visualization, the foreign body can be extracted safely and atraumatically with a Boedeker forceps (**Fig. 29**).

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Video laryngoscopic image of a fish bone lodged at the supraglottic level. The patient presented with a cough and foreign-body sensation (C-MAC® D-BLADE).

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With the addition of size 0 and 1 Miller blades, the range of applications has been expanded to include infants and neonates (**Fig. 30**). These blades, like conventional Miller blades, should allow direct laryngoscopy so that the user will not necessarily have to rely on the video screen image. Older children can be intubated with the size 2 Macintosh blade. One advantage of video technology is that it virtually moves the viewer's eye to the blade tip in the direction of the glottis and thus permits glottic visualization even when the blade is inserted less deeply into the mouth compared with conventional direct laryngoscopy of the glottis.

References

1. MACINTOSH RR. A new laryngoscope. Lancet 1943;1:205.
2. HERNANDEZ A, CARRASCO M, AUSINA V. Mycobactericidal activity of chlorine dioxide wipes in a modified prEN 14563 test. J Hosp Infect 2008;69:384-388.
3. STREET I, HAMANN J, HARRIES M. Audit of nasendoscope disinfection practice. Surgeon 2006;4:11-13.
4. COMBES X, LE ROUX B, SUEN P, et al. Unanticipated difficult airway in anesthetized patients: prospective validation of a management algorithm. Anesthesiology 2004;100:1146-1150.
5. CROSBY ET, COOPER RM, DOUGLAS MJ, et al. The unanticipated difficult airway with recommendations for management. Can J Anaesth 1998;45:757-776.
6. MORT TC. Emergency tracheal intubation: complications associated with repeated laryngoscopic attempts. Anesth Analg 2004;99:607-613, table of contents.
7. COOPER RM. Complications associated with the use of the GlideScope videolaryngoscope. Can J Anaesth 2007;54: 54-57.
8. CROSS P, CYTRYN J, CHENG KK. Perforation of the soft palate using the GlideScope videolaryngoscope. Can J Anaesth 2007;54:588-589.
9. HIRABAYASHI Y. Pharyngeal injury related to GlideS- cope videolaryngoscope. Otolaryngol Head Neck Surg 2007;137:175-176.
10. HSU WT, HSU SC, LEE YL, HUANG JS, CHEN CL. Penetrating injury of the soft palate during GlideScope intubation. Anesth Analg 2007;104:1609-1610; discussion 1611.
11. VINCENT RD, JR., WIMBERLY MP, BROCKWELL RC, MAGNUSON JS. Soft palate perforation during orotracheal intubation facilitated by the GlideScope videolaryngoscope. J Clin Anesth 2007;19:619-621.
12. CAVUS E, KIECKHAEFER J, DOERGES V, et al. The C-MAC® videolaryngoscope: First experiences with a new device for videolaryngoscopy-guided intubation. Anesth Analg 2010;110:473-477.
13. CAVUS E, CALLIES A, DOERGES V, et al. The C-MAC® videolaryngoscope for prehospital emergency intubation: a prospective, multicentre, observational study. Emerg Med J 2011;28:650-653.
14. CAVUS E, NEUMANN T, DOERGES V, et al. First clinical evaluation of the C-MAC® D-BLADE videolaryngoscope during routine and difficult intubation. Anesth Analg 2011;112: 382-385.
15. LEE RA, VAN ZUNDERT AA, MAASSEN RL, et al. Forces applied to the maxillary incisors during video-assisted intubation. Anesth Analg 2009;108:187-191.
16. AZIZ MF, DILLMAN D, FU R, BRAMBRINK AM. Comparative effectiveness of the C-MAC® video laryngoscope versus direct laryngoscopy in the setting of the predicted difficult airway. Anesthesiology 2012;116:629-636.
17. PIEPHO T, FORTMUELLER K, HEID FM, et al. Performance of the C-MAC® video laryngoscope in patients after a limited glottic view using Macintosh laryngoscopy. Anaesthesia 2011;66:1101-1105.
18. HENDERSON JJ. The use of paraglossal straight blade laryngoscopy in difficult tracheal intubation. Anaesthesia 1997;52:552-560.
19. MILLER RA. A new laryngoscope. Anesthesiology 1941;2: 317-320.
20. SEROCKI G, NEUMANN T, SCHARF E, DORGES V, CAVUS E. Indirect videolaryngoscopy with C-MAC® D-BLADE and GlideScope: a randomized, controlled comparison in patients with suspected difficult airways. Minerva anestesiologica 2013;79:121-129.

2.3 New Developments in the C-MAC® Video Laryngoscope

Mark Schmelzer

The C-MAC® monitor is the heart of the entire system. It is vitally important, therefore, not only to constantly improve the instruments but also to equip the C-MAC® monitor for the future.

The resolution of the new monitor has been increased to 1280 x 800 pixels, making it compatible with the new VGA CMOS chips that will be installed in future C-MAC® endoscopes. The 7" screen has also been improved and provided with a TFT WVA (wide viewing angle), allowing observers to see the screen clearly from a viewing angle up to 80° on each side. This is particularly important for training additional personnel (e.g., in the induction room) and for assisting colleagues who can still see the display clearly from the side. A new feature is dynamic menu navigation, which allows fast operation with indicative softkeys. The intubation image can also be displayed on an external monitor via the HDMI interface on the side of the monitor, replacing the cinch connectors previously used. Image and video data are still stored on SD cards as before. Data can also be stored on a USB stick, providing double backup and greater storage flexibility for users (**Fig. 31**).

The most important innovation is a new endoscope port on the side of the monitor. It allows two CMOS endoscopes to be connected at one time, such as a C-MAC® video laryngoscope and a FIVE. If local anatomy requires changing to an alternative instrument, the user can toggle between the video sources quickly and easily with the push of the toggle-button. Thus the instrument for “Plan B” is already connected and don't has to be brought in a time critical situation. This saves valuable time during endotracheal intubation and contributes significantly to optimal patient safety (**Fig. 32**).

Of course, all C-MAC® video endoscopes are compatible with the new C-MAC® monitor (see **Fig. 17**, C-MAC® system, Chapter 2.2), so the full range and flexibility of the C-MAC® system will continue to be available to users in the future (**Fig. 33**).

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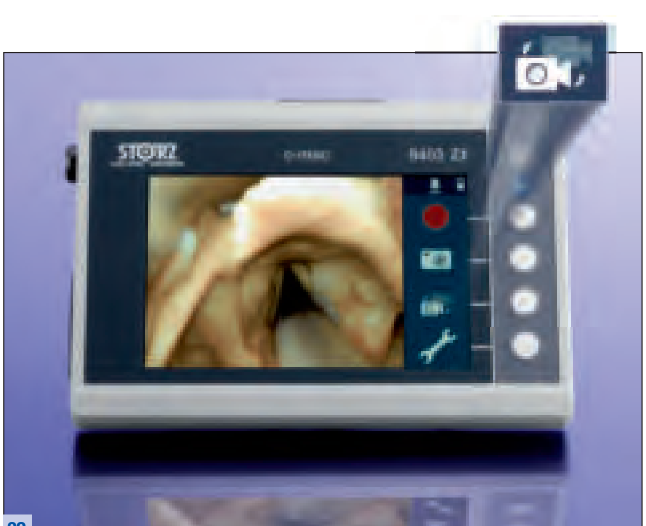

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3

Use of the C-MAC® Videolaryngoscope for Teaching Intubation

3.1 Why is Airway Management with Direct Laryngoscopy So Difficult to Learn?

3.2 Developing a Solution for Teaching Intubation

3.3 Strategies of Airway Management Education

Thomas A. Nicholas IV, M.D.
Department of Anesthesiology
University of Nebraska Medical Center
Department of Veterans Affairs
Nebraska Western Iowa Health Care System
Omaha, Nebraska

Ben H. Boedeker, M.D.
Professor of Anesthesiology
Center for Advanced Technology and Telemedicine
Department of Anesthesiology
University of Nebraska Medical Center
Omaha VA Medical Center, Omaha, Nebraska

Mary Barak-Bernhagen, B.S.
Research Service
Department of Veterans Affairs
Nebraska Western Iowa Health Care System
Omaha, Nebraska

W. Bosseau Murray, M.D.
Simulation Development and Cognitive Science
Laboratory
Pennsylvania State University College of Medicine
Hershey, Pennsylvania

Introduction

Endotracheal intubation is considered the definitive method for controlling the human airway. Succesful intubation has been shown to reduce morbidity and mortality in patients who have been critically injured.[12, 38, 47] It is therefore paramount that health care providers learn to proficiently perform this technique. However, it has been demonstrated that health care providers have not all been trained to the same level of expertise with this technique.[1, 10, 24, 25, 29, 41, 43] Numerous factors play a role in the wide discrepancy of health care providers' ability to intubate. The most addressable factor is airway management training. It has been demonstrated that no standardized training for orotracheal intubation exists throughout different medical fields.[10, 15, 25, 35, 41, 42] Performing endotracheal intubation is a highly skilled technique which requires multiple levels of education in order to understand the procedure and perform effectively, but emphasis on intubation training has not been applied as rigorously outside of anesthesia.[15, 25, 35, 41, 42] Even in anesthesia training programs inadequacies are present. For instance, several articles have indicated that adequate formal training in advanced and difficult airway management is not present in some anesthesia residency programs in the U.S. and U.K.[11, 24, 29]

Perhaps one would argue that complications from unsuccesful airway management are inevitable since some airways are difficult to manage even in the best of hands. However, this fact does not account for the continued unacceptable level of airway mismanagement which certainly points to inadequate training across the medical field. For example, unsuccessful airway management is a major contributor to morbidity and mortality in the prehospital and out-of-operating room hospital settings (**Fig. 1**). *Helm et al.*[16] have reported that several studies examining prehospital deaths from trauma in the United Kingdom have shown that airway obstruction was thought to have contributed to death from major trauma in up to 85% of patients who died.[16, 18, 31, 33]


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Mort[31] reported that in patients requiring reintubation outside the operating room after an unplanned tracheal extubation (n = 57), there was an incidence of a difficult laryngoscopy in 16%, difficult intubation in 14%, and esophageal intubation in 14%. Less than one third of the patients he studied underwent a mishap-free reintubation. An analysis by the *Medical Advisory Secretariat of Canada* found that rates of difficult intubation in the operating room are slightly lower (1.5% – 3%) than in the emergency room (3%–5%) or out in the field (3%–10%). They speculated that the lower rate of difficult intubation in the operating room was because the operating room is a relatively controlled environment, the patient is often unconscious (and fully relaxed) during intubation attempts, and the intubation is performed by trained anesthesia personnel who perform this procedure routinely.[1]

The *American Society of Anesthesiologists' Closed Claims Project* monitors airway management problems that lead to anesthesia malpractice claims in the United States.[30] This database demonstrates that difficult intubation is the second most frequent primary damaging event leading to anesthesia malpractice claims. It is responsible for 6.4% of 4,459 claims in the closed claims database.[30] Not only does difficult intubation lead to a significant proportion of claims, the severity of outcome can be devastating.[30] Brain damage or death was the outcome in 57% of the 283 claims involving difficult intubation.[30] In a review of closed claim cases, *Robbertze et al.*[36] demonstrated that non-operating room anesthesia claims had a higher severity of injury and more substandard care than operating room claims. It was also identified that lack of oxygenation and/or ventilation was the most common mechanism of injury.

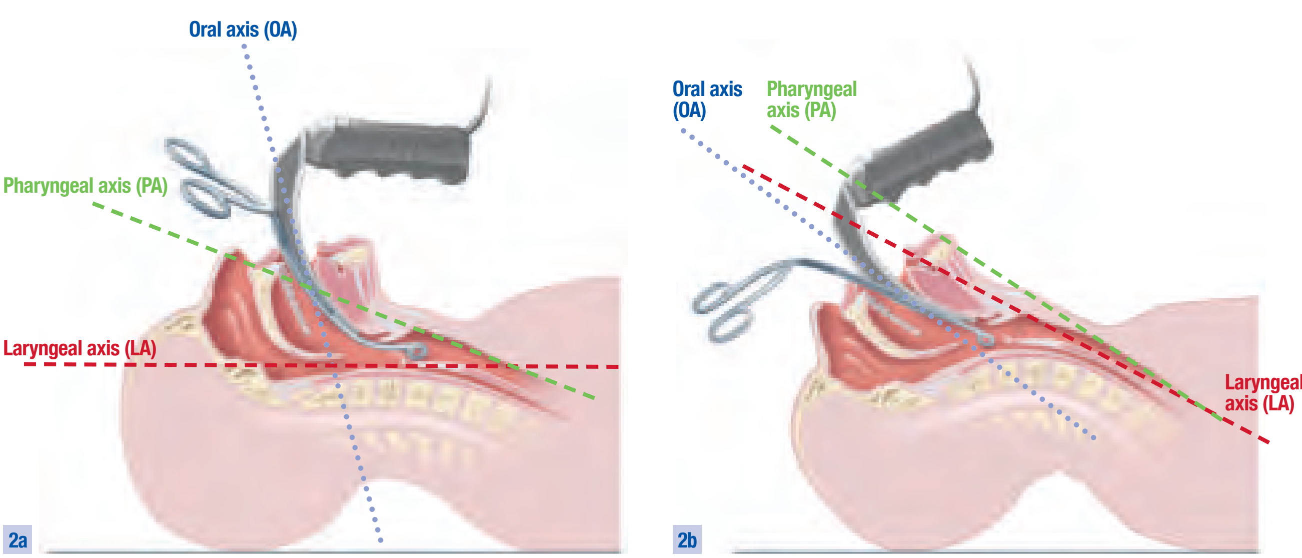
These statistics clearly identify a need for improvement in the teaching of the management of airways by the use of tracheal intubation. However, we are currently not achieving this by traditional means of education of the novice to this specialized psychomotor skill. For example, it has been identified in several studies that emergency medical technicians (EMTs) with mannequin training with direct laryngoscopy only achieved a 50% success rate of intubation in out-of-hospital patients.[7, 39, 40] This is not surprising, since EMTs have limited training and manage airways in more uncontrolled environments in the field. However, it has been identified in a study by *Konrad et al.*[23] that even anesthesia residents in controlled environments have a mean intubation success rate below 50% with their first 10 patients, and not until they reach 57 patients does their success rate increase to 90%. This certainly suggests that the learning curve for direct laryngoscopy is quite flat even in residents who receive experienced attending anesthesia oversight. Perhaps reduced case loads and work hours have caused a learning deficit for anesthesia residents obtaining advanced airway skills as discussed in an editorial by *Underwood et al.*[43] Furthermore, the introduction of laryngeal airway masks and other supraglottic airway devices has caused a decline of valuable learning experience of tracheal intubation experience.[29]

3.1 Why is Airway Management with Direct Laryngoscopy So Difficult to Learn?

A typical airway management course utilizing direct laryngoscopy includes text instruction, airway diagrams or models, and mannequin training with perhaps, a period of very limited experience with live human intubation. Traditional training for tracheal intubation has been shown to require considerable exposure and continued experience to maintain skills.[13, 14, 23, 32, 44] The complex anatomy of the upper airway, and the standard intubation equipment, combine to make acquisition of skills a slow and difficult process. As with most skills, once intubation is learned, if it is not used on a regular basis, then the skill will be lost. The actual process of learning to perform intubation requires that several educational components be obtained in order to properly prepare and train an individual. The most difficult and time consuming component for a trainee is obtaining human training. Namely, the controlled setting of an OR has been utilized as a training area for novice intubators but this is not available to all fields of medicine e.g. paramedics or personnel outside of anesthesia. Also, several factors prevent the OR from providing an adequate amount of patients for airway training. For example, many providers are utilizing laryngeal mask airways (LMAs) or laryngeal tracheal devices (LTDs) cutting down on actual intubations.[29, 43] Similarly, an instructor may not feel comfortable allowing a novice to attempt intubation on a potentially difficult airway patient. The large numbers of trainees (fellows, residents, students) present in the OR at one time may not allow for an outside trainee to have an opportunity to intubate. Obtaining human training outside the OR in uncontrolled environments is even more hazardous for the patient, trainee, and instructor mainly because of the factors discussed later concerning ability to share the limited airway view. These environments are much more stressful for all parties because safety measures like preoxygenation and proper equipment are not uniformly present. Furthermore, many patients in an out-of-OR scenario have potentially more disastrous airways.[3, 20, 25] Therefore, many novices have limited exposure to this type of human training and rely heavily on mannequin training. Mannequin training alone can help prepare a novice for human intubation, but is inadequate as the sole training modality in providing proficiency at this technique.[32] Simulators have attempted to approximate the human airway but are still unable to provide a complete appreciation for the complex human airway which has dynamic and variable characteristics like tissue color, anatomy, secretions, and tissue texture.

It is important to have a deeper understanding of the human airway since difficulties that occur during establishment of a definitive airway are usually related to the intubator not being able to achieve an adequate view of the glottic opening to allow insertion of an endotracheal tube. Review of the anatomy related to intubation shows why obtaining an adequate view of the glottic opening is often difficult (**Figs. 2a, b**).

In order to attain a view of the glottic opening through the patient's mouth, the oral, pharyngeal, and laryngeal axes must be aligned. This is anatomically very difficult in many patients, such as those with limited cervical spine mobility, large tongues, short necks of large circumference, protruding incisors, small mandibles, cervical trauma, or other abnormalities of the neck or



Alignment of the oral (**OA**), laryngeal (**LA**), and pharyngeal (**PA**) axes must be accomplished during intubation to allow visualization of the glottic opening from the mouth.

3

Both trainer and student have direct view – difficult to mentor.

4

The portability of the C-MAC® enhances its utility in out-of-the-OR or out-of-hospital scenarios and also enables multiple trainees and health care workers to simulataneously observe the process.[6]

mouth. In the out-of-operating room cases, the victim's neck is often in a collar, and the present advice and management is to avoid extension of the neck. This creates a problem for visualizing the glottic opening of the patient as the axes cannot be readily aligned.

The problem of adequately viewing the vocal cords and glottis opening is exponentially increased when an instructor is attempting to share the view over the shoulder of a trainee. (**Fig. 3**) Furthermore, the trainee is many times unsure of anatomical structures and a limited view doesn't allow for feedback to be given by the instructor. Therefore the two operators (trainee and instructor) are unable to effectively communicate during intubation with only the 15°-view offered by traditional laryngoscopes. Thus, events like airway trauma cannot be avoided and averted nor can the instructor explain anatomy and guide repositioning maneuvers.

3.2 Developing a Solution for Teaching Intubation

There are numerous newer intubation devices that incorporate an optical image transmitter alongside a **modified laryngoscope blade** to facilitate visualization of the glottic opening. These rigid fiberoptic laryngoscopes offer the advantage of providing a non–line-of-sight view of the vocal cords and visual control of endotracheal tube advancement through the vocal cords.[8]

Examples include the Bullard laryngoscope (Gyrus ACMI, Inc, Southborough, MA), the WuScope (Achi Corporation, San Jose, CA), and the UpsherScope Ultra (Mercury Medical, Clearwater, FL).[2, 8, 9, 22, 45, 46, 48] These devices have been shown to be effective in providing visualization of difficult airways, but they have a long and difficult learning curve, which results in abandonment by many prospective operators before they acquire competence.[8, 21] Some newer devices have a viewing angle which is significantly different from the pathway of the endotracheal tube. The device is effectively acting as an "*endoscope or telescope with a 15° viewing angle*". After watching many novices attempting their first intubations with such a device, we came to the conclusion that the angled view has a slower learning curve than a device with a straight-on-view (effectively acting as a 0°-telescope).

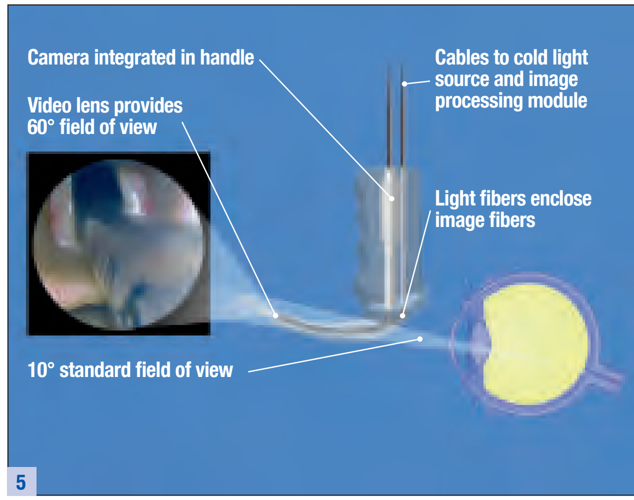
When performing an intubation, a key to whether or not it will be successfully accomplished is obtaining an adequate view of the glottic opening to achieve insertion of the endotracheal tube. Views of the glottic opening are often classified using a Cormack-Lehane grading scale, as shown in **Fig. 6,** with a grade of 1 allowing a full view of the glottic opening and a grade of 4 revealing only the epiglottis. Having the view on a monitor enables the instructor to guide the trainee to obtain the best possible view, as well as learning the scoring system (**Figs. 3, 7, 8**).

Numerous studies have validated the use of the videolaryngoscope in improving airway visualization as well as improving the training impact on novice intubators. A study using the GlideScope by *Nouruzi et al.*[34] found that novice intubators had several significant performance improvements while using the GlideScope. Two hundred patients with class I and II Mallampati scores were intubated using either the Macintosh blade or the GlideScope. It was found that the novice intubators using the GlideScope had an overall success rate of 93% whereas the novice intubators using the traditional Macintosh blade had only a 51% success rate. It was also identified that after two attempts using the GlideScope, the novice intubators had an overall success rate of 95 to 100% which is much higher than in previously described studies[23, 32] providing evidence that the learning curve to intubation was markedly improved. The GlideScope operators' time to intubation was also significantly less than the Macintosh operators' (63 ± 30 seconds versus 89 ± 35 seconds).

Maharaj et al.[28] studied 40 medical students with no prior airway management training. The students attempted intubation on a Laerdal® trainer using either the traditional Macintosh blade or the Airtraq® laryngoscope. *Maharaj et al.* found that the students using the Airtraq® in several intubation scenarios (head left lateral position, cervical spine immobilization, pharyngeal obstruction, normal airway) had a significantly ($p < 0.01$ to $p < 0.05$) decreased duration of intubation atttempts, a reduced number of optimization maneuvers, and a reduced potential for dental injuries. The researchers also identified a rapid learning curve for the Airtraq and the students found it significantly easier to use.

Low et al.[27] utilizing simulated difficult airways, compared 25 novice subjects using the KARL STORZ BERCI DCI® videolaryngoscope to 24 novice subjects using the standard Macintosh blade. After the two groups performed the intubations, they found that the KARL STORZ group had improved confidence in endotracheal tube placement ($p = 0.035$), less teeth trauma ($p = 0.034$), fewer blade repositionings ($p = 0.046$), overall perception of easier intubation ($p = 0.042$), fewer attempts to intubate the simulation difficult airways ($p = 0.02$), and had an improved knowledge of airway anatomy ($p = 0.011$).

In another evaluation, *Howard-Quijano et al.*[17] studied 37 novice intubators attempting intubation on 222 patients. They found that when the novices utilized the KARL STORZ

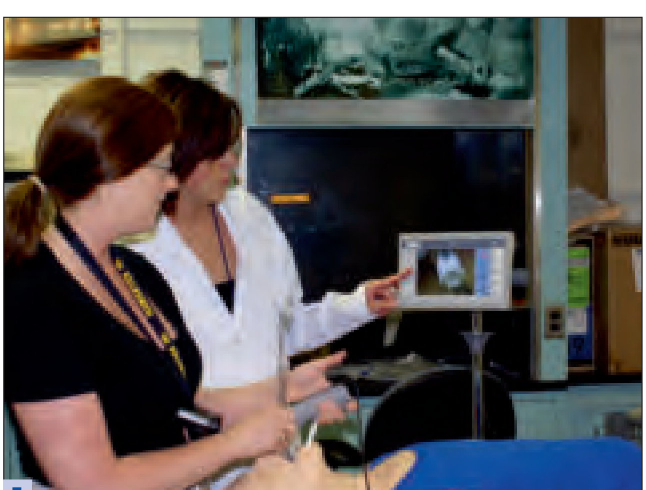


5

Visualization of the airway using classic direct laryngoscopy (10° field of view) and indirect laryngoscopy (60° field of view). (Figure courtesy of Volker Dorges, MD, University of Kiel, Kiel, Germany).

6 Grade I Grade II Grade III Grade IV

Cormack-Lehane views of the glottic opening. **Grade 1,** full view; **Grade 2**, posterior portion is visible; **Grade 3,** only the tip of the epiglottis is visible; **Grade 4,** only soft tissue is visible. © 2009, The Center for Advanced Airway Techology, Board of Regents of the University of Nebraska.



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8

Trainer has indirect view, student has direct view.

video Macintosh system, they had less airway trauma, less malpositions of the blade, significantly fewer esophageal intubations, and a significantly improved successful intubation rate. The improved rate of intubation success in this study was felt to be due to the instructor's ability to monitor the indirect view. A 69% success rate was noted in the novice intubators who utilized the KARL STORZ system which implied a shorter learning curve than previous studies by *Konrad et al.*[23] and *Mulcaster et al.*[32]

Boedeker et al.[6] studied 45 participants (35 medical students, three residents, one internal medicine resident, one fellow, and one respiratory technician, four unspecified participants) intubating a *Laerdal Difficult Airway Mannequin™*. The Laerdal® intubators using the KARL STORZ Tele Pack™ laryngoscope, were significantly more successful intubating the mannequin in a diffcult airway mode ($p = 0.05$) and in an easy mode ($p < 0.001$). It was also noted that the instructors believed they could better advise the students on intubation aspects, as well as instruct them on anatomy during the procedure. The trainees believed a similar improvement in the training experience occurred by receiving better real time instruction on the procedure and the anatomy. The students also believed that they could learn faster by having the instructor view the indirect monitor during the intubation attempts (**Fig. 8**).

3.3 Strategies of Airway Management Education

A revised system of teaching and learning tracheal intubation needs to be formulated to improve and shorten the learning curve for tracheal intubation. This new system can be achieved adding videolaryngoscope technology to existing training as identified in several current studies.[4, 19, 22, 27, 28] Not only does the videolaryngoscope allow for the actual intubation process to be a greater learning and teaching experience for the novice and supervisor, but it can also provide a valuable learning tool such as historical intubation video which can be reviewed later as a learning experience before live human intubation occurs.[4] This has been shown to improve the student's success rate.[26]

The Center for Advanced Technology and Telemedicine (CATT) of the *University of Nebraska Medical Center* has successfully developed a higher impact airway management course which utilizes the actual videolaryngoscope, video information gathered from its use, web-based teaching modules, mannequin and human training. The *CATT* uses the KARL STORZ C-MAC® in its mannequin and human intubation training sessions. The following is a brief description on the center's modified basic intubation training course:

Mannequin intubation training-students of the *CATT* complete an online intubation training course and test (http://www.unmc.edu/apps/catt/), plus a pre-training questionnaire prior to participating in the mannequin and human intubation training. The student then participates in the center's mannequin training session. In this course, the trainee attempts a series of endotracheal intubations using a Laerdal Difficult Airway Mannequin™ set in both standard and difficult airway modes using both direct (monitor turned away from the student) and indirect (monitor view) laryngoscopy. The device used is the KARL STORZ C-MAC® videolaryngoscope fitted with a Mac-3-blade. Intubation attempts are timed and graded on success/no success in intubating the trachea.

The four training and practice intubation scenarios include:

- direct view (monitor turned away from the student) on a standard mannequin airway;
- indirect view (view of the monitor) on a standard mannequin airway;
- direct view on a difficult mannequin airway, and;
- indirect view on a difficult mannequin airway.

In all scenarios, the student is directed to grade the glottic view of the mannequin using a modified Cormack-Lehane (CL) scoring system.

After the intubation exercise, the subjects complete a post-training questionnaire which measures their perceived value of the mannequin training session. They are then ready to participate in the human intubation training session.

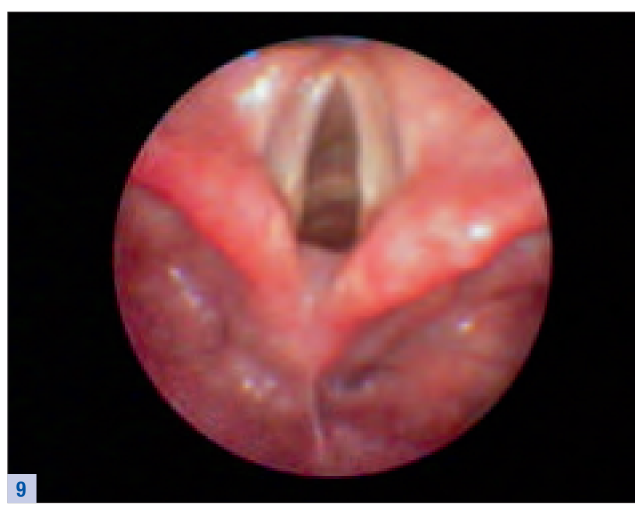
Use of the KARL STORZ C-MAC® in human intubation training under direct supervision of the training anesthesiologist, the student performs an endotracheal intubation on a patient with the videolaryngoscope (C-MAC®). The student is directed to note the CL grade of the airway (using the monitor) at the time of insertion of the endotracheal tube. After insertion of the endotracheal tube and before removal of the laryngoscope, the student is directed to record the direct view CL grade of the airway. After the human intubation session, the student completes the post-training questionnaire.

Boedeker et al. have demonstrated significantly improved intubation success rates in a variety of trainees, including medical students and prehospital personnel.[4] This figure far exceeds the 69% intubation success rate by novices utilizing a videolaryngoscopy (VL) system in human studies conducted by *Howard-Quijano et al.*[17] Clearly, this study demonstrates multiple areas of benefits of using a VL system for the purpose of training the novice in orotracheal intubation. These benefits were not only present in the mannequin simulation but were also present in the human portion of this study.[4]

Advantages of Using the C-MAC® Videolaryngoscope in Airway Training

The C-MAC® videolaryngoscope appears to offer several advantages for use in intubation training

- In both mannequin and human intubation training, the use of the KARL STORZ C-MAC® videolaryngoscope offers an expanded and enlarged view of the glottic opening. The displayed anatomy is magnified, making recognition of standard anatomy, distorted anatomy, as well as anomalies easier, as shown in **Fig. 9**.[22]
- In human intubations when laryngeal manipulations must be performed to improve the glottic view, the assistant performing these manuevers can see on the monitor what impact this effort is having on the view of the larynx. This greatly coordinates efforts between the laryngoscopist and the assistant performing laryngeal manipulations, as shown in **Fig. 9**.
- Videolaryngoscopy also facilitates complex maneuvering and advancement of the endotracheal tube and stylet. Due to a greater curvature of some videolaryngoscopes, a second "pair of hands" may be required to advance the endotracheal tube off of the stylet. For instance, while using the GlideScope™, the stiffened endotracheal tube (stiffened due to the introducer) is approaching the glottic opening at such an angle that the stiffened endotracheal tube impinges upon the anterior wall of the trachea, thereby preventing the "intubation" (i.e. preventing further passage of the tube into the trachea. When this occurs, the second person (second "pair of hands") can see this on the external monitor and can help to advance the endotracheal tube off of the stylet, and deeper into the trachea. The video image enables the intubator and the assistant to see and work off of the same image. The trainee can also practice, under guidance, to feed the endotracheal tube off the stylet in a single handed mode.
- In the OR, when a trainee intubator is attempting to intubate a patient, the videolaryngoscope allows the staff physicians and the student to share the same view of the glottic opening. The trainer is able to directly observe the view the trainee has attained and assess the actions in manipulating the airway. This view enables improved mentoring of the trainee and decreases the chances of the trainee damaging the vocal cords during intubation attempts. It does not, however, help to "see" damage to the teeth.
- As the C-MAC® blade enters the mannequin or human hypopharynx, the student is able to be taught airway anatomy and the intubation technique by utilizing the shared indirect view. Familiarity with the anatomy and technique likely is a component to the improved confidence levels and success seen in students being instructed with the KARL STORZ laryngoscope blade.[4]
- In the OR intubation training, if the airway exceeds the intubation skills of the student, the more experienced laryngoscopist can recognize the difficulty early in the intubation process and intervene.
- Projection of the image of the airway to the video monitor facilitates teaching of multiple students who may be observing this procedure.
- The portability of the C-MAC® allows it to be utilized outside of the OR or hospital setting in more stressful situations which typically would not be an acceptable teaching environment. However, the instructor is able to see the exact progress of the student and intervene if necessary. This allows for a valuable training experience to occur in a situation which typically wouldn't be available for the student (**Fig. 4**).
- Documentation (pictures or movies) of proper intubation, recording of pathologic findings, or incorporation in video teaching modules is possible. The KARL STORZ C-MAC® enables video output, which in the future could enable it to serve as a telemedicine.



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The epiglottis is at the top of the picure (out of view). The two arytenoid cartilages are clearly visible at the bottom of the picture. A full view of the vocal cords is present in the middle of the picture. (Photographs courtesy of *Volker Dörges,* MD, University of Kiel, Germany.)

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platform, if interfaced with video conferencing communication system; this could then be used for telementoring (**Fig. 10**).

- The portability of the C-MAC® allows it to be used to intubate a patient from a difficult position (such as an accident scene when the patient may not be in an optimal position for intubation) (**Fig. 11**).
- Videolaryngoscopy enables visualization of the endotracheal tube going through the vocal cords with a Seldinger technique improving safety. If the tip of the endotracheal tube gets caught (or "hung up") on the vocal cords, this can be visualized, and remedied, thereby preventing trauma to the vocal cords.
- The C-MAC® can be easily transported between operating rooms and out of the OR cases, making it cost effective since it does not need to be physically dedicated to one area.

Disadvantages of using videolaryngoscopy in intubation training:

- The optics of the videolaryngoscope blades can be distorted or disabled by thick body secretions or blood. This is true for most indirect techniques.
- The wired connection between the digital camera and CMOS can be damaged but connections are more rugged in the C-MAC® configuration rather than traditional fiberoptic connections.
- Videolaryngoscope systems require mannequin and human training in order to become proficient with their use. However, the time required to become proficient with a KARL STORZ videolaryngoscope is quite short as previously identified.[4]

Conclusion

Learning to intubate is a slow process due to the complex anatomy of the upper airway (**Fig. 2**). Teaching a novice to become proficient is also a difficult process which requires experienced teachers and suitable equipment.[13, 14, 23, 32] Failure of the teaching and learning process has contributed to multiple problems with airway management throughout the medical community, as identified in prior studies[10, 14, 15, 18, 30, 31, 33, 36, 38, 40] Loss of the airway commonly contributes to death in the prehospital trauma setting[16, 18, 33] as well in hospital settings.[1, 30, 36] It is therefore imperative that the medical community develop an improved system of training our providers to safely and effectively perform intubation. This new system of training should have a short learning curve and be uniform throughout the field of medicine. The advancements of videolaryngoscopy has made this tool the most viable option as an addition to current training methods. Numerous rigid fiberoptic laryngoscopes have been developed and would offer similar improvements in the shared indirect glottic view, but they are much more difficult to learn to operate because their shapes are different from the commonly used Macintosh blade, and the movements required to obtain a view are not as familiar as the Macintosh blade. Also, many of these devices are not sufficiently portable that they can be used in an out of OR setting. These novel videolaryngoscopes are being introduced to the field of medicine and are undergoing validation studies which may help determine the viablity of each individual device as an airway management and educational tool. The

GlideScope uses a laryngoscope blade design based on a Macintosh blade but with a much greater curvature. The Storz system utilizes standard straight as well as curved laryngoscope blades. The KARL STORZ C-MAC® accommodates the Macintosh 3 and 4 blades and offers the advantage of portability.[5, 37] Because laryngoscopists are familiar and comfortable with these commonly used blade designs, this may create the very short learning curve that facilitates the quick mastering of these instruments.

It is likely that videolaryngoscopy will become the standard for education in airway management as demonstrated in the studies reviewed in this article. The videolaryngoscope, particularly the KARL STORZ C-MAC® with its portability, familiarity of shape, short learning curve, and proven technology can provide a superior means of high impact training in a traditional OR setting as well as out-of-OR settings. Novice intubators can now benefit from live human training in settings outside the OR which were typically stressful environments for the trainee as well as the trainer. This expanded role will give trainees the confidence and proficiency to deal with airway situations which many times are more difficult and unpredictable than a relaxed and sedated patient in the OR.

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References

1. Medical Advisory Secretariat. Video laryngoscopy for tracheal intubation: an evidencebased analysis. Ontario Health Technology Assessment Series 2004;4(5).

2. ABRAMS KJ, DESAI N, KATSNELSON T. Bullard laryngoscopy for trauma airway management in suspected cervical spine injuries. Anesth Analg 1992 Apr;74(4):623.

3. ADNET F, LAPOSTOLLE F, RICARD-HIBON A, CARLI P, GOLDSTEIN P. Intubating trauma patients before reaching hospital – revisited. Crit Care 2001 Dec;5(6):290–1.

4. BOEDEKER BH, BERNHAGEN MA, NICHOLAS TA, MURRAY WB. The Combined Use of Simulated and Human Intubation Training for 4 th Year Medical Students. Presentated at the 2009 Annual Meeting of the American Society Anesthesiologists.

5. BOEDEKER BH, BERG BW, BERNHAGEN MA, MURRAY WB. Endotracheal intubation comparing a prototype Storz C-MAC® and a glidescope videolaryngoscope in a medical transport helicopter – a pilot study. Stud Health Technol Inform 2009;142:37–9.

6. BOEDEKER BH, HOFFMAN S, MURRAY WB. Endotracheal intubation training using virtual images: learning with the mobile telementoring intubating video laryngoscope. Stud Health Technol Inform 2007;125:49–54.

7. BRADLEY JS, BILLOWS GL, OLINGER ML, BOHA SP, CORDELL WH, NELSON DR. Prehospital oral endotracheal intubation by rural basic emergency medical technicians. Ann Emerg Med 1998 Jul;32(1):26–32.

8. COOPER RM. The GlideScope videolaryngoscope. Anaesthesia 2005 Oct;60(10):1042.

9. COOPER RM, PACEY JA, BISHOP MJ, MCCLUSKEY SA. Early clinical experience with a new videolaryngoscope (GlideScope) in 728 patients. Can J Anaesth 2005 Feb;52(2):191–8.

10. CORMACK RS, ROCKE DA, LATTO IP, COOPER GM. Failed intubation in obstetric anaesthesia. Anaesthesia 2006 Feb;61(2):192–3; author reply 3–4.

11. DUNN S, CONNELLY NR, ROBBINS L. Resident training in advanced airway management. J Clin Anesth 2004 Sep;16(6):472–6.

12. GARNER A, RASHFORD S, LEE A, BARTOLACCI R. Addition of physicians to paramedic helicopter services decreases blunt trauma mortality. Aust N Z J Surg 1999 Oct;69(10):697–701.

13. GARZA AG, GRATTON MC, COONTZ D, NOBLE E, MA OJ. Effect of paramedic experience on orotracheal intubation success rates. J Emerg Med 2003 Oct;25(3):251–6.

14. GERBEAUX P. Should emergency medical service rescuers be trained to practice endotracheal intubation? Crit Care Med 2005 Aug;33(8):1864–5.

15. GOLDHILL DR, COOK TM, WALDMANN CS. Airway incidents in critical care, the NPSA, medical training and capnography. Anaesthesia 2009 Apr;64(4):354–7.

16. HELM M, HOSSFELD B, SCHAFER S, HOITZ J, LAMPL L. Factors influencing emergency intubation in the pre-hospital setting – a multicentre study in the German Helicopter Emergency Medical Service. Br J Anaesth 2006 Jan;96(1):67–71.

17. HOWARD-QUIJANO KJ, HUANG YM, MATEVOSIAN R, KAPLAN MB, STEADMAN RH. Video-assisted instruction improves the success rate for tracheal intubation by novices. Br J Anaesth 2008 Oct;101(4):568–72.

18. HUSSAIN LM, REDMOND AD. Are pre-hospital deaths from accidental injury preventable? BMJ 1994 Apr 23;308(6936):1077–80.

19. IWASE Y, MATSUSHIMA H, NEMOTO M, FUJITA A, OZAKI M, UENO K, et al. [The efficacy of video intubating laryngoscope for novice residents]. Masui 2004 Mar;53(3):313–9.

20. JABER S, AMRAOUI J, LEFRANT JY, ARICH C, COHENDY R, LANDREAU L, et al. Clinical practice and risk factors for immediate complications of endotracheal intubation in the intensive care unit: a prospective, multiple-center study. Crit Care Med 2006 Sep;34(9):2355–61.

21. JENKINS K, WONG DT, CORREA R. Management choices for the difficult airway by anesthesiologists in Canada. Can J Anaesth 2002 Oct;49(8):850–6.

22. KAPLAN MB, WARD DS, BERCI G. A new video laryngoscope – an aid to intubation and teaching. J Clin Anesth 2002 Dec;14(8):620–6.

23. KONRAD C, SCHUPFER G, WIETLISBACH M, GERBER H. Learning manual skills in anesthesiology: Is there a recommended number of cases for anesthetic procedures? Anesth Analg 1998 Mar;86(3):635–9.

24. KOPPEL JN, REED AP. Formal instruction in difficult airway management. A survey of anesthesiology residency programs. Anesthesiology 1995 Dec;83(6):1343–6.

25. LEIBOWITZ AB. Tracheal intubation in the intensive care unit: extremely hazardous even in the best of hands. Crit Care Med 2006 Sep;34(9):2497–8.

26. LEVITAN RM, GOLDMAN TS, BRYAN DA, SHOFER F, HERLICH A. Training with video imaging improves the initial intubation success rates of paramedic trainees in an operating room setting. Ann Emerg Med 2001 Jan;37(1):46–50.

27. LOW D, HEALY D, RASBURN N. The use of the BERCI DCI Video Laryngoscope for teaching novices direct laryngoscopy and tracheal intubation. Anaesthesia 2008 Feb;63(2):195–201.

28. MAHARAJ CH, HIGGINS BD, HARTE BH, LAFFEY JG. Evaluation of intubation using the Airtraq or Macintosh laryngoscope by anaesthetists in easy and simulated difficult laryngoscopy – a manikin study. Anaesthesia 2006 May;61(5):469–77.

29. MASON RA. Education and training in airway management. Br J Anaesth 1998 Sep;81(3):305–7.

30. MILLER CG. Management of the Difficult Intubation in Closed Malpractice Claims. ASA Newsletter 2000;64(6):13–6 + 9.

31. MORT TC. Unplanned tracheal extubation outside the operating room: a quality improvement audit of hemodynamic and tracheal airway complications associated with emergency tracheal reintubation. Anesth Analg 1998 Jun;86(6):1171–6.

32. MULCASTER JT, MILLS J, HUNG OR, MACQUARRIE K, LAW JA, PYTKA S, et al. Laryngoscopic intubation: learning and performance. Anesthesiology 2003 Jan;98(1):23–7.

33. NICHOLL J, HUGHES S, DIXON S, TURNER J, YATES D. The costs and benefits of paramedic skills in pre-hospital trauma care. Health Technol Assess 1998;2(17):i–iv, 1–72.

34. NOURUZI-SEDEH P, SCHUMANN M, GROEBEN H. Laryngoscopy via Macintosh blade versus GlideScope: success rate and time for endotracheal intubation in untrained medical personnel. Anesthesiology 2009 Jan;110(1):32–7.

35. OWEN H, PLUMMER JL. Improving learning of a clinical skill: the first year's experience of teaching endotracheal intubation in a clinical simulation facility. Med Educ 2002 Jul;36(7): 635–42.

36. ROBBERTZE R, POSNER KL, DOMINO KB. Closed claims review of anesthesia for procedures outside the operating room. Curr Opin Anaesthesiol 2006 Aug;19(4):436–42.

37. ROSE DK, COHEN MM. The incidence of airway problems depends on the definition used. Can J Anaesth 1996 Jan;43(1):30–4.

38. SANSON G, DI BARTOLOMEO S, NARDI G, ALBANESE P, DIANI A, RAFFIN L, et al. Road traffic accidents with vehicular entrapment: incidence of major injuries and need for advanced life support. Eur J Emerg Med 1999 Dec;6(4):285–91.

39. SAYRE MR, SAKLES JC, MISTLER AF, EVANS JL, KRAMER AT, PANCIOLI AM. Field trial of endotracheal intubation by basic EMTs. Ann Emerg Med 1998 Feb;31(2):228–33.

40. SPAITE D. Intubation by basic EMTs: lifesaving advance or catastrophic complication? Ann Emerg Med 1998 Feb;31(2):276–7.

41. STEWART RD, PARIS PM, PELTON GH, GARRETSON D. Effect of varied training techniques on field endotracheal intubation success rates. Ann Emerg Med 1984 Nov;13(11):1032–6.

42. STRINGER KR, BAJENOV S, YENTIS SM. Training in airway management. Anaesthesia 2002 Oct;57(10):967–83.

43. UNDERWOOD SM, MCINDOE AK. Influence of changing work patterns on training in anaesthesia: an analysis of activity in a UK teaching hospital from 1996 to 2004. Br J Anaesth 2005 Nov;95(5):616–21.

44. WANG HE, SEITZ SR, HOSTLER D, YEALY DM. Defining the learning curve for paramedic student endotracheal intubation. Prehosp Emerg Care 2005 Apr–Jun;9(2):156–62.

45. WEISS M, HARTMANN K, FISCHER J, GERBER AC. Video-intuboscopic assistance is a useful aid to tracheal intubation in pediatric patients. Can J Anaesth 2001 Jul–Aug;48(7):691–6.

46. WEISS M, HARTMANN K, FISCHER JE, GERBER AC. Use of angulated video-intubation laryngoscope in children undergoing manual in-line neck stabilization. Br J Anaesth 2001 Sep;87(3):453–8.

47. WINCHELL RJ, HOYT DB. Endotracheal intubation in the field improves survival in patients with severe head injury. Trauma Research and Education Foundation of San Diego. Arch Surg 1997 Jun;132(6):592–7.

48. WU TL, CHOU HC. A new laryngoscope: the combination intubating device. Anesthesiology 1994 Oct;81(4):1085–7.

Use of Videolaryngoscopy in the Operating Room

4

4.1 Videolaryngoscopy in Obese Patients

4.2 Videolaryngoscopy in the Expected and Unexpected Difficult Airway

Carin A. Hagberg, M.D.
Joseph C. Gabel Professor and Chair
Department of Anesthesiology
University of Texas Medical School at Houston, Houston, Texas, USA

Robert G. Clark
Medical Student III
Stanford University, Palo Alto, California, USA

Introduction

Over the past decade, incorporation of video techniques in surgical practice has become routine for various surgical procedures. The advantages and success of video technology during surgery has encouraged anesthesiologists to include video systems into their practice of both routine and emergent airway management. With the increase in its availability, videolaryngoscopy can be used for routine tracheal intubation in the operating room setting. Videolaryngoscopes are fairly easy to use, even when used by operators relatively inexperienced with the device,[1] afford better laryngeal exposure, and allow improved teaching of laryngoscopy. Additionally, they help the user to achieve a line-of-sight view by the tissue compression, distraction, and external force. Also, although they cannot be introduced into the nose, they can be used to direct nasal intubation. Lastly, experience with videolaryngoscopes should be acquired when no difficulty with laryngoscopy or intubation is anticipated so that when a difficult airway is encountered, the chance of successful intubation with these devices is increased. The utilization of video techniques has demonstrated significant advantages especially in management of the difficult airway.[2]

4.1 Videolaryngoscopy in Obese Patients

Carin A. Hagberg, Robert G. Clark

Patients who weigh more than 20% over their ideal weight are considered obese and if more than 100% over their ideal weight, "morbidly obese".[3] There are unique considerations that should be taken into account regarding airway management of these patients.[4] Firstly, the obese patient has a reduced functional residual capacity with decreased pulmonary oxygen stores and increased oxygen consumption, leading to rapid desaturation when apnea occurs.[5–7] Thus, if poor glottis exposure occurs, prolonged or multiple attempts at laryngoscopy are likely to be required, putting this patient population at an even greater risk of oxygen desaturation. Therefore, it is important to develop methods in order to facilitate intubation and decrease the duration of apnea. Secondly, the obese patient with a short thick neck, a large tongue, or redundant folds of oropharyngeal tissue may be difficult to ventilate and/ or intubate and is at an increased risk of developing airway obstruction.[8, 9] It is these patients who exhibit challenging circumstances for the operator that alternate laryngoscopes should especially be considered, and alternative methods of securing the airway become of significant importance.

Difficult laryngoscopy and tracheal intubation of the morbidly obese population remains a debatable concern among anesthesiologists and has been addressed in the literature *Juvin et al.*[10] reported a difficult intubation rate of 15.5% in obese patients and 2.2% in lean patients. They determined that the chances for a successful first attempt at oral intubation decreases as patient weight increases. On the other hand, *Brodsky et al.*[11] found that neither obesity nor body mass index (BMI) predicted problems with tracheal intubation. Rather, they determined that a high Mallampati score and a large neck circumference increases the potential for difficult laryngoscopy and intubation. *Frappier et al.*[12] found that 16% (19 out of 118) of morbidly obese patients had a Cormack-Lehane grade III or IV views during direct laryngoscopy, thus anesthesiologists should be prepared for difficult intubation in this patient population. Additionally, morbidly obese patients are frequently more difficult to ventilate, and they tend to become hypoxic more quickly, as mentioned previously.[5–9]

Videolaryngoscopes have been introduced as a successful method to manage airways of morbidly obese patients who are at risk of a difficult intubation by the rationale of improved laryngoscopic view in order to facilitate intubation.[13–15] In fact, *Marrel et al.*[13] recently demonstrated that videolaryngoscopy improves intubation conditions in morbidly obese patients. The authors found that in morbidly obese patients with a laryngoscope grade of 2 or higher, the videolaryngoscopes nearly always allows improved visualization of the airway anatomy, thereby improving the intubation conditions. They also found that it will also most likely facilitate faster endotracheal intubation. Thus, it is their routine practice to now intubate all morbidly obese patients with the videolaryngoscope. In contrast to results from *Sun et al.*,[16] *Marrell* found a significantly shorter intubation duration with the videolaryngoscope. Like the KARL STORZ Macintosh videolaryngoscopes, the Rüsch X-Lite® System (introduced in 2001, also manufactured by KARL STORZ) uses the conventional shaped Macintosh blades. Thus, a shortened duration of intubation may benefit the morbidly obese population, as the incidence of severe desaturation may decrease with the use of videolaryngoscopy. *Cooper et al.*[1] also demonstrated an improved laryngoscopic view with the GlideScope, yet intubation failed in 3.7% of the cases despite a good or excellent glottis view. They attributed these failures to limited experience or difficulty in ETT manipulation when viewing the monitor. Advantages and limitations of videolaryngoscopy within this particular group not only includes those inherent with their use in all patients but some pertain specifically to the obese patient population. Certain anatomical difficulties have a higher incidence in obese patients than in lean patients which can interfere with tracheal intubation, even when videolaryngoscopy is used.[17] Large breasts, which typically accompany morbidly obese patients, can interfere with the introduction of the blade into the mouth as the wiring for the light source of videolaryngoscopes often arises from the top of the handle. Alternative positioning by extending the patient's neck is suggested as a way to overcome this limitation.[18] Some blades may be disarticulated from the handle and then reattached once the blade has been placed in the oropharynx. Morbidly obese patients experience a larger reduction in lung volume than normal-weight patients following induction and paralysis which allows the anesthesiologist less time for successful intubation. Tracheal intubation performed with a videolaryngoscope by a seasoned operator in these patients could be advantageous. One series reported the use of the Macintosh videolaryngoscopes in 100 consecutive bariatric cases resulted in successful intubation on the first attempt in 98 patients and on the second attempt in the remaining 2 patients.[19]

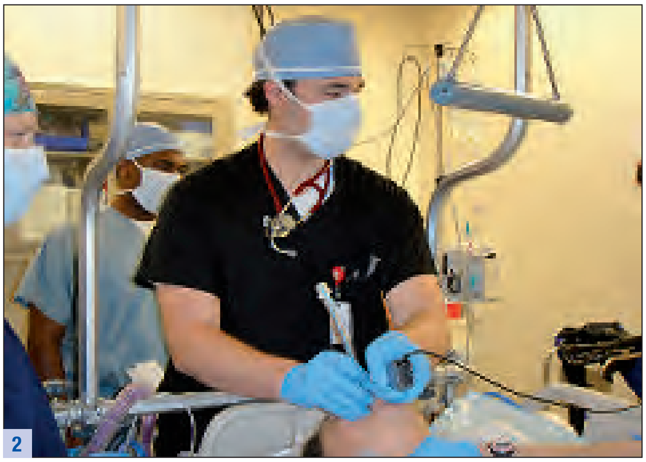
Videolaryngoscopy may provide patients with a reduced risk of airway trauma or damage. The operator is able to place the endotracheal tube (ETT) with greater precision and caution due to the enlarged image that appears on the monitor (**Fig. 1**). The reduction of airway trauma in morbidly obese patients is particularly beneficial at extubation, especially in those with obstructive sleep apnea. A recent study by *Maassen et al.*[20] compared three different videolaryngoscopes, the GlideScope Ranger™, the C-MAC®, and the McGrath®, in adult morbidly obese patients. They found that these videolaryngoscopes differ significantly in their ease of use (in terms of intubation time, number of attempts, and the need for additional adjuncts), even when the visual quality is essentially identical. This study demonstrated that in this patient population, the KARL STORZ videolaryngoscopes had a better overall satisfaction score, intubation time, number of intubation attempts, and necessity for extra adjunctors, as compared to the other two videolaryngoscopes. Maassen's study confirmed that a styletted ETT is highly desirable to intubate the trachea in morbidly obese patients with the McGrath and GlideScope, but not necessarily with the KARL STORZ videolaryngoscopes. If difficulty does occur in passing an ETT, an intubation catheter such as the gum elastic bougie, can be utilized especially when only a partial view of the vocal cords or only the epiglottis is visible.

Trauma to the airway may be reduced if laryngoscopy and intubation can be performed without the use of a stylet. The GlideScope and McGrath videolaryngoscopes have blades that are angled approximately 60 degrees upward, thus the larynx is in most cases not directly visible with these devices. Despite an adequate view on the video monitor, it may be difficult to perform tracheal intubation. Thus, a stylet should always be used and a special GlideRite™ metal stylet has been manufactured by Verathon for use with the GlideScope laryngoscopes, although the use of metal stylets is not universal due to an increased injury rate with their use. The blades of the KARL STORZ MVL, V-MAC®, and C-MAC®, on the other hand, resemble a conventional Macintosh blade, therefore it is often possible to intubate without a stylet.[21]

In contrast to lean patients, morbidly obese patients typically have a larger neck circumference, which is indicative of a thicker area of adipose tissue that envelops the airway anatomy. This characteristic can hinder the use of certain airway maneuvers, such as external laryngeal manipulation, that are utilized in order to obtain a better view of the glottis. However, videolaryngoscopy can alleviate this obstacle. In fact, *Hagberg et al.*[22] found that in a randomized comparison of laryngoscopy techniques using the videolaryngoscope and the traditional Macintosh laryngoscopes (MLS) in 102 obese patients, the videolaryngoscope system provided a superior view (larger image, improved Cormack-Lehane grade of the glottis), as compared to the MLS. In this study, all videolaryngoscope cases exhibited a monitor view of ≤ 2b, as compared to 84% of the ML cases ($p = 0.007$). In 86.8% of the videolaryngoscope cases with a direct view > 1, the Cormack-Lehane grade improved by ≥ 1 on the monitor view. External laryngeal manipulation was required less often when using the videolaryngoscope, yet improvements in visualization of the glottis by this maneuver were similar. Here, the magnified view, which no longer has to be observed directly from the mouth, allows the laryngoscopist to place the ETT or intubation stylet (bougie) in patients who might otherwise require an awake intubation or may even experience a difficult intubation. Although the use of this system utilizes a different intubation technique (videolaryngoscope), the time and number of attempts for successful tracheal intubation, as well as complications, were similar. Most monitors that accompany videolaryngoscopes are viewable and accessible by all interested parties in

1

Enlarged image of glottic area is afforded on monitors as compared to direct vision.[29]


2

Unlike traditional direct laryngoscoopy, many individuals may view the intubation process via the monitor.

the operating room (**Fig. 2**), as opposed to being only accessible by the laryngoscopist. Thus, when a novice is attempting intubation, the instructor can precisely see the results of the manipulation, and can guide the laryngoscopist to position the top of the blade correctly, to expose the vocal cords, and to confirm the passage of the ETT into the trachea.[23, 24] In the event that airway manipulation is needed, the assistant performing the manipulation is able to see the effect of his or her movement in order to improve the laryngeal view.

4.2 Videolaryngoscopy in the Expected and Unexpected Difficult Airway

Carin A. Hagberg, Robert G. Clark

A typical airway management course utilizing direct laryngoscopy includes text instruction. In addition to routine use for transoral / transnasal intubation in the operating room, videolaryngoscopy (VL) is an excellent option for the difficult airway, both expected and unexpected (**Table 1**).

Table 1: Applications of Videolaryngoscopy

- Routine oral/nasal intubation (elective/emergency)
- Anticipated difficult laryngoscopy
  - Awake intubation (adult/pediatric)
  - Intubation following general anesthesia
- Unanticipated failed laryngoscopy
- Combination (in all of the above) with other airway devices techniques
  - Flexible fiberoptic laryngoscopy
  - Lighted Stylet (e.g., Trachlight)
- Confirmation of airway device (endotracheal tube/ Combitube or Laryngeal Tube) placement
- Placement of double lumen tube/Univent tube
- Exchange of extralaryngeal airway devices, endotracheal tubes, double lumen tubes
- Teaching airway anatomy/intubation procedures
- Telemedicine

This method of intubation could potentially find a place in the ASA Difficult Airway Algorithm, as more physicians have access to and become familiar with the various videolaryngoscopes. Although not specifically listed, VL could be included under “alternative approaches to intubation” as a videolaryngoscope may be considered an alternative laryngoscope blade. It may also be placed in the difficult airway algorithm as a technique to establish an airway after failed attempts at a traditional approach, both in an unexpected and expected[25] difficult airway or even as a first choice option for those familiar with it. Previously, the use of VL for managing the unexpected difficult airway was limited by restricted mobility and extended preparation time. The current videolaryngoscopes available are so mobile and quick to set up that this is not an issue anymore. Recently, *Serocki et al.*[25] found that VL was very helpful in many clinical conditions of an expected difficult airway, including limited neck mobility, reduced thyromental distance, reduced inter-incisor distance or retrognathia. Their data confirmed that both the DCI® videolaryngoscope and the GlideScope enhanced glottic visualization in patients with difficult conventional laryngoscopy.

Videolaryngoscopy cannot and should not replace awake fiberoptic intubation in many cases of a predictable difficult airway. Nonetheless, in an expected difficult airway, VL may be a worthy addition as an awake intubation technique.[26, 27] Although the ASA guidelines highlight the approach of awake intubation as the preferred method to manage expected difficult airways, consideration of videolaryngoscopy under general anesthesia maybe investigated as the primary method for intubation if difficulty with intubation but not mask ventilation is expected.[28] VL may also be used and be advantageous over direct laryngoscopy for the exchange of one airway device for another. A recent case report demonstrated the use of VL to exchange a Combitube, which was placed by paramedics after failed direct vision intubation, for an endotracheal tube to establish a definitive airway.[29] It is not unusual for an extraglottic airway device such as a laryngeal tube or Combitube to be placed in the prehospital setting when direct laryngoscopy is unsuccessful and the patient’s airway is indeed difficult, thus exchanging this device for an ETT may be extremely difficult. Additionally, anesthesiologists are even utilizing videolaryngoscopes in routine cases without any suspicion of difficult airway management or before any attempt of direct laryngoscopy is performed since they are simple to use and have a high rate of intubation success.

Videolaryngoscopes have the advantage in the unanticipated situation because their rigidity facilitates rapid control of the position of the laryngoscope tip and they can be ready for immediate use.[30] These devices allow retraction of soft tissues so that there is a line-of-sight from the lens to the distal structures, without the necessity of lining the oral and laryngotracheal axes with the naked eye. Although the three different sized C-MAC® blades[21, 25] are traditionally used in the usual Macintosh fashion (tip of blade in vallecula), the epiglottis may be directly elevated – referred to as the "straight blade technique" for improved viewing (**Fig. 3**). This type of positioning is often performed for difficult airways. In a recent study of 60 patients by *Cavus et al.*[21], a size 4 rather than a size 3 C-MAC® blade was used in 3 patients with unexpected intubation difficulty. The Macintosh size 4 blade is more curved compared with the size 3, resulting in a higher angulation with a wider view of the glottis. In all 3 of these patients, the Cormack-Lehane score improved by 2 classes using this technique. Also, some users position the tip over the dorsum of the tongue, proximal to the epiglottis, achieving indirect elevation of the epiglottis without conventional tensioning of the hyoepiglottic ligament. Because of their optics, these devices allow the operator to visualize structures that may not be seen with the direct line-of-sight view available to the naked eye. Additionally, video capture offers recording capabilities of airway procedures for education or documentation purposes. Control buttons are located on either the handle or the monitor (**Fig. 4**) for both video and picture taking.

Nonetheless, there are some restrictions to the use of videolaryngoscopes. A short training period is necessary in order to use it correctly and obtain its full benefit. Additional training is also necessary for the correct handling of the ETT while viewing the monitor instead of direct visualization of the larynx.

3 Use of the C-MAC® as the straight blade technique in which the epiglottis is physically elevated by the blade.

4 Performance of videolaryngoscopy with the C-MAC® unit being recorded by control buttons located on the monitor.

Conclusion

With the increasing use of videolaryngoscopy on a daily basis, there will be a need to reassess the traditional predictive factors and definitions of a difficult airway and difficult laryngoscopy. Our predictive tests for difficult larygoscopy are neither specific nor sensitive.[30] Video techniques, in general, have improved enormously in the last decade, with smaller cameras producing higher-quality images. There are many nontraditional yet extremely useful applications of videolaryngoscopy that should be considered in our anesthetic practice (**Table 2**). Suitable devices should be available whenever anesthesia is administered and all airway practitioners should develop skill in their use so that they may be effectively utilized when the need arises. It may not be long before videolaryngoscopy becomes the standard for all routine intubations in the operating room, the

Table 2:
Miscellaneous Application of Videolaryngoscopy

- Advancement of dilating bougie for esophageal procedures
- Evaluation of the oral cavity, oro- and hypopharyngeal structures for trauma, infections, and healing
- Foreign body extraction (e.g., bridgework, tooth, crown, filling)
- Passage of nasogastric, orogastric, or enteral feeding tubes
- Passage of transesophageal echocardiography probe
- Placement of upper gastrointestinal endoscopy equipment
- Visualize laryngeal function (prior to or following intubation/extubation)

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intensive care unit, in the emergency department and in prehospital emergency medicine, as there is tremendous potential in terms of intubation success and a reduction in the incidence of critical situations in airway management.

References

1. COOPER RM, PACEY JA, BISHOP MJ, MCCLUSHEY SA. Early clinical experience with a new videolaryngoscope (GlideScope) in 728 patients. Can J Anaesth 52: 191-8, 2005.
2. STROUMPOULIS K, PAGOULATOU A, VIOLARI U, IKONOMOU I, KALANTZI N, KALANTIZI N, KASTRINAKI K, XANTHOS T, MICHALOBIAKOU C. Videolaryngoscopy in management of the difficult airway: a comparison with the Machintosh blade. Eur J Anaesthesiol 26:218-22,2009.
3. BRAY GA, GRAY DS. Obesity. Part 1: Pathogenesis. West J Med 149(4):429-41, 1988.
4. ROSE DV, COHEN UM. The airway: problems and predictions in 18,500 patients. Can J Anaesth 41:372-83.
5. BUCKLEY FP, ROBINSON NB, SIMONOWITZ DA, DELLINGER EP. Anaesthesia in the morbidly obese: a comparison of anaesthetic and analgesic regiments for upper abdominal surgery. Anaesthesia 38:840, 1983.
6. FAREBROTHER MJB. Respiratory function and cardiorespiratory response to exercise in obesity. Br J Dis Chest 73:211, 1979.
7. LUCE JM. Respiratory complications of obesity. Chest 78:626, 1980.
8. LEE JJ, LARSON RM, BUCKLEY JJ, ROBERTS AB. Airway maintenance in the morbidly obese. Anesthesiol Rev 7:33, 1980.
9. NORTON ML, BROWN ACD. Evaluating the patient with a difficult airway for anesthesia. Otolaryngol Clin North Am 23:771, 1990.
10. JUVIN P, LAVAUT E, DUPONT H, LEFEVRE P, DEMETRIOU M, DUMOULIN JL. Desmonts JM. Difficult tracheal intubation is more common in obese than in lean patients. Anesth Analg 97(2): 595-600, 2003.
11. BRODSKY JB, LEMMENS HJ, BROCK-UTNE JG, VIERRA M. Saidman LJ. Morbid obesity and tracheal intubation. Anesth Analg 94:732-6, 2002.
12. FRAPPIER J, GUENOUN T, JOURNOIS D, PHILIPPE H, AKA E, CADI P, SILLERAN-CHASSANY J, SAFRAN D. Airway management using intubating laryngeal mask airway for the morbidly obese patient. Anes Anal 96:1510-15, 2003.
13. MARREL J, BLANC C, FRASCAROLO P, MAGNUSSON L. Videolaryngoscopy improves intubation condition in morbidly obese patients. Eur J Anaesthesiol 24(12):1045-9, 2007.
14. HAGBERG CA, VOGT-HARENKAMP CC, BOGOMOLNY Y, ELLIS S, NGUYEN TV. A comparison of laryngoscopy techniques using the video laryngoscope and the traditional Macintosh laryngoscope in potentially difficult to intubate patients. Anesth Analg S-212, 2005.
15. DHONNEUR G, NDOKO SK, YAVCHITZ A, FOUCRIER A, FESSENMEYER C. Pollian C, Combes X, Tual L. Tracheal intubation of morbidly obese paients: LMA CTrach™ vs direct larygoscopy. Br J Anaesth 97:742-5, 2006.
16. SUN DA, WARRINER CB, PARSONS DC, KLEIN R, UMEDALY HS, MOULT M. TheI glidescope video laryngoscope: randomized trial in 200 patients. Br J Anaesth 94:381-4, 2005.
17. LUNDSTRØM LH, MØLLER AM, ROSENSTOCK C, ASTRUP G, WETTERSLEV J. High body mass index is a weak predictor for difficult and failed tracheal intubation: a cohort study of 91,332 consecutive patients scheduled for direct laryngoscopy registered in the danish anesthesia database. Anesthesiology 110(2):266-74, 2009.
18. SINHA A, SHARMA B, SOOD J. ProSeal as an alternative to endotracheal intubation in pediatric laparoscopy. Paeditar Anaesth 17(4):327-32, 2007.
19. KAPLAN MB, WARD D, HAGBERG CA, BERCI G, HAGIIKE M. Seeing is believing: the importance of video laryngoscopy in teaching and in managing the difficult airway. Surg Endosc 20 Suppl 2:S479-83.
20. MAASSEN R, LEE R, HERMANS B, MARCUS M, ZUNDERT A. A comparison of three videolaryngoscopes:the macintosh laryngoscope blade reduces, but does not replace, routine stylet use for intubation in morbidly obese patients. Anes Anal 109(5):1560-5, 2009.
21. CAVUS E, KIECKHAEFER J, DOERGES V, MOELLER T, THEE C, WAGNER K. The C-MAC® Videolaryngoscope: First experiences with a new device for videolaryngoscopy-guided intubation. Anesth Analg 110; 473-7, 2010.
22. HAGBERG C, MATUSZCZAK M, ELLIS S, IANNUCCI D. A randomized comparison of laryngoscopy techniques using the video laryngoscope and the traditional macintosh laryngoscope in obese patients. Anesthesiology 103:A1421, 2003.
23. IWASE Y, MATSUSHIMA H, NEMOFO M, et al. The efficacy of video intubating laryngoscope for novice residents. Masui 53: 313-9, 2004.
24. WEISS M, SCHWARTZ M, DILLIER CM, GERBER AC. Teaching and supervising tracheal intubation in paediatric patients using videolaryngoscopy. Paediatr Anaesth 11:343-8, 2001.
25. SEROCKI G, BEIN B, SCHOLZ J, DOERGES V. Management of the predicted difficult airway: a comparison of conventional blade laryngoscopy with video-assisted blade laryngoscopy and the Glidescope. Eur J Anaesthesiol 27(1):24-30, 2010.
26. MCGUIRE BE. Use of the McGrath video laryngoscope in awake patients. Anaesthesia 64(8):912-4, 2009.
27. VILLALONGA A, DIAZ MARTINEZ M, et al. GlideScope videolaryngoscopic intubation of the awake patient: 4 cases of anticipated difficult tracheal intubation. Rev Esp Anestesiol Reanim 55(4):254-6, 2008.
28. American Society of Anesthesiologists Task Force on Management of the Difficult Airway. Practice guidelines for management of the difficult airway: an updated report by the American Society of Anesthesiologists Task Force on Management of the Difficult Airway. Anesthesiology 98: 1269-77, 2003.
29. HAGBERG CA, VOGT-HARENKAMP CC, IANNUCCI DG. Successful airway management of a patient with a known difficult airway with the direct coupler interface video laryngoscope. J Clin Anesth 19:629-31, 2007.
30. HAGBERG CA, LAW ADAM J. Video laryngoscopy and the difficult airway- image is everything. Anesthesiology News Guide to Airway Management 91-8, 2008.

The Role of Videolaryngoscopy in Emergency Medicine

5.1 Videolaryngoscopy in Prehospital Emergency Use[1]

5.2 Video Laryngoscopy with the C-MAC® PM in Emergency Medicine[2]

5.3 Videolaryngoscopy in the Emergency Department[3]

5

[1] **Gilbert Heller,** M.D.
Department of Anaesthesiology and Intensive Care Medicine,
University Hospital Schleswig-Holstein, Campus Kiel, Germany

[2] **Björn Hossfeld** and **Matthias Helm**
Department of Anesthesiology and Intensive Care Medicine, Hospital of the Federal Armed Forces, Ulm, Germany

[3] **Paul E. Phrampus,** M.D.
Associate Professor and Director of the Peter M. Winter Institute for Simulation, Education and Research (WISER)
University of Pittsburgh, PA, U.S.A.

5.1 Videolaryngoscopy in Prehospital Emergency Use

G. Heller

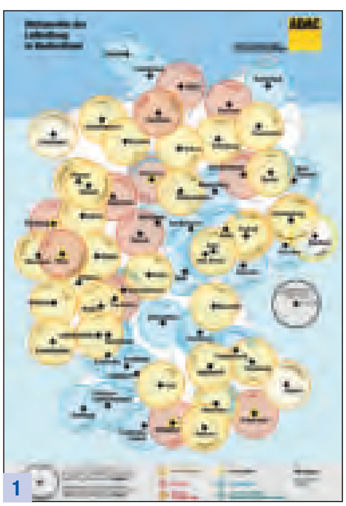
Introduction

Emergency Medical Service in Germany

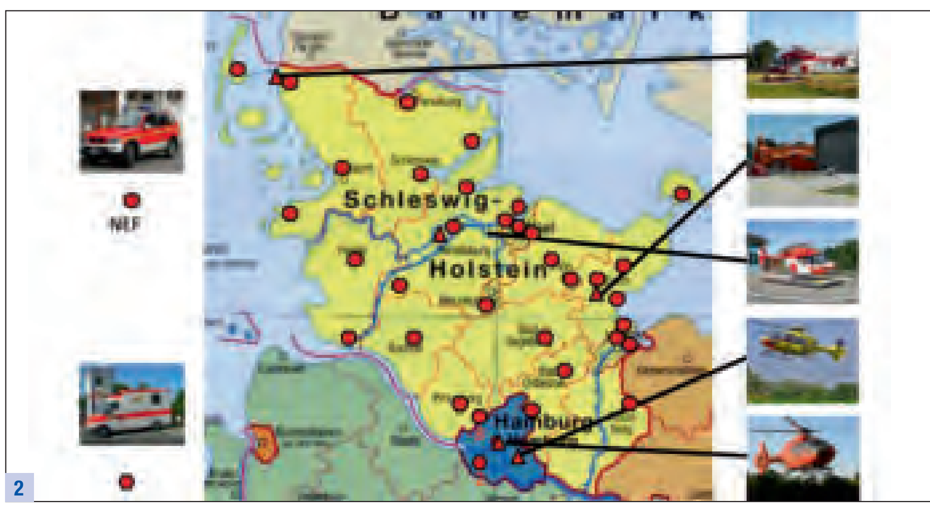
A nationwide emergency medical service has been operating in the Federal Republic of Germany since the 1970s. There are even laws stipulating how much time may pass before professional rescuers arrive at the scene of an emergency call.

When we compare emergency medical systems in different countries, we find that a distinctive feature of the German system is that is a highly organized rescue system that is based on the services of emergency physicians. This means that a physician specially trained in emergency medicine is dispatched to the sick or injured patient and in most cases will arrive within 10 minutes of the emergency call. This rapid response is made possible by a network of rescue stations that maintain physician-staffed and non-physician-staffed rescue vehicles as well as a nationwide network of rescue helicopter stations (**Figs. 1, 2**).

The deployment of rescue vehicles and helicopters is coordinated and controlled by regional and even transregional emergency dispatch centers that receive and process calls through an emergency telephone number that is valid throughout Germany.



1 Distribution of rescue helicopter stations in Germany.



2 Distribution of physician-staffed rescue vehicles, illustrated for the German state of Schleswig-Holstein.

Intubation in the Emergency Medical Service

Endotracheal intubation has become the gold standard for airway management in hospitals as well as emergency settings. Intubation conditions are usually quite favorable for in-hospital anesthesia induction or a planned intubation in ICU (the incidence of difficult intubation ranges from 0.5% to 10%, depending on the setting; it is highest in oromaxillofacial surgery, otorhinolaryngology, and gynecology).[2, 8, 10] But prehospital intubations are quite different.

There is no such thing as a “routine intubation” in the field. Every intubation poses a special challenge to the entire team, especially the intubating emergency physician. Environmental factors make it difficult to establish a standard work routine for anesthesia induction, and even trained emergency physicians are faced with special tasks that require a differentiated approach.

Studies have shown that the out-of-hospital incidence of difficult intubation is significantly higher than in hospitals.[1,7,9,14] The reasons for the difficulties of prehospital care relate to the diverse situations and conditions that rescue crews encounter in every call. It is also known that alarmingly high numbers of endotracheal tubes are misplaced by rescue personnel, reflecting the difficulties of prehospital intubation.[3–7, 11–17] This is reason enough to carefully test and highlight every available means for improving the current situation (**Fig. 3**).

Table 1: Causes of Difficult Prehospital Intubation:

- **External conditions**
  Light, temperature, noise, patient access, bad weather, hectic surroundings
- **Patient-related factors**
  Nonfasted state, anatomically difficult airway, bleeding, associated injuries, preexisting morbidity
- **Team factors**
  Frequent lack of formal intubation training, lack of team practice and coordination, lack of backup personnel, working under time pressure, difficult situation assessment

Table 2: Indications for Endotracheal Intubation[8]

- **Absolute:**
  – Apnea
  – Resuscitation
- **Urgent:**
  – Respiratory failure
  – Glasgow Coma Score (GCS) < 9
  – Multiple injuries
  – Severe head trauma
  – Inhalation trauma
  – Risk of aspiration

Prehospital intubation in an emergency setting is among the greatest challenges in airway management, and strategies are needed to compensate for the difficult ambient conditions. Besides rigorous personnel training on intubation in stressful situations including proper situation assessment, it is essential that rescue personnel be furnished with proper equipment. Particular attention should be given to the difficult airway. Besides conventional endotracheal tubes, it is important to have backup systems in the form of supraglottic airway devices such as the laryngeal tube or (intubation) laryngeal mask in every physician-staffed rescue vehicle.

Another innovation in emergency medicine is a device that has become an indispensable tool for in-hospital intubations: the videolaryngoscope.

3

Difficult access to the patient.

As a result of technical advances leading to a dramatic size reduction in formerly cumbersome and nonportable systems, videolaryngoscopy has also been adopted in emergency medical services. The camera lens provides a magnified view of the glottis displayed on a compact color screen. It is mounted close to the distal end of the laryngoscope blade, where it is protected from secretions and is exposed to significantly higher light levels than in conventional laryngoscopes. When used in difficult anatomical and/or positional situations, the videolaryngoscope permits a safer and more precise intubation that might not be possible without this technical aid.

The KARL STORZ C-MAC® videolaryngoscope features a familiar Macintosh shape, which can provide both a direct and indirect videoscopic view of the glottic plane. The control elements of the scope are logically structured to eliminate confusion in its operation and use. As a result, even physicians who have little experience with anesthesia are able to use the videolaryngoscope safely and successfully.

4

Loading emergency equipment into a rescue helicopter.

Regular use of the videolaryngoscope at multiple air rescue stations has generated consistently positive reports from the field. With its compact design, the C-MAC® videolaryngoscope fits easily into an emergency backpack and can be taken along on every call. Stowing the device in a backpack or carrying case along with other airway equipment ensures that the videolaryngoscope will be available when needed. At several test stations, the C-MAC® laryngoscope has become so fully integrated into the intubation routine that it is used for all endotracheal intubations, not just unexpected difficult cases. Two case reports are presented below to illustrate the value of the videolaryngoscope in emergency situations.

Case report 1: Acid Burns

A rescue helicopter was dispatched to an emergency involving a verbally unresponsive patient. What began as a routine call became a worst-case scenario of airway management following initial examination of the patient.

The patient, a male approximately 55 years of age, had taken sleeping pills with suicidal intent and had subsequently ingested a large quantity of highly concentrated hydrofluoric acid.

The patient had an old surgical scar in the lower jaw and a preexisting skin change on the neck. A third party stated that the patient had undergone a prior neck dissection with skin grafting and radiation for cancer of the lower jaw.

The anatomic changes about the neck and jaw (markedly decreased mouth opening, neck structures immobile and deviated laterally) combined with acid burns to the mucosa were clear indicators of an expected difficult intubation.

Endotracheal intubation was definitely indicated, however: The sleeping pills had caused respiratory failure and diminished reflexes, and the acid had induced secretions that were being aspirated by the patient.

Once the need for intubation had been confirmed, preparations were swiftly made: The patient was preoxygenated with an oxygen mask, and short-acting agents were drawn for anesthesia induction. The crew prepared assorted sizes of endotracheal tubes with stylets and a suction pump, and the videolaryngoscope was placed within the visual field of the emergency physician.

Following anesthesia induction, a size 3 C-MAC® videolaryngoscope was introduced orally despite limited mouth opening. Viewing the monitor, the emergency physician was now able to survey the oropharyngeal and laryngeal anatomy and note the extent of the acid burns. A direct view of the oropharynx was not obtainable at any time for anatomic reasons.

7

Preoxygenation.

5

Suctioning the airway under vision.

6

Suctioning the airway under vision.

A size 16-Ch catheter was advanced under optical control through the guide slot in the laryngoscope blade to the tip of the laryngoscope. Suction was applied, removing a large portion of the bloody discharge under video control. The endotracheal tube was then advanced through the glottic opening, also under videolaryngoscopic control, to establish a definitive airway.

The C-MAC® continued to record throughout the laryngoscopic procedure. When the patient was transferred to the physicians at the receiving hospital, the SD memory card (readable on any computer) allowed the doctors to view the intubation as a video sequence and thus gain valuable information on the injury pattern and further management.

The patient in this example could not have been intubated by conventional means, and a supraglottic airway device would have been as harmful as a Combitube because of injuries to the pharyngeal mucosa. This case illustrates the immense gain in safety that is obtained with a video screen. The patient could not have been intubated without videolaryngoscopic assistance.

Endotracheal intubation under vision. The inset shows the glottic plane displayed on the video monitor of the C-MAC® system.

The patient is intubated with a cervical collar in place, without moving the cervical spine. Note: Intubation in this case was aided by a separate monitor (not shown).

Case Report 2: Motor Vehicle Accident

A young woman was involved in a traffic accident which hurled her automobile against a tree. She sustained multiple injuries from the impact, including severe head trauma, and she initially reported severe pain in the cervical spine with painful limitation of motion and tingling paresthesias in both hands.

Given the patient's associated injuries, progressive neurologic deficits, deteriorating status, and impending air transport with limited interventional capabilities, the decision was made to intubate the patient.

After the patient was moved to the protected environment of the rescue vehicle, preparations began for inducing general anesthesia. Main attention focused on intubating the patient without moving her potentially injured cervical spine. Emergency care in the accident vehicle had begun by placing a cervical collar to immobilize and protect the cervical spine. The next priority was to secure the airway by endotracheal intubation without disturbing the neck splint.

Following induction of anesthesia, use of the C-MAC® videolaryngoscope enabled an endotracheal tube to be placed without complications and without causing any movement of the cervical spine. Interestingly, laryngoscopy showed that the larynx was distorted by the presence of a goiter that would have made it extremely difficult to visualize the glottis by conventional laryngoscopy without hyperextending the head.

As in the previous case, use of the videolaryngoscope enabled the airway to be secured without problems. A conventional technique would also have been possible in this example, but videolaryngoscopy reduced the intubation trauma to an absolute minimum and did not have to be abandoned due to unexpected anatomic variations, which contributed further to patient safety.

10

Routine use of the videolaryngoscope during resuscitation.

11

Nonroutine use: intubating a patient in a rescue helicopter at night.

Summary

Use of the C-MAC® videolaryngoscope in prehospital settings provides emergency physicians and their patients with a significant gain in safety.

Given the inherently difficult intubation conditions in emergency medicine, the use of portable, easy-to-use video technology in airway management creates a safety reserve that was previously inconceivable to this degree. The magnified view of the glottic plane afforded by the camera on the laryngoscope blade can reduce the number of difficult intubations. Owing to the capability for conventional laryngoscopy under extremely bright light with the familiar Macintosh blade, even emergency physicians who are not anesthesiologists can feel comfortable performing intubations.

The simple and logical handling of the system, the rapid availability of the video image with almost no delay, the simplicity of cleaning, and a simple battery charging schedule with a good standby time have led to extremely high acceptance of the C-MAC® system by all members of the emergency medical team.

The growing number and increasingly attractive pricing of videolaryngoscopes are certain to promote their widespread use in emergency medical services. Because they provide a significant safety gain in establishing a secure airway – one of the core skills of emergency physicians – it would be highly desirable to include videolaryngoscopes in the standard equipment of physician-staffed rescue vehicles.

Unlimited suitability for everyday use and ease of operation are prime considerations in the selection of equipment, which should include a rugged device that meets the rigorous demands of the emergency medical service and is so easy to transport that it can be taken along and used on routine calls. With the KARL STORZ C-MAC® videolaryngoscope, we have found a system that has proven itself under the most demanding conditions and fully conforms to our requirements.

References

1. ADNET F, JOURILES NJ, LE TOUMELIN P, HENNEQUIN B, TAILLANDIER C, RAYEH F, et al. Survey of out-of-hospital emergency intubations in the French prehospital medical system: a multicenter study. Ann Emerg Med 1998 Oct;32(4):454-60.
2. COOPER RM, PACEY JA, BISHOP MJ, MCCLUSKEY SA. Early clinical experience with a new videolaryngoscope (GlideScope) in 728 patients. Can J Anaesth 2005 Feb;52(2):191-8.
3. DAVIS DP, PEAY J, SISE MJ, VILKE GM, KENNEDY F, EASTMAN AB, et al. The impact of prehospital endotracheal intubation on outcome in moderate to severe traumatic brain injury. J Trauma 2005 May;58(5):933-9.
4. GAUSCHE M, LEWIS RJ, STRATTON SJ, HAYNES BE, GUNTER CS, GOODRICH SM, et al. Effect of out-of-hospital pediatric endotracheal intubation on survival and neurological outcome: a controlled clinical trial. JAMA 2000 Feb 9;283(6):783-90.
5. GRIES A, ZINK W, BERNHARD M, MESSELKEN M, SCHLECHTRIEMEN T. Realistic assessment of the physician-staffed emergency services in Germany. Anaesthesist 2006 Oct;55(10):1080-6.
6. KATZ SH, FALK JL. Misplaced endotracheal tubes by paramedics in an urban emergency medical services system. Ann Emerg Med 2001 Jan;37(1):32-7.
7. KEUL W, BERNHARD M, VOLKL A, GUST R, GRIES A. [Methods of airway management in prehospital emergency medicine]. Anaesthesist 2004 Oct;53(10):978-92.
8. KLEEMANN PP. [The difficult intubation]. Anaesthesist 1996 Dec;45(12):1248-67.
9. LACKNER CK, REITH MW, RUPPERT MEA. Prähospitale Intubation und Verifizierung der endotrachealen Tubuslage. Notfall Rettungsmed 2002;5:430-40.
10. NOLAN J, CLANCY M. Airway management in the emergency department. Br J Anaesth 2002 Jan;88(1):9-11.
11. ORLIAGUET G, TARTIÈRE S, LEJAY MEA. Prospective in-field evaluation of orotracheal intubation by emergency medical services physicians. J Eur Urgences 1997;1:27-32.
12. PEPE PE, ZACHARIAH BS, CHANDRA NC. Invasive airway techniques in resuscitation. Ann Emerg Med 1993 Feb;22 (2 Pt 2):393-403.
13. SAYRE MR, SAKLES JC, MISTLER AF, EVANS JL, KRAMER AT, PANCIOLI AM. Field trial of endotracheal intubation by basic EMTs. Ann Emerg Med 1998 Feb;31(2):228-33.
14. THIERBACH A, PIEPHO T, WOLCKE B, KUSTER S, DICK W. [Prehospital emergency airway management procedures. Success rates and complications]. Anaesthesist 2004 Jun;53(6):543-50.
15. TIMMERMANN A, RUSSO SG, EICH C, ROESSLER M, BRAUN U, ROSENBLATT WH, et al. The out-of-hospital esophageal and endobronchial intubations performed by emergency physicians. Anesth Analg 2007 Mar;104(3):619-23.
16. VON GOEDECKE A, HERFF H, PAAL P, DORGES V, WENZEL V. Field airway management disasters. Anesth Analg 2007 Mar;104(3):481-3.
17. VON KNOBELSDORF G. Qualitätsmanagement, Ausbildung und Training. Qualitätsmanagement und Dokumentation. In:. Doerges V, Paschen HR Management des schwierigen Atemwegs Springer 2004.

5.2 Video Laryngoscopy with the C-MAC® PM in Emergency Medicine

Björn Hossfeld and Matthias Helm

Summary

Establishing a secure **airway** is the top priority in most algorithms for emergency patient care.

Given the vital importance of a secure airway in emergency patients, all emergency physicians who work in prehospital settings must have a routine mastery of necessary airway management procedures, even if they are practiced in relatively low case numbers.

The use of modern video laryngoscopes in prehospital emergency medicine can make a significant contribution to patient safety.

Problem

While the need for endotracheal intubation – still considered the „gold standard“ of airway management – is less common in ground-based emergency care than in air rescues, every emergency physician must still be proficient in the procedure.[1]

Bernhard et al. were able to show that the 25 endotracheal intubations required for emergency physician training in Germany were not nearly enough to master this skill.[2] A publication on the incidence of endotracheal intubations shows that an emergency physician at an urban facility staffed by anesthesiologists may expect to perform one prehospital intubation every 55 days, one every 77 days at an urban facility with an interdisciplinary staff, and that an emergency physician at a rural facility will, on average, perform one every 213 days. The authors conclude that emergency physicians cannot be expected to gain routine proficiency in airway management without adjunctive clinical experience.[3] This problem led the International Liaison Committee on Resuscitation (ILCOR) to state that intubations should be performed in at least 6–12 emergency patients per year in order to maintain routine proficiency.[4]

It should be emphasized that prehospital settings differ substantially from in-hospital conditions. Relevant factors are greater time urgency, the generally nonfasted state of emergency patients, poor lighting, confined space, and certainly the experience and skills of the care providers.[5, 6] Because of these factors, the rate of difficult intubations in out-of-hospital settings is more than twice as high as in hospitals.[7] This in turn may have significant adverse effects on the patient.[8]

These circumstances underscore the need for sound education and regular training in airway management on the one hand, plus the need to establish an effective algorithm for management of the „difficult airway“.[6, 8]

The Eastern Association for the Surgery of Trauma in the U.S. has stated that modern video laryngoscopy can provide a tool for reducing the incidence of difficult airways in emergency tracheal intubations.[10] It should be added that video laryngoscopy cannot replace necessary training, and that every emergency physician should master the techniques of airway management. Accordingly, an appraisal of one‘s own skills should be a factor in deciding whether to perform a prehospital intubation.[11]

Illustrative Case Summary

The dispatch center sends a rescue vehicle and emergency physician to a patient in respiratory distress. On arrival the emergency physician finds the patient in distress with marked stridor and cyanosis. The patient has a history of advanced oral floor cancer, for which he previously refused surgical treatment. High-dose oxygen is administered (15 L/min by mask and bag), and O2 saturation measured by pulse oximetry rises from 84% to 89%. Since the airway status is uncertain, the emergency physician decides not to sedate the agitated patient and calls a rescue helicopter for transport to a suitable hospital with a maxillofacial surgery department.

The emergency physician in the rescue helicopter decides that a secure airway needs to be established before reaching the hospital. Thiopental and succinylcholine are prepared for anesthesia induction. An endotracheal tube with guidewire and the C-MAC® PM video laryngoscope are also prepared. A laryngeal mask and cricothyrotomy set are additionally prepared for possible alternative airway management.

Direct laryngoscopy initially shows a Cormack-Lehane grade 4 view, which improves to grade 2 on video laryngoscopy without changing the laryngoscope (**Fig. 12**). At that point endoscopic intubation is easily accomplished over a guidewire.

Videolaryngoscopy

Videolaryngoscopy has become established at many hospitals in recent years. In patients with a potentially difficult airway due to limited neck extension or other anatomic problems, video laryngoscopes offer the ability to surmount an optical angle (indirect laryngoscopy), whereas conventional laryngoscopy always requires a direct optical axis.

Models available on the market have become increasingly smaller and easier to handle. This makes video laryngoscopes theoretically suitable for emergency use in prehospital settings, and several centers have already implemented them for this purpose.

To date, few evaluations have been published on the prehospital use of video laryngoscopes. *Cavus et al.* conducted an observational study at four air-rescue centers in Germany and found that the C-MAC® video laryngoscope was helpful under difficult intubation conditions.[12] Their analysis also showed that a video laryngoscope with a standard Macintosh blade offered a significant advantage over other video laryngoscopes: If the monitor view is compromised for any reason (lighting, secretions, technical problems), the user can switch to conventional direct laryngoscopy at any time while using the same device. This was necessary and successful in 4 of 83 study patients.[12] Additionally, the C-MAC® video laryngoscope has the option of using a more curved difficult-airway blade (the D-BLADE) in cases where the glottic plane is poorly visualized for anatomic reasons.

Previously the C-MAC® has been equipped only with an external monitor packed in a handy field bag. One problem with this monitor is that it is sometimes difficult to place it where it can be seen clearly by the emergency physician in a prehospital setting. Now Karl Storz offers the C-MAC® PM, a compact video laryngoscope that was described in the illustrative case above. It is equipped with a small but high-resolution monitor mounted directly on the handle (**Fig. 13**). Particularly in confined situations where the user does not have access from the head end, a video laryngoscope with an integrated, tiltable monitor can be an invaluable aid for emergency intubation.

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It should be added, however, that better visualization with a video laryngoscope does not necessarily mean easier intubation. While the video laryngoscope does compensate for the optical angle, that angle must still be surmounted during placement of the endotracheal tube. This requires experience and practice on the part of the user. A proven aid in such cases is the use of a pre-bendable intubation catheter, which must be used in any case during intubation with the more curved D-BLADE.

Given the risk of hypoxia and the time demands placed on the user when managing a difficult airway, especially in a prehospital setting, video laryngoscopy should not be an extra alternative in the difficult airway algorithm, thus prolonging the time needed to establish a secure airway. Instead, video laryngoscopy should be considered a primary alternative to conventional laryngoscopy. It is hoped that this recommendation can reduce the prehospital incidence of the difficult airway, and that the regular practice of video laryngoscopy will provide greater experience in the routine management of difficult situations.

Karl Storz offers a field kit that can hold the C-MAC® PM plus a set of assorted blades and also has room for various sizes of endotracheal tubes, guidewires, and fixation materials.

A battery pack can be attached to the handle as a backup and used with direct C-MAC® blades (Macintosh and Miller) in the unlikely event that the video unit of the C-MAC® PM stops working (**Fig. 14**).

References

1. GRIES A, ZINK W, BERNHARD M, MESSELKEN M, SCHLECHTRIEMEN T. Einsatzrealität im Rettungsdienst. Notfall und Rettungsmedizin. 2005;8:391-8.
2. BERNHARD M, MOHR S, WEIGAND MA, MARTIN E, WALTHER A. Developing the skill of endotracheal intubation: implication for emergency medicine. Acta anaesthesiologica Scandinavica. 2012 Feb;56(2):164-71.
3. GENZWÜRKER HV, FINTEIS T, WEGENER S, HESS-JÄHNIG F, SEGIET W, KUHNERT-FREY B, ELLINGER K, HINKELBEIN J. Inzidenz der endotrachealen Intubation im Notarztdienst: adäquate Erfahrung ohne klinische Routine kaum möglich. Anästh Intensivmed. 2010;4:202-10.
4. The American Heart Association in Collaboration with the International Liaison Committee on Resuscitation (ILCOR). Guidelines 2000 for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2000; 102(suppl I). p. I-86-I-9.
5. TIMMERMANN A, RUSSO SG, EICH C, ROESSLER M, BRAUN U, ROSENBLATT WH, QUINTEL M. The out-of-hospital esophageal and endobronchial intubations performed by emergency physicians. Anesthesia and analgesia. 2007 Mar;104(3): 619-23.
6. HOSSELD B, LAMPL L, HELM M. Notwendigkeit eines Algorithmus für den „schwierigen Atemweg“ in der Präklinik. Notfall Rettungsmed. 2011;14:10-4.
7. HELM M, GRIES A, MUTZBAUER T. Surgical approach in difficult airway management. Best practice & research Clinical anaesthesiology. 2005 Dec;19(4):623-40.
8. HELM M, KREMERS G, LAMPL L, HOSSFELD B. Incidence of transient hypoxia during pre-hospital rapid sequence intubation by anaesthesiologists. Acta anaesthesiologica Scandinavica. 2013 Feb;57(2):199-205.
9. HELM M, HOSSFELD B, SCHÄFER S, HOITZ J, LAMPL L. Factors influencing emergency intubation in the pre-hospital setting – a multicentre study in the German Helicopter Emergency Medical Service. British Journal of Anaesthesia. 2006 January 1, 2006;96(1):67-71.
10. MAYGLOTHLING J, DUANE TM, GIBBS M, MCCUNN M, LEGOME E, EASTMAN AL, WHELAN J, SHAH KH, EASTERN ASSOCIATION FOR THE SURGERY OF T. Emergency tracheal intubation immediately following traumatic injury: an Eastern Association for the Surgery of Trauma practice management guideline. The journal of trauma and acute care surgery. 2012 Nov;73 (5 Suppl 4):333-40.
11. TIMMERMANN A, BYHAHN C, WENZEL V, EICH C, PIEPHO T, BERNHARD M, DÖRGES V. Handlungsempfehlung für das präklinische Atemwegsmanagement: Für Notärzte und Rettungsdienstpersonal aus dem Wiss. Arbeitskreis Notfallmedizin der DGAI und der Kommission Atemwegsmanagement der DGAI. Anaesth Intensivmed. 2012:294-308.
12. CAVUS E, CALLIES A, DOERGES V, HELLER G, MERZ S, ROSCH P, STEINFATH M, HELM M. The C-MAC videolaryngoscope for prehospital emergency intubation: a prospective, multicentre, observational study. Emergency medicine journal : EMJ. 2011 Aug;28(8):650-3.

5.3 Videolaryngoscopy in the Emergency Department

Paul E. Phrampus

Emergency Medicine in the United States

Emergency Departments in the United States are specialized areas in the hospital designed to care for life threatening critical emergencies as well as minor care activities that occur on an unscheduled basis. Patient loads range from as few as 20 to over 200 patients per day depending on the size and location of the hospital. Many large emergency departments have special qualifications recognizing them for excellence in specialty care such as trauma, stroke, cardiac and burns for example. Emergency medicine physicians in the United States are generally board-certified in emergency medicine and practice in the emergency department full-time. Emergency departments in the United States are open 24 hours per day and always staffed by a minimum of one emergency physician. Larger hospitals operate emergency departments with multiple emergency physicians. Teaching hospitals often include resident physicians who work in the emergency department, however, they are always supervised by a qualified board-certified emergency physician faculty member. Some emergency physicians are former internists, family doctors, anesthesiologists or surgeons who have migrated to the emergency department as a career change. All physicians who practice emergency medicine in the United States need to be competent in advanced airway management as well as other area of critical care such as Advanced Cardiac Life Support (ACLS), Pediatric Advanced Life Support (PALS) and trauma care.

Case Presentation

A 45 year old massively obese female is brought into the Emergency Department obtunded on high flow oxygen after attempting suicide by polypharmaceutical overdose. The paramedics reported the need to suction her airway of secretions and the presence of a decreased gag reflex. The patient required bag valve mask assistance to keep her saturations above 90% SaO_2.

The physical examination revealed a 170 kilogram female (**Fig. 15**) who was unconscious and unresponsive to painful stimulus. She had a nasopharyngeal airway in place, and was being bag-valve-mask-ventilated by the paramedics. They had been suctioning clear secretions from her airway periodically. Vital signs revealed a blood pressure of 118/62; a heart rate of 138; respiratory rate of eight and pulse oximetry revealed saturations of 92% with bag valve mask ventilation's. Examination of the oropharynx revealed a Mallampati class 4, with a relatively small mouth. Additionally, she had a proportionally large head, short, thick neck, a thyromental distance greater than 3 cm, and cricothyroid membrane landmarks that were difficult to palpate because of redundant neck tissue.

A potential difficult airway was anticipated based on the physical examination. A second-year emergency medicine resident was managing the case. The resident was experienced with direct laryngoscopy and endotracheal intubation techniques but not videolaryngoscopy. The resident was oriented to the KARL STORZ C-MAC® system. The residents initial plan was to perform direct laryngoscopy with the C-MAC® system. Once the rapid sequence induction (RSI) medications were administered, the resident performed the laryngoscopy utilizing the Macintosh 4 blade connected to the C-MAC® system. The resident physician encountered

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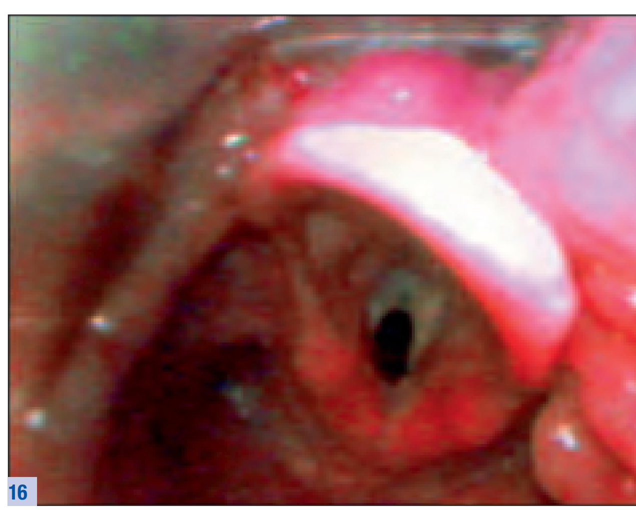

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clear secretions that required suctioning, and quickly realized that it was a case in which to use direct laryngoscopy was going to be impossible, as she was not able to visualize anything. The combination of a relatively small mouth, large tongue and excessive redundant tissue obscured the visualization. She immediately looked up at the video screen and was able to observe the equivalent to a Cormack and Lehane Grade 1 airway (**Fig. 14**). She successfully placed the endotracheal tube via video assistance to secure the airway.

Introduction

Airway management is a critical aspect of the practice of emergency medicine. Emergency physicians must be able to assess the need for emergent airway management, create a plan, and possess the competence to carry it out. Patients requiring airway management in the emergency department can be particularly challenging because of the acuity and concern for airway care in the setting of trauma as well as other critical and rapidly deteriorating conditions such as stroke and respiratory failure. Often, patients present with little or no history and require an urgent action plan.

Emerging technologies and equipment are changing the landscape of the care of patients requiring airway management in the emergency department. The use of rapid sequence intubation has become widespread in the clinical practice of emergency medicine and is supported by the literature. While many emergency departments rely on traditional direct laryngoscopy as the standard, many clinician leaders are evaluating videolaryngoscopy (VL) as a safer and cost effective alternative. There are a number of tools available for emergency physicians for providing emergent airway care. It is important that the practicing physician develop competence with several tools and that they be intimately familiar with those tools that are immediately available to them in their respective clinical environment. *Thong* and *Lim*[6] published characteristics of an "ideal intubating device" (**Table 1**), a scheme of evaluation to assist in the decision-making to identify the ideal equipment for laryngoscopy in given clinical settings. While no single device will satisfy every category, it can assist in the decision-making when trying to navigate the numerous options available for emergent airway management.

Employing videolaryngoscopy is becoming a realistic solution to airway management in the emergency department where endotracheal intubation is deemed necessary. Busy emergency departments see a patient mix with relative high acuity. Emergent airways are not uncommon in the emergency department given the acuity and challenges associated with such a diverse patient population. Conversely, less busy emergency departments of smaller and rural hospitals do not often provide the environment to allow ideal proficiency at the maintenance of routine skills of direct laryngoscopy.

Videolaryngoscopy can be utilized for routine use for endotracheal intubation as well as teaching efforts to ensure higher standards of patient care and patient safety. Increased visualization of the glottic opening as well as decreased time for intubation and reduced force applied to the teeth are several reasons to consider implementing VL. Teaching institutions will highly appreciate VL because the C-MAC® system allows the faculty member to directly observe the view from a vantage point close to the end of the laryngoscope which is impossible using traditional laryngoscope equipment.

The KARL STORZ C-MAC® system is the ideal choice of equipment for VL. This is predicated on its ease of use, essentially non-existent equipment learning curve because of its similarity to standard laryngoscopy equipment. The psychomotor skills used during the intubation procedure using the C-MAC® are nearly identical to those used in traditional laryngoscopy with the added benefits as noted above. The design allows physicians to switch back and forth between VL and SL without having to develop an additional skill set.

Table 1:
Characteristics of an Ideal Intubating Device

- Ease of use
  - Easy for novice to master
  - Simple, fast set up – suitable for emergency
  - Allow fast intubation times to minimize risk of aspiration
  - Portable – for field use
- Minimum anatomy and physiologic disturbance
  - Minimum airway trauma and cervical manipulation
  - Minimum haemodynamic disturbance
  - Enables awake intubation
- Suitable for nasal intubation and patients with small mouth-opening
- Available in different sizes for pediatric and adult use
- Disposable components available which may shorten turn around time and lessen risk of infection
- High margin of safety
  - Allows ventilation during intubation
- Cost effective

Reproduced from THONG SY, LIM Y. Video and optic laryngoscopy assisted tracheal intubation – the new era. Anaesth Intensive Care 2009 Mar;37(2):219–33.

Airway Care in the Emergency Department

Emergency Department Environment

The emergency department presents a unique and challenging environment for airway management. The undifferentiated nature of the patients demands proficiency on the part of the clinician as well as familiarity with a wide range of equipment and procedures, as well as adherence to best practices that have been identified for emergency airway management.

Patients arriving at the emergency department in extremis are often unannounced and many times have little accompanying history or clinical information. This challenge is quite different from the elective surgical patient on whom a complete history and physical examination can be conducted in a low-stress environment to develop a plan for operative airway management.

Clinical indications requiring emergency airway management are diverse but revolve around the need to protect the airway of the patient who is otherwise unable, or the need to provide invasive positive pressure oxygenation, ventilation or both to the critically ill. In most emergency departments in the US, this includes a mix of both pediatric and adult patients. The wide variety of patients that presents to the emergency department also necessitates the need for a variety of sizes and equipment available since the airway is not a one-size-fits-all anatomic challenge.

Patients presenting with such pathology as allergic reactions, cardiac arrest, burns, decreased levels of consciousness and multi-systems traumatic injury are common in the nearly 120 million emergency department visits that occur annually in the US alone. There is an important need to carefully evaluate the ability of the patient to protect their airway to maintain adequate oxygenation and ventilation. Procedural sedation occurs routinely in the emergency department in the United States and the ability to manage the airway in the case of complications is essential.

Unlike the normal routine preparations for cases of elective intubations, patients presenting to the emergency department must be presumed to have a full stomach. This fact requires the emergency physician to consider the risks of gastric content aspiration into the management of airways in the ED. Rapid sequence induction has long been recognized as the safest, most efficient choice for emergency department intubations. This technique is a combination of sedative and muscle relaxants with a rapid onset, short half life that creates a favorable physiologic situation to facilitate endotracheal intubation via direct laryngoscopy.

Decreased levels of consciousness from a variety of causes can impair the normal protective reflexes and require airway management. Drug overdoses, stroke, and cardiac arrest patients present routinely to emergency departments across the United States on a daily basis and serve as examples of those who may be unable to protect their own airway. Patients presenting with a decreased gag reflex, GCS < 8, or demonstrating the inability to clear their own secretions will often require invasive airway management.

Other conditions such as acute pulmonary edema, pneumonia, sepsis and pulmonary contusion are all examples of situations that can impair the ability for functional oxygenation and ventilation to occur. Patients presenting with low oxygen saturations despite supplemental oxygen as well as those displaying signs of respiratory distress or failure will often require endotracheal intubation.

Multi-system trauma patients are another category of airway challenges unique to the emergency department. Complicated cases of head, neck and face trauma can result in extraordinarily difficult situations regarding airway management. Many factors combine to create challenging situations in trauma patients. Distortions of the normal anatomy from swelling, bony or soft tissue injury along with bleeding, burns, foreign bodies and vomiting that can occur. Head injury and intoxication can lead to decreased effectiveness of the normal protective airway reflexes.

Trauma patients presenting with head and neck trauma, altered mental status or intoxication are presumed to have a cervical spine injury and require strict spinal immobilization precautions. Cervical spinal immobilization prevents the ideal positioning of the patient for direct laryngoscopy which is why such cases should be automatically regarded as a potential for a difficult airway, or at a minimum, a difficult laryngoscopy. Such a trauma patient requiring endotracheal intubation must be handled in a way that reduces or eliminates potential movement of the cervical spine.

The number of patients in the US suffering from obesity also adds to the potential increase in the prevalence of difficult airway potential. Obesity causes an increase in redundant tissues which contributes to anatomical features that may lead to a difficult laryngoscopy.

Predicting the Difficult Airway

Unlike elective intubations that occur in the operating room emergency department, patients are rarely able to be thoroughly examined to predict the potential difficult airway. However several methods of examination can be carried out in a rather short amount of time. The Malampatti exam is to be conducted with the patient sitting in the upright position. This is not always feasible in the ED and is often governed by the clinical circumstances. If a patient can remain supine as long as they are cooperative and alert, a modified Malampatti can often be performed.

The overall size of the head and neck should be evaluated. Large head, larger neck circumferences as well as shorter neck lengths are considered characteristics that favor a more difficult laryngoscopy. Examining the neck for thyromental distance should be carried out and a distance of less than three centimeters favors a potential difficult case.

The ability to open the incisors a distance of less than three centimeters should be concerning. Palpation of the landmarks of the cricothyroid membrane should be carried out to assess the probability of a successful cricothyroidotomy should it become necessary in critical situations.

Safety

Implementation of videolaryngoscopy into the practice of airway management in the emergency department increases patient safety. The ability to obtain rapid visualization of the glottic opening and increasing first pass intubation success as well as decreasing the time to intubation represents significant patient safety efforts. This is particularly important in the emergency department where airway encounters are usually unplanned events that occur under urgent and emergent situations. Standardizing the emergency department airway practice to always include the videolaryngoscope will likely improve the outcomes of intubation attempts in unplanned difficult airway situations as it will increase the physician's familiarity with the equipment.

Teaching and Academics

The demands for adequate clinical experience with airway management are increasing in training programs of Emergency Medicine. The C-MAC® system offers the unique experience of being able to be utilized in various ways to benefit both the precepting faculty member as well as the trainee.

In the emergency department, environment providing acute airway management is often accomplished in the setting of high stress, high acuity settings. Allowing the trainee to manage the airway is a crucial decision that is made by the faculty member who must always take into account the level of acuity of the patient and the clinical circumstance as well as factor in the confidence and perceived confidence in the trainee who will be afforded the clinical experience. The use of videolaryngoscopy allows the supervising faculty member to directly observe the actions of the trainee thereby reducing the anxiety associated with allowing the trainee to perform the intubation. During direct laryngoscopy attempts by the trainee, the faculty member is able to analyze the airway and make better informed decisions with regard to the prudence of allowing the trainee to continue. In the absence of the videolaryngoscope the faculty member is more likely to take over the procedure earlier if a problem is encountered, thereby reducing the experience afforded to the trainee.

The C-MAC® system essentially offers two modes of clinical experience to the trainee. Both direct laryngoscopy as well as intubation with video assistance can be utilized in the teaching setting. The unique design of the C-MAC® that employs standard Macintosh blade equipment allows the trainee to perform laryngoscopy in standard fashion without the use of the video assistance. This important aspect allows for the proper development of the psychomotor skills associated with standard laryngoscopy equipment by the trainee while affording the preceptor the ability to observe the case via the video screen for patient safety and teaching efforts.

The use of videolaryngoscopy allows the supervising faculty member to directly observe the actions of the trainee, thereby reducing the anxiety associated with allowing the trainee to perform the intubation. During direct laryngoscopy attempts by the trainee, the faculty member is able to analyze the airway and make better informed decisions with regard to the prudence of allowing the trainee to continue. In the absence of the videolaryngoscope, the faculty member is more likely to take over the procedure earlier if a problem is encountered, thereby reducing the experience afforded to the trainee.

The second mode of clinical experience that is created by the C-MAC® system is for the trainee to develop the necessary hand-eye coordination and decision-making skills associated with videolaryngoscopy. Achieving competence in this skill will allow the practitioner to increase their competence and confidence in managing difficult airways. By simple repositioning of the angle of the video screen, the trainee can perform the laryngoscopy via video. Similar to the former mode of developing direct laryngoscopy skills, the faculty member is able to observe, and record the event, if desired, to enhance the teaching experience.

Vantage Point Closer to the Glottic Opening

Performing traditional laryngoscopy is a complex and relatively difficult skill. The ideal patient positioning and the ability to achieve ideal visualization of the vocal cords are subject to a number of challenges. Cases which demand keeping the cervical spine in a neutral position are particularly challenging. The traditional alignment of

17

the pharyngeal and tracheal axes is often difficult or not possible, if the patient cannot be positioned properly and precludes unassisted standard laryngoscopy to accomplish the intubation.

The ability to open the mouth widely as well as the overall size of the mouth relative to the tongue are often limiting factors in achieving adequate visualization to perform endotracheal intubation. Similarly, clinical situations such as trauma, bleeding, disfiguration of normal anatomy from any cause can increase the chances of a difficult or impossible laryngoscopy attempt using traditional laryngoscopy equipment. The fact, that the C-MAC® system places the visual vantage point available to the operator close to the end of the laryngoscope blade, overcomes much of limitation caused by the anatomy of the patient in terms of the ability to achieve glottic opening visualization.

Glottic opening visualization is one of the most important aspects of laryngoscopy. Since video-assisted laryngoscopy has been shown in multiple studies to increase this visualization in both speed and numbers, it furthers the case for wide-spread implementation. The selection of the equipment may then be a factor as the ideal video-assisted system would not require the operator to develop a new set of psychomotor skills to effectively and safely utilize the device. This is a principal advantage of the C-MAC® system, since it is designed with traditional laryngoscopy equipment at its core. Thus, the motor skills of performing laryngoscopy with a standard Macintosh blade will transfer from someone familiar with direct laryngoscopy to those learning video-assisted laryngoscopy on the C-MAC® system.

Ease of Use and Rapid Set Up

Equipment selected for use in the emergency department should be easy to use and intuitive. The demands of the modern emergency department require physicians and nurses to be familiar with a wide range of equipment. Airway management equipment in particular is often utilized during stressful and chaotic times in the emergency department. Thus the demand for intuitive, straightforward operations of technical equipment is paramount. The C-MAC® system provides an icon-encoded menu system that allows easy navigation of the functionality of the equipment. In fact, many times after activating the power button there is no other manipulation of the control panel of the unit necessary to use the device. The handle and blade system are constructed with a simplistic approach that allows for easy attachment of the initial blade selection as well as enabling an easy method to change the blade if required by the clinical status. The wide variety of patients seen in the emergency department necessitate the equipment to be flexible in terms of size of components and the ability to switch from one to the other in stressful situations.

The practice dynamics of the emergency department demand that the equipment selected for airway care be able to be utilized at moment's notice. Few other situations dealt with in the providing of care to the emergency department patient are as time-sensitive as emergently managing the airway of a patient presenting unannounced in a state of respiratory failure, and exhibiting an obstructed or, potentially obstructed airway. Videolaryngoscopy equipment selected must be readily available and devoid of any unnecessary delays associated with start up or equipment set up. Equipment requiring long periods of time for start up and booting sequences is far less desirable.

Set up and storage of the equipment must be designed to be a simplified and portable solution. The nature of the emergency department equipment is that it can easily be moved from room to room or area to area with ease. Equipment set up must be intuitive, reliable and straight forward.

Portability

The C-MAC® system is designed for portability. This is critical to its role in the emergency department as the need for emergent airway management can occur in any treatment room in a moment's notice. Flexible design attachments allow for the C-MAC® to be mounted on a standard IV pole that would be common in many emergency departments.

An alternative method of deployment allows the unit to be placed in a protective travel bag (**Fig. 17**). This allows for maximum operational portability and is particularly important if the system is expected to be able to be emergently deployed outside of the emergency department in such situations as in-hospital code team responses for example.

In addition to the functional portability for physical deployment of the unit, the fact that it can run on the self-contained rechargeable battery further increases the operational flexibility of the system.

Documentation Capabilities

The ability to document the laryngoscopy can be a significant benefit at a number of levels. Medical legal liability can likely be reduced by the systematic and regular practice of either photographic or video documentation of the airway management procedure. This is particularly true in the case of patients who present with trauma to the head, face and neck region making the laryngoscopy difficult. Pre-existing conditions such as dental trauma and trauma to the airway from unsuccessful laryngoscopy attempts can similarly be documented. Lastly, the ability to document that a tube was properly placed between the vocal cords, can be very important in the event of an unintended dislodgment of the tube.

No Disposable Costs

The design of the C-MAC® system incorporates rugged blades and equipment that is easy to clean and does not require the use of disposable equipment parts. This is an important operational consideration when making choices on the appropriate equipment for the emergency department along with the financial planning that must occur in the modern emergency department. Ongoing costs of disposable equipment are far less desirable and are often part of the hidden costs of the purchase and implementation of systems incorporated into the emergency department.

Flexibility with Clean Up

The implications for clean up, care and maintenance of videolaryngoscopy equipment are numerous. The C-MAC® system allows for easy "in-department" clean up and rapid return to service options that can be adapted to many circumstances. This substantially increases the up-time of the equipment to ensure a maximal state of readiness. This can be hampered by such requirements as autoclaving or other cleaning procedures that reduce the availability of the equipment because of a need to send it out of the department.

Summary

The variability and undifferentiated nature of the patient presenting to the emergency department demand a diverse skill set with regard to airway management on the part of the emergency physician. The incorporation of the use of videolaryngoscopy will decrease the time to glottis visualization and result in less dental pressure applied to the upper teeth. The routine use of videolaryngoscopy will increase the practicing emergency physician's familiarization with the VL device. The KARL STORZ C-MAC® system offers the unique ability to be used as a traditional laryngoscope and function in a manner similar to traditional laryngoscopy, along with the benefit that the user can instantly switch to a video-aided view.

The camera location of the C-MAC® system allows a more proximate video-assisted view of the glottis opening which is particularly important in suspected, or actual difficult laryngoscopy cases. The C-MAC® system offers the advantage in teaching situations to facilitate a direct video-assisted observation for the precepting faculty member. This, in turn, will facilitate the teaching experience along with improving the safety of the trainee's experience on the patient.

References

1. AZIZ M, DILLMAN D, KIRSCH JR, BRAMBRINK A. Video laryngoscopy with the macintosh video laryngoscope in simulated prehospital scenarios by paramedic students. Prehosp Emerg Care 2009 Apr–Jun;13(2):251–5.
2. BROWN CA, 3RD, BAIR AE, PALLIN DJ, LAURIN EG, WALLS RM. Improved glottic exposure with the video macintosh laryngoscope in adult emergency department tracheal intubations. Ann Emerg Med 2010 Aug;56(2):83–8.
3. JUNGBAUER A, SCHUMANN M, BRUNKHORST V, BORGERS A, GROEBEN H. Expected difficult tracheal intubation: a prospective comparison of direct laryngoscopy and video laryngoscopy in 200 patients. Br J Anaesth 2009 Apr;102(4):546–50.
4. LEE RA, VAN ZUNDERT AA, MAASSEN RL, WILLEMS RJ, BEEKE LP, SCHAAPER JN, et al. Forces applied to the maxillary incisors during video-assisted intubation. Anesth Analg 2009 Jan;108(1):187–91.
5. POTT LM, MURRAY WB. Review of video laryngoscopy and rigid fiberoptic laryngoscopy. Curr Opin Anaesthesiol 2008 Dec;21(6):750–8.
6. THONG SY, LIM Y. Video and optic laryngoscopy assisted tracheal intubation – the new era. Anaesth Intensive Care 2009 Mar;37(2):219–33.
7. TINTINALLI JE, KELEN GD, STAPCZYNSKI JS. Emergency Medicine : A Comprehensive Study Guide. 6th ed. New York: McGraw-Hill, Medical Pub Division 2009;xxxix.
8. WOLFSON AB, HENDEY GW, LING LJ, ROSEN CL, SCHAIDER JJ, SHARIEFF GQ. Harwood-Nuss' Clinical Practice of Emergency Medicine. Philadelphia: Wolters Kluwer/Lippincott Williams & Wilkins 2009;5th ed.

Tips and Tricks

6.1 Use of the BOEDEKER Forceps[1]

6.2 Use of the BOEDEKER DOERGES Suction Blade[1]

6.3 Alternative for the Difficult Airway: the Miller Technique[2]

6

[1] **Ben H. Boedeker,** M.D.
Professor of Anesthesiology
Center for Advanced Technology and Telemedicine
Department of Anesthesiology
University of Nebraska Medical Center
Omaha VA Medical Center, Omaha, Nebraska

[2] **Erol Cavus,** M.D.
Department of Anaesthesiology and Intensive Care Medicine,
University Hospital Schleswig-Holstein, Campus Kiel, Germany

6.1 Use of the BOEDEKER Forceps

Ben H. Boedeker

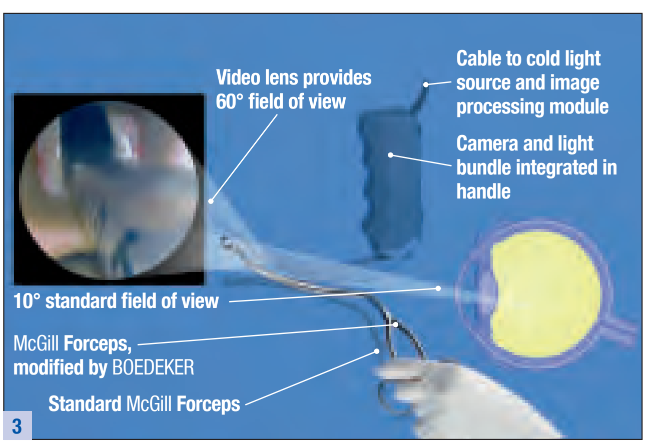
The Boedeker intubating forceps is a modification of the McGill's forceps. It has a curve to accommodate reach to the field of vision seen by the videolaryngoscope. The pictures left show the straight McGill forceps and the curved Boedeker intubating forceps.

1

Standard McGill Forceps.

2

McGill Forceps, modified by Boedeker.



3

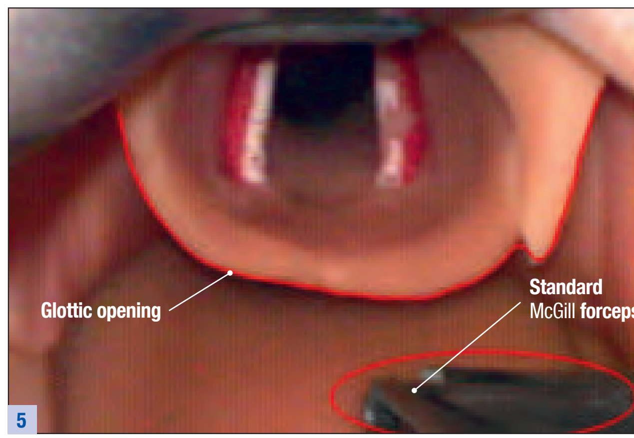
The drawing on the left compares the reach offered by the McGill forceps compared to the Boedeker forceps. The Boedeker forceps can reach into the areas of visualization seen by the videolaryngoscope, while the standard McGill forceps is designed to work in a direct line of sight.

The Boedeker intubating forceps can be used in the standard fashion to insert the endotracheal tube through the glottis opening during nasal intubations (as shown in **Fig. 4**).


4

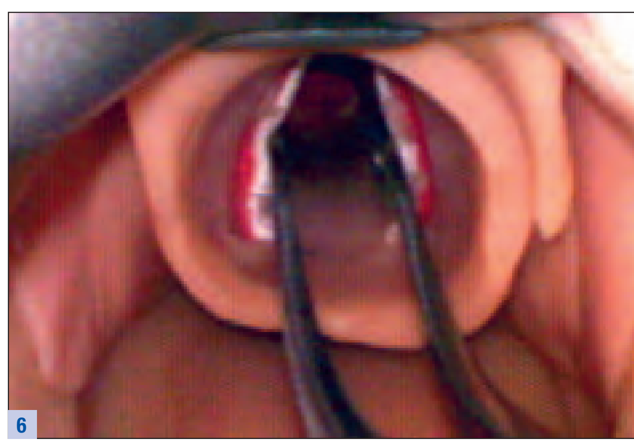
It is also useful for the removal of foreign bodies using the videolaryngoscope. In **Fig. 5**, a coin is being removed from the glottis opening using the Boedeker forceps and a C-MAC®.

The circular area indicates the reach into the field of visualization by the standard McGill forceps. The McGill forceps is designed to operate in a straight line of sight and cannot reach into the area of visualization of the videolaryngoscope (which "sees around the corner").



5

Fig. 6 shows the Boedeker curved forceps being able to extend into the field of view offered by the C-MAC® allowing the coin in the glottic opening to be grasped.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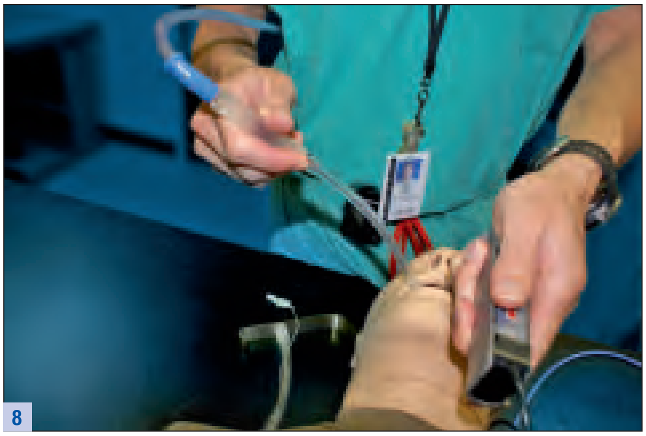
Standard McGill forceps compared to the curvature of the MacIntosh blade.


7



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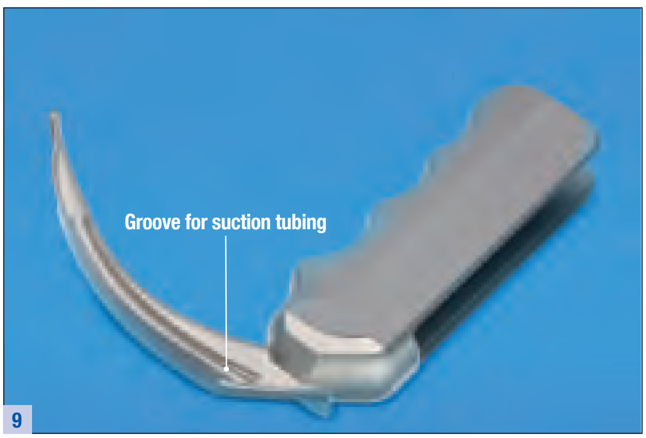
McGill Forceps.

6.2 Use of the BOEDEKER DOERGES Suction Blade

Ben H. Boedeker

During intubation, secretions or bleeding is often encountered which limits the laryngoscopist's view of the airway. Secretions are cleared using a Yankauer suction as shown below. This maneuver requires two hands to accomplish and may add time to the intubation process.



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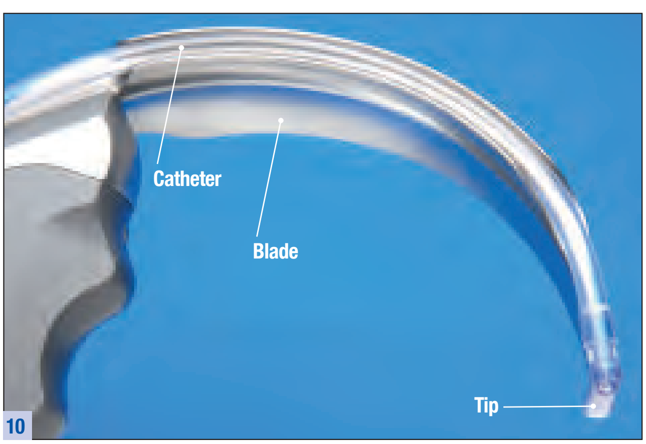
Boedeker forceps.

The Boedeker Doerges blade has a suction attached to its distal tip. As seen in the picture below, there is a groove which holds the suction tubing along the shaft of the laryngoscope.



10

The distal end of the tubing is clipped to the laryngoscope blade as shown left.

The distal end of the suction blade is slid over the ridge at the end of the laryngoscope blade to hold it in place, as shown right.


11

The tubing is placed in the groove along the shaft of the blade as shown here.


12

This blade shows the tubing affixed at the distal end and in place along the groove of the shaft.


13

14

Fig. 14 shows the proximal end which is attached to the suction tubing. It can be left open or the cap can be closed to create continuous suction. The disposable tubing is discarded after use.

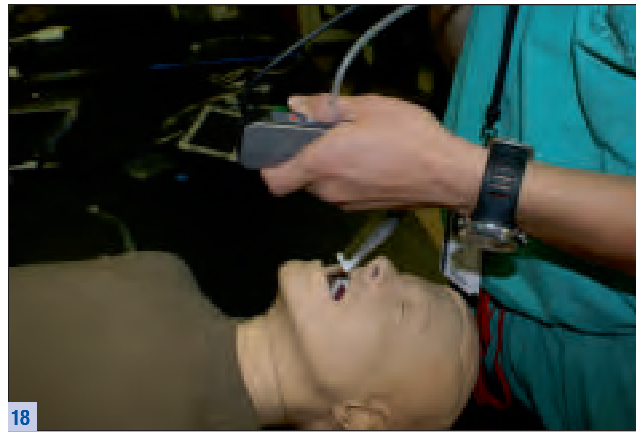
15

16

Fig. 16 shows the suction tubing being attached to the long suction tubing which goes to the suction canister.

17

Fig. 18 shows the suction tubing on the Boedeker Doerges blade being inserted into the patient's mouth.



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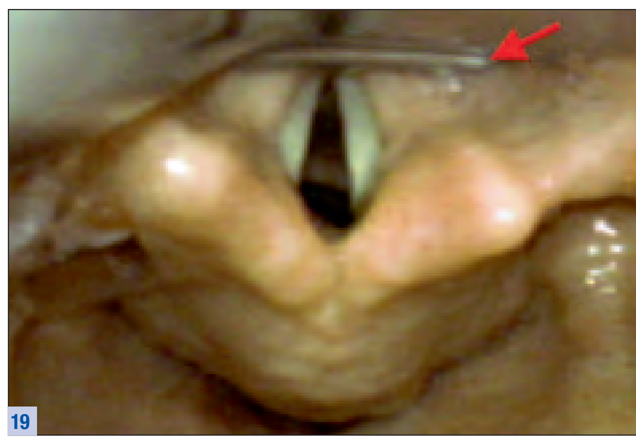
6.3 Alternative for the Difficult Airway: the Miller Technique

Erol Cavus

In cases of expected or unexpected difficult intubation where adequate glottic visualization is not obtained despite videolaryngoscopy with a C-MAC® size 3 or 4 Macintosh blade, there is a way to further improve intubation conditions: by using the C-MAC® size 4 Macintosh blade in conjunction with the "Miller technique".[2,3] The original Macintosh size 4 blade is more curved than the size 3 blade. If the epiglottis is loaded onto the laryngoscope blade (**Fig. 19**) in the technique first described by *Miller* and later adopted by *Henderson* ("straight blade technique"),[2,3] the Cormack-Lehane grade will be significantly improved, resulting in improved intubation conditions.[1] The D-BLADE (KARL STORZ 8401 BXC) should be reserved for the remaining small percentage of extremely difficult airways owing to its considerably greater curvature.[4]



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Laryngoscopic view with the C-MAC® size 4 blade (Cormack-Lehane grade 1) using the Miller technique. The arrow indicates the visible blade tip lifting the epiglottis.

References

1. HENDERSON JJ (1997). The use of paraglossal straight blade laryngoscopy in difficult tracheal intubation. Anaesthesia 52:552–60.
2. MILLER RA (1941). A new laryngoscope. Anesthesiology 2:317-20.
3. CAVUS E, KIECKHAEFER J, DOERGES V, MOELLER T, THEE C, WAGNER K (2010). The C-MAC® videolaryngoscope: First experiences with a new device for videolaryngoscopy-guided intubation. Anesth Analg 110:473–7.
4. CAVUS E, NEUMANN T, DOERGES V, MOELLER T, SCHARF E, WAGNER K, BEIN B, SEROCKI G. First clinical evaluation of the C-MAC D-Blade videolaryngoscope during routine and difficult intubation. Anesthesia and analgesia. 2011 Feb;112(2):382-5.

7 The C-MAC® Airway Management Technology and System

Frank Stock
KARL STORZ GmbH & Co. KG, Tuttlingen, Germany

The C-MAC® Airway Management Technology and System

Frank Stock

The development of airway management products at KARL STORZ always begins with an idea drawn from medical science. Developers define the essential-elements of a new product by looking at it from the viewpoint of the treating physician. This is the only perspective that can produce innovative technologies that are actually helpful in carrying out specialized tasks during daily routines.

The C-MAC® videolaryngoscope is a new tool for video-assisted airway management that employs advanced CMOS technology at the semiconductor level.

The laryngoscope is unquestionably the most successful instrument for endotracheal airway management. But why a videolaryngoscope?

Your daily work requires an instrument for routine intubation. The Macintosh blade design, combined with an image sensor mounted near the tip of the blade, gives you a "virtual eye" at the threshold of the glottic plane.

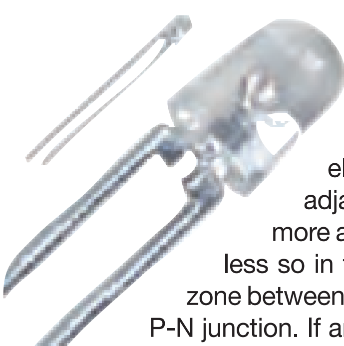
1 The C-MAC® videolaryngoscope with monitor and electronic module.

This enables you to survey the intubation site more clearly and work with greater confidence.

In order for an image sensor to function, adequate illumination is needed. The C-MAC® employs high-intensity LEDs that produce white light.

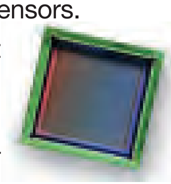
… How Does an LED Produce Light?

A light-emitting diode (LED) is based on semiconductor technology. Areas with different charges are placed adjacent to each other on a very small scale. The difference in charges results from the difference in the number of electrons present in the adjacent areas. Electrons are more abundant in the N area and less so in the P area. The boundary zone between the two areas is called the P-N junction. If an electrical voltage is now applied to the LED, the electrons must perform the electrical work necessary to cross the boundary. Once they have crossed to the adjacent area, the expended energy is released and can be emitted as light.



There are two main types of semiconductor sensors: CCD image sensors and CMOS image sensors.

Conventional CCD image sensors consist only of the photodetectors themselves, known as "**c**harge-**c**oupled **d**evices." Signals from the sensors are fed into a separate device for sophisticated processing. With the new CMOS image sensor technology, the photodetectors and electronic signal processing are combined on one chip. The "CMOS" acronym, like "CCD," expresses the semiconductor technology that is used: "**c**omplementary **m**etal **o**xide **s**emiconductor."



CCD image sensors are still popular in applications that require very high resolution. But as semiconductor technology improves, CMOS image sensors are finding greater use. They are increasingly used in areas that have previously been reserved for CCD image sensors.

The image produced by the image sensor is transmitted by a connecting cable to the centerpiece of the C-MAC® system, the intelligent monitor. The display unit of the monitor is the TFT screen. "TFT" stands for "**t**hin-**f**ilm **t**ransistor" and reflects how the screen works: Every pixel in the image is represented by a semiconductor element that is individually activated by the image signals and determines how much light is let through the background illumination for display on the screen. Since the background illumination level can be adjusted in the C-MAC® system, the screen performs very well under adverse lighting conditions, such as viewing the screen outdoors in broad daylight. The special situation of emergency intubation, whether done in a hospital or in the field, places rigorous demands on the portability and reliability of a video-laryngoscope.

While many factors contribute to the portability and reliability of the C-MAC® system, none is more important than the use of advanced battery technology. The C-MAC® is powered by a lithium-ion battery pack. There is a sophisticated battery management system with built-in hardware and software to ensure that the battery pack always has an optimum charge.

A lithium-ion battery consists of two electrode areas, a separator area, and an electrolyte. The electrodes are rolled into a cylinder and packaged in a metal can. The negative electrode usually contains graphite, while the positive electrode is composed of lithium material which gives the battery its name. Because of its chemistry a lithium-ion battery has no memory effect, so it does not have to be completely discharged before recharging, as with traditional nickel-cadmium batteries, for example. This forms the basis of its excellent dependability.

… What is Our Perspective?

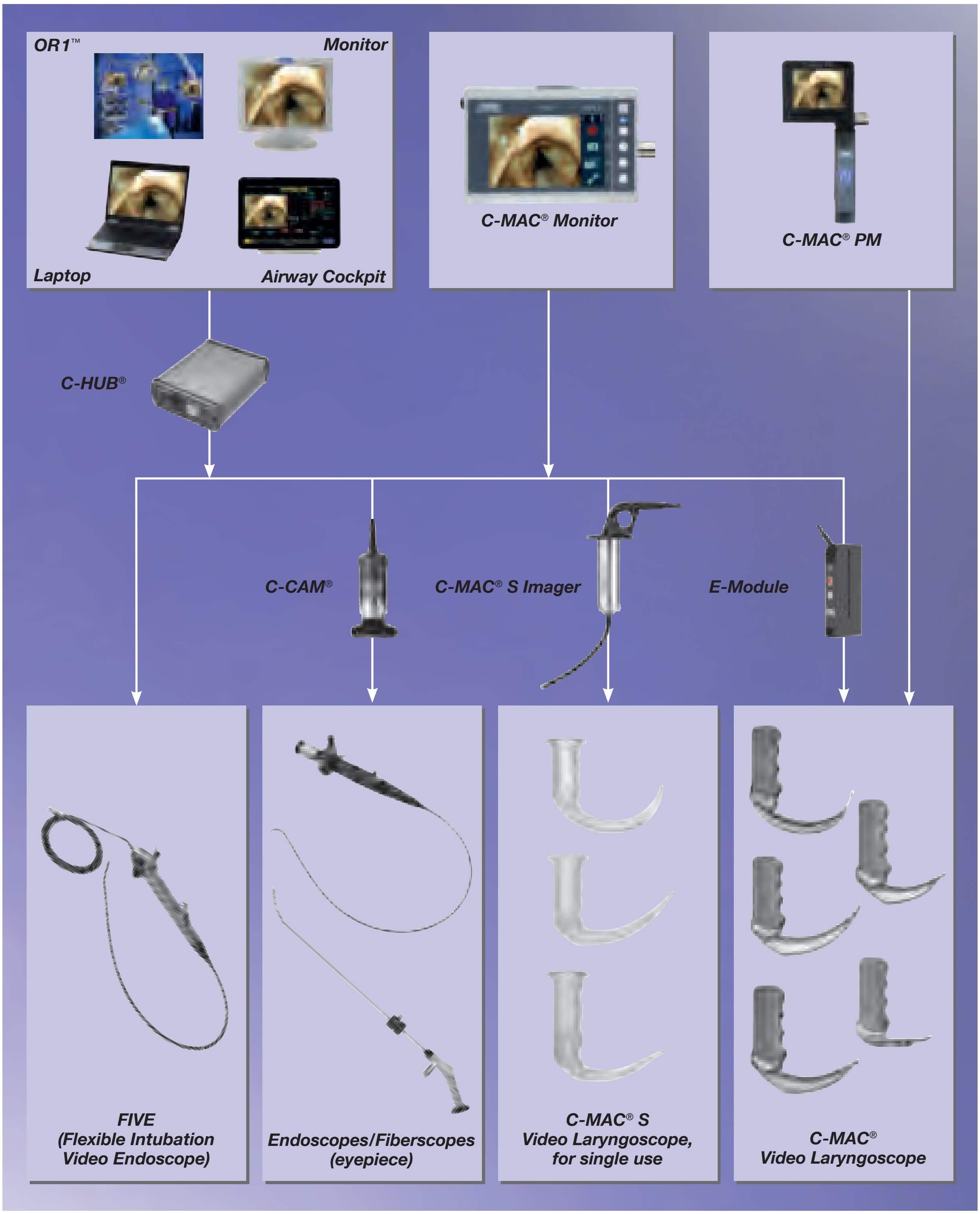
For us, airway management is more than just video-laryngoscopy!

… therefore, KARL STORZ airway management will continue to feature C-MAC® products that give you the confidence to deal successfully with expected or unexpected difficulties in the hospital or in the field.

… What is Your Perspective?

Video Systems for Airway Management

KARL STORZ offers a complete armamentarium of instruments and videoendoscopic devices, that is tailored to a wide range of airway management modalities. The broad scope of KARL STORZ products gives you all options – for dealing with a standard or unexpectedly difficult intubation. In addition, all of our fiberscopes are powered by an LED battery light source to make sure that even in an emergency you will never be left in the dark.



It is recommended to check the suitability of the product for the intended procedure prior to use.

C-MAC® Video Laryngoscope

for visual endotracheal intubatio

Monitor/Electronic Module

Special Features:

- **Resistant ABS plastic housing**
- **Splash-proof according to IP54**
- **7" TFT wide view angle display with resolution of 800 x 480 pixels**
- **Ready for use within seconds**
- **Documentation of still images (JPEG) and videos (MPEG4) on SD memory card**
- **VESA 75 norm for connecting and attaching racks**
- **Soft keys enable use within seconds**
- **Cinch video output for connecting external monitor**
- **System open for further components**
- **Operating time with lithium-ion batteries of about 2 hours**
- **World power supply 100 – 240 VAC, 50/60 Hz**
- **Operation with line voltage and rechargeable lithium-ion batteries**
- **Processing of the electronic module: Suitable and validated for the following low-temperature reprocessing methods up to bis max. 60 °C: manual/machine cleaning and disinfection, sterilization with Steris® AMSCO VPRO 1, Sterrad® (50S, 100S, 200S, NX, 100NX) and EtO gas; High-Level Disinfection (HLD) acc. to US standards**
- **Additional standards: RTCA/DO-160F, EMI Test Report (German air rescue service DRF Luftrettung)**

8403 ZX

8402 X

8403 ZX — **C-MAC® Monitor für CMOS Endoscopes,** screen size 7" with 1280 x 800 pixel resolution, two camera inputs, a USB and a HDMI port, optimized user interface, video and image capturing in real time on SD card, playback of recorded video clips and still images, data transfer from SD card to USB flash drive possible, splash-proof according to IP54, suitable for wipe disinfection, shock-resistant ABS plastic housing, intelligent power management with rechargeable Li-Ion batteries, VESA 75 mounting option, power adaptor for EU, UK, USA and Australia, power supply 110 - 240 VAC, 50/60 Hz

8402 ZX — **Monitor for CMOS Endoscopes,** screen size 7**"**, documentation can be stored directly on SD card, rechargeable Li-Ion batteries, power adaptor for EU, UK, USA and Australia, power supply 110 – 240 VAC, 50/60 Hz, additional standards: RTCA/DO-160F, EMI Test Report (German air rescue service DRF Luftrettung), **suitable for wipe disinfection**

8402 X — **Electronic Module,** for C-MAC® Monitor 8402 ZX, for use with C-MAC® video laryngoscopes

Accessories included in delivery with 8402 ZX:

8401 YCA

8401 YCA — **VESA 75 Quick Clip,** with 4 fixation screws, for mounting C-MAC® to tube up to diameter 25 mm

BERCI-KAPLAN **C-MAC® Video Laryngoscope**

for visual endotracheal intubation

Video Laryngoscope

Special Features:

- **European closed laryngoscope blade design**
- **Angle of view approx. 80°**
- **Ergonomically designed handle**
- **CMOS technology with LED illumination**
- **Proximal slanted blade**
- **Available with or without suction**
- **Processing video laryngoscopes: suitable and validated for the following low-temperature reprocessing methods up to bis max. 60 °C: manual/machine cleaning and disinfection, sterilization with Steris® AMSCO V-PRO 1, Sterrad® (50S, 100S, 200S, NX, 100NX) and EtO gas; High-Level Disinfection (HLD) acc. to US standards**
- **Blade tips of all blade types visible for safe navigation**

MACINTOSH

- **For direct and indirect laryngoscopy**
- **Original English MACINTOSH blade shape**

D-BLADE

- **Special curved blade shape for difficult intubation**

MILLER

- **For pediatrics and neonatology in the day-to-day clinical routine, teaching and training as well difficult airway management**

8401 DXC/GXC

8401 KXC/AXC/BXC

NEW	8401 DXC	MILLER **C-MAC® Video Laryngoscope,** CMOS technology, size 0, for use with Electronic Modules 8401 X and 8402 X
NEW	8401 GXC	**Same,** size 1
	8401 KXC	BERCI-KAPLAN **C-MAC® Video Laryngoscope #2,** CMOS technology, with MACINTOSH laryngoscope blade, size 2, for use with Electronic Modules 8401 X and 8402 X
	8401 AXC	**Same,** size 3
	8401 BXC	**Same,** size 4

BOEDEKER-DÖRGES **C-MAC® Video Laryngoscope**

for visual endotracheal intubation

8401 HX

8401 AX/BX

8401 AX	BOEDEKER-DÖRGES **C-MAC® Video Laryngoscope #3,** CMOS technology, with MACINTOSH laryngoscope blade, size 3, with catheter introduction sizes 14 – 16 Fr., for use with Electronic Modules 8401 X and 8402 X
8401 BX	**Same,** size 4, with catheter introduction sizes 16 – 18 Fr.
8401 HX	**C-MAC® Video Laryngoscope D-BLADE,** CMOS technology, with DÖRGES laryngoscope blade, for difficult intubation, with catheter introduction sizes 16 – 18 Fr., for use with Electronic Modules 8401 X and 8402 X

C-MAC® S Video Laryngoscope *NEW*

Video Laryngoscope for Single Use

Special Features:

- **Blade and handle form one continuous piece: optimum protection against infections**
- **D-BLADE with short handle**
- **Original English MACINTOSH blade shape**
- **Sturdy plastic material**
- **Compatible with C-MAC® monitor**
- **Blade tip always under direct view for safe navigation**
- **Ergonomically designed handle**
- **Compact design**

C-MAC® S Imager:

- **Handling oriented towards hygiene**
- **Reprocessing of the imager: suitable and validated for the following low-temperature reprocessing methods up to bis max. 60 °C: manual/machine cleaning and disinfection, sterilization with EtO gas; High-Level Disinfection (HLD) acc. to US standards**
- **Compatible with C-MAC® monitor**
- **Blade can be exchanged within seconds**

051113-10

051114-10

051113-10*	BERCI-KAPLAN **C-MAC® S Video Laryngoscope MAC #3,** with MACINTOSH laryngoscope blade, size 3, for single use, sterile, package of 10, for use with C-MAC® Monitor 8402 ZX and C-MAC® S Imager 8402 XS
051114-10*	**Same,** size 4

*mtp medical technical promotion gmbh,
Take-Off GewerbePark 46, 78579 Neuhausen ob Eck, Germany

C-MAC® S Video Laryngoscope NEW

051116-10

051116-10* **C-MAC® S Video Laryngoscope D-BLADE,** with DÖRGES laryngoscope blade, sterile, package of 10, for use with C-MAC® Monitor 8402 ZX and C-MAC® S Imager 8402 XS

8402 XS

8402 XS **C-MAC® S Imager,** for C-MAC® Monitor 8402 ZX-1, suitable for manual and mechanical disinfection up to 60 °C and High-Level Disinfection (HLD) acc. to US standards, for use with C-MAC® S-Video Laryngoscopes 051113-10, 051114-10 and 051116-10

*mtp medical technical promotion gmbh,
Take-Off GewerbePark 46, 78579 Neuhausen ob Eck, Germany

C-MAC® PM – The Pocket Monitor NEW

Special Features:

- **Exchange of video laryngoscope within seconds**
- **Compatible with all C-MAC® video laryngoscopes (D-BLADE, MACINTOSH sizes 2-4, MILLER sizes 0 & 1)**
- **One hour operating time**
- **Rechargeable Li-ion battery with capacity control and intelligent power management**
- **High-resolution 2.4" LED display with 240 x 320 pixels for optimal view**
- **No additional on/off buttons thanks to the "Open-to-Intubate-Display"(OTI)**
- **Important for preclinical use: classified for protection class IPX8**
- **Due to the closed design, the entire pocket monitor unit can be fully immersed in disinfection solution which allows for easy and smooth reprocessing**
- **Suitable and validated for the following low-temperature reprocessing methods up to max. 60 °C: manual/machine cleaning and disinfection**
- **Additional standard: RTCA/DO-160F**

8401 XDK

8401 XDL

8401 XDK **C-MAC® Pocket Monitor, Set,** unit with LCD monitor and power supply for all C-MAC® laryngoscopes, screen size 2.4", monitor movable via two rotation axis, rechargeable Li-Ion batteries, 1 h operation time, 2 h charging time, power management with capacity indicator: switches off automatically after 10 min, protection class IPX8, additional standard: RTCA/DO-160F, validated for up to a max. of 60 °C, manual/mechanical cleaning and disinfection, for use with C-MAC® video laryngoscopes

including:

Protection Cap

8401 XDL **Charging Unit,** for C-MAC® Pocket Monitor 8401 XD, with fix integrated power supply and adaptor for EU, UK and USA, power supply 110 – 240 VAC, 50/60 Hz, suitable for wipe disinfection

FIVE – Flexible Intubation Video Endoscope for C-MAC® NEW

Special Features:

- **Compatible with C-MAC® monitor and C-HUB®**
- **Compact design**
- **Ergonomically designed handle**
- **Lightweight at 385 g**
- **High image resolution**
- **Video imaging in 4:3 format**
- **Possible to exchange components within seconds**
- **Integrated LED light source**
- **Suitable and validated for the following low-temperature reprocessing methods up to max. 60 °C: manual/machine cleaning and disinfection, sterilization with Sterrad® (100S, NX, 100NX) and EtO gas; High-Level Disinfection (HLD) acc. to US standards**

11301 BNXK

11301 BNXK **Flexible Intubation Video Endoscope 5.5 x 65,** CMOS technology, with suction valve, for use with C-MAC® Monitor 8402 ZX and C-HUB® **20** 2901 01

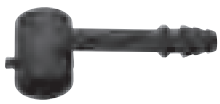
Deflection up/down:	140°/140°
Direction of view:	0°
Angle of view:	85°
Working length:	65 cm
Total length:	93 cm
Working channel inner diameter:	2.3 mm
Distal tip outer diameter:	5.5 mm

Accessories

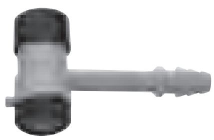
Flexible Intubation Video Endoscopes

Accessories included in delivery:

29100 **Plug,** for LUER-Lock connector
for cleaning, **black, autoclavable,**
package of 10



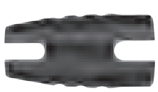
11301 CD1 **Irrigation Adaptor,** for machine cleaning,
reusable, for Flexible Intubation Video Endoscope
11301 BNX



11301 CE1 **Suction Valve,** for single use, package of 20,
for use with Flexible Intubation Video Endoscope
11301 BNX

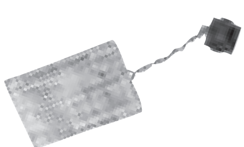
10309 **Bronchoscope Insertion Tube,** size 4,
with integrated mouthpiece, for single use,
sterile, insertion length 85 mm,
made from EVA, package of 10

10310 **Bronchoscope Insertion Tube,** size 2,
with integrated mouthpiece, for single use,
sterile, insertion length 65 mm,
made from EVA, package of 10



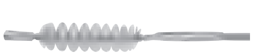
11301 CFX **Tube Holder,** for use with Flexible Intubation
Video Endoscope 11301 BNX

27677 FV **Case**



11025 E **Pressure Compensation Cap,**
for ventilation during gas sterilization

13242 XL **Leakage Tester,**
with bulb and manometer



27651 B **Cleaning Brush,** flexible, round,
outer diameter 3 mm, for working channel
diameter 1.8 – 2.6 mm, length 100 cm

8401 YZ **Protection Cap,** for the C-MAC® video
laryngoscope and electronic module,
to protect plug contact during reprocessing,
cap is reusable

Accessories

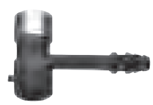
Flexible Intubation Video Endoscopes

Optional Accessories:

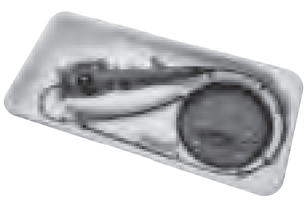
11001 KL — **Biopsy Forceps,** flexible, spoon-shaped, round, double action jaws, diameter 1.8 mm, working length 120 cm

11002 KS — **Grasping Forceps,** flexible, alligator jaws, double action jaws, diameter 1.8 mm, working length 120 cm

11301 CA — **Leaflet Valve,** for single use, package of 20

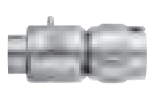


11301 CB1 — **Suction Valve,** reusable, for use with Flexible Intubation Video Endoscope 11301 BNX



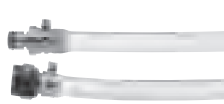
39405 AS — **Plastic Container for Flexible Endoscopes,** specially suited for gas and hydrogen peroxide (Sterrad®) sterilization and storage, for use with one flexible endoscope, external dimensions (w x d x h): 550 x 260 x 90 mm

11301 BM — **Adaptor,** for leakage test, for Belimed washer-disinfectors



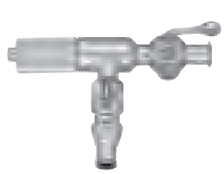
11301 FF2 — **Adaptor for MIELE Cleaning Machines,** with safety valve, for automatic leakage test of flexible KARL STORZ endoscopes

11301 GG2 — **Adaptor,** for cleaning and disinfecting the irrigation and working channels of flexible endoscopes, for MIELE-ETD washer-disinfectors



11301 HH — **Adaptor for BHT Cleaning Machines,** for automatic leakage test of flexible KARL STORZ endoscopes

11301 KK2 — **Adaptor,** for working channel of flexible endoscopes, for MIELE-ETD 03 washer/disinfectors
Please note: Adaptors 11301 FF2 and 11301 GG2 have to be ordered separately!



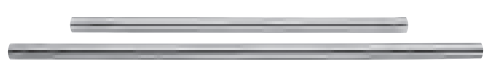
6927691 — **Adaptor for Two-Way Stopcock,** LUER-Lock, with O_2 tube connection

600007 — **LUER-Lock Tube Connector,** male, tube diameter 6 mm

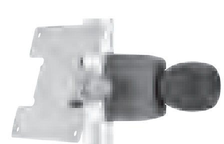
Accessories

C-MAC® Video Laryngoscope

8401 YA



8401 YAA
8401 YAB

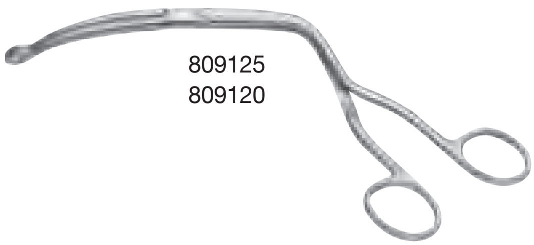


8401 YB

8401 YA	**Stand,** for C-MAC® monitor, height 120 cm, rollable with five feet and antistatic castors, crossbar 25 cm x diameter 25 mm, for positioning the monitor, with tray for laryngoscopes, dimensions (w x d x h): 30 x 20 x 10 cm
8401 YAA	**Crossbar,** for Stand 8401 YA, 50 cm x diameter 25 mm, or positioning C-MAC® Monitors 8401 ZX and 8402 ZX with VESA 75 Quick Clip 8401 YCA
8401 YAB	**Same,** 70 cm x diameter 25 mm
8401 YB	**Clamp,** VESA 75 standard, for fixation of C-MAC® monitor to round profile with diameter 20 – 43 mm and square profile with diameter 16 – 27 mm, for use with Monitors 8401 ZX/8402 ZX

Accessories

C-MAC® Video Laryngoscope



809125
809120

8402 YD

8402 YD-1

8402 YD-2

39501 LC2

8401 YZ

8402 YD-3

8402 YD*	**Protective Bag,** blue, for C-MAC® system, made of water-resistant and sturdy material, washable, separate compartments for the monitor and two C-MAC® video laryngoscopes with electronic module
8402 YD-1*	**Same, red**
8402 YD-2*	**Same, orange**
8402 YD-3*	**Same, NATO-olive**
809125	MAGILL **Forceps,** modified by BOEDEKER, length 25 cm, suitable for endoscopic foreign body removal, for use with video laryngoscopes size 2 – 4
NEW 809120	MAGILL **Forceps,** for children, modified by BOEDEKER, length 20 cm, for use with video laryngoscopes size 1 and 2
39501 LC2	**Wire Tray for Cleaning, Sterilization and Storage** for two C-MAC® and D-BLADE video laryngoscope blades incl. electronic module, with holder for fixing and sealing electrical connections, external dimensions (w x d x h): 260 x 120 x 170 mm
8401 YZ	**Protection Cap,** for the C-MAC® video laryngoscope and electronic module, to protect plug contact during reprocessing, cap is reusable

*** Crash test carried out by Furtwangen University of Applied Sciences (Germany): C-MAC® system in a protective bag dropped from a height of 5 – 9 meters showed no noteworthy damage.**

Please note: The instruments displayed are not included in the sterilization and storage tray.

C-CAM® and C-HUB®

Nothing could be easier!

C-CAM® transforms the C-MAC® video laryngoscope into an all-round system unit for complete airway management. The C-MAC® monitor is at the core of all imaging systems. C-CAM® is a high-grade CMOS camera with VGA resolution which can be connected to all KARL STORZ endoscopes with eyepieces. Illumination is ensured through the Power-LED battery light sources. Consequently, this is the first battery-powered video system to guarantee high-quality documentation. KARL STORZ has once again proven that high quality and mobility are not mutually exclusive.

The C-HUB® is the interface for computer and/or monitor connectivity. The signal from the front end is transmitted directly to a computer or monitor with the aid of the C-HUB®. The enhanced output can be directly linked to any computer via a USB/S-VHS connection. Thanks to the safety offered by galvanic isolation in the C-HUB®, medical products can now be connected to non-medical products (e.g. computer/ monitor).

C-HUB® is the perfect signal converter from C-MAC®/ C-CAM® to USB or S-Video.

C-CAM® and C-HUB®

20 2901 32/**20** 2901 31

20 2901 32 **C-CAM® Camera Head,** 8-pin, one-chip CMOS camera head, resolution 640 x 480, focal length f = 20 mm, compatible with C-HUB® **20** 2901 01 and C-MAC® 8402 ZX

20 2901 31 **C-CAM® Camera Head,** 6-pin, one-chip CMOS camera head, resolution 640 x 480, focal length f = 20 mm, compatible with C-MAC® 8401 ZX

20 2901 01

20 2901 01 **C-HUB® Camera Control Unit,** for use with C-CAM® **20** 2901 32, Electronic Module 8402 X or compatible CMOS video endoscopes, Interfaces: USB 2.0, S-Video output (NTSC), power socket

including:

C-HUB® Power Supply

S-Video (Y/C) Connecting Cable

USB Connecting Cable

Intubation Fiberscopes

Eyepiece Versions

KARL STORZ provides the instruments you need to meet the special challenges of patients who cannot be intubated with conventional methods. Nasopharyngeal awake intubation is regarded as the gold standard of difficult airway management. We offer solutions for any challenge!

Our versatile intubation fiberscopes can be used in all clinical settings whether in intensive care units or emergency rooms as well as for patients with anticipated difficult airways during induction. The various sheath diameters enable you to select the ideal instrument for your patient and allow a swift reaction thanks to the compact, flexible LED light sources.

Special Features:

- **Sheath stiffness adapted to anesthesiological requirements**
- **Suitable for both fiber optic intubation and bronchoscopy**
- **Patented sheath surface special treatment requires only minimal lubrication and provides optimal tube insertion**
- **Developed for use in the OR, ICU, ER**
- **Even safer tube introduction due to video-assisted control on the monitor**
- **Tube position of ETT, LMA, DLT can be verified**
- **Video-assisted monitoring for percutaneous tracheostomy**
- **Adaptable for foreign body removal or bronchial lavage**
- **Various outer diameters: 2.8; 3.7; 5.2 mm**
- **Diameter of working channel ranging from 1.2 to 2.3 mm**
- **Extremely bright, white light due to the LED light source with rechargeable Li-Ion batteries**
- **Intubation fiberscope can be directly connected to the C-MAC® monitor with the mobile camera head C-CAM®**
- **Suitable and validated for the following low-temperature reprocessing methods up to a max. of 60 °C: manual/mechanical cleaning and disinfection, sterilization with Steris® AMSCO VPRO 1, Sterrad® (50S, 100S, 200S, NX, 100NX) and EtO gas; High-Level Disinfection (HLD) acc. to US standards**

Intubation Fiberscopes – eyepiece version, with optional LED battery light source

Intubation Fiberscopes

Eyepiece Versions

2.8 x 65 Intubation Fiberscope with optimized imaging

Intubation Fiberscope 11301 AA1 is ideal for use in neonatology due to its small outer diameter of 2.8 mm. This fiberscope is the only one of its size that has a working channel with 1.2 mm.

Intubation Fiberscope 11301 AA1 features a connector for suction valves for single or multiple use.

The special sheath surface combined with increased stiffness improves the gliding properties of the ETT over standard intubation fiberscopes.

The use of a mobile LED light source enables independent work under optimal lighting conditions.

Benefits:

- **Effective suction possible via the 1.2 mm working channel**
- **Suitable for use with endotracheal tubes as of 3.5 mm**
- **Increased stiffness and smoother passage of the ETT**
- **Ready for immediate use and easy to clean and reprocess**
- **Optimized for use with mobile light sources**
- **Intubation fiberscope can be connected to the C-MAC® monitor via the mobile C-CAM® camera head**
- **Practical tube fixation via special adaptor**

11301 AA1

11301 AA1	**Intubation Fiberscope 2.8 x 65,**	
	Deflection up/down:	140°/140°
	Direction of view:	0°
	Angle of view:	90°
	Working length:	65 cm
	Working channel inner diameter:	1.2 mm
	Distal tip outer diameter:	2.8 mm

Intubation Fiberscopes

Eyepiece Versions

3.7 x 65 Intubation Fiberscope with optimized imaging

The 3.7 x 65 intubation fiberscope is a universal working instrument as it provides gold standard intubation for both adult and pediatric patients. Due to its small diameter, it is an excellent tool for the placement of double lumen tubes. Using a mobile LED light source and C-CAM®, the intubation fiberscope can be directly connected to the C-MAC® monitor for a monitor-assisted intubation solution that is both mobile and flexible – also suitable for electronic documentation.

Benefits:

- **Effective suction possible via 1.5 mm working channel**
- **Suitable for use with endotracheal tubes as of 4 mm**
- **Increased stiffness and smoother passage of the ETT**
- **Practical tube fixation via special adaptor**
- **Ready for immediate use and easy to clean and reprocess**
- **Optimized for use with mobile light sources**
- **Intubation fiberscope can be connected to the C-MAC® monitor via the mobile C-CAM® camera head**

11302 BD2

11302 BD2	**Intubation Fiberscope 3.7 x 65,**	
	Deflection up/down:	140°/140°
	Direction of view:	0°
	Angle of view:	90°
	Working length:	65 cm
	Working channel inner diameter:	1.5 mm
	Distal tip outer diameter:	3.7 mm

Intubation Fiberscopes

Eyepiece Versions

5.2 x 65 Intubation Fiberscope with optimized imaging

The 5.2 x 65 intubation fiberscope creates an ideal balance between image size, working channel size and fiber optics. Effective suction is possible via the 2.3 mm working channel. The fiberscope is also suitable for removing foreign bodies or for bronchial lavage in the intensive care unit. Using a mobile LED light source and C-CAM®, the intubation fiberscope can be directly connected to the C-MAC® monitor for a monitor-assisted intubation solution that is both mobile and flexible – also for electronic documentation.

Benefits:

- **Effective suction possible via the large 2.3 mm working channel**
- **Suitable for use with endotracheal tubes as of 5.5 mm**
- **Increased stiffness and smoother passage of the endotracheal tube**
- **Practical tube fixation via special adaptor**
- **Ready for immediate use and easy to clean and reprocess**
- **Optimized for use with mobile light sources**
- **Intubation fiberscope can be connected to the C-MAC® monitor via the mobile C-CAM® camera head**

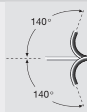
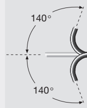
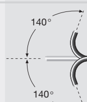
11301 BN1

11301 BN1 **Intubation Fiberscope 5.2 x 65,**

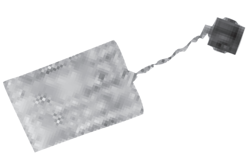
Deflection up/down:	140°/140°
Direction of view:	0°
Angle of view:	110°
Working length:	65 cm
Working channel inner diameter:	2.3 mm
Distal tip outer diameter:	5.2 mm

Intubation Fiberscopes

Eyepiece Versions

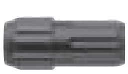
	Order No.									
Intubation Fiberscopes	**Eyepiece**		**Deflection up/down**	**Direction of view**	**Angle of view**	**Working length**	**Total length**	**Working channel inner diameter**	**Distal tip outer diameter**	**Recommended ETT diameter as of***
2.8 x 65	11301 AA1		 140° 140°	0°	90°	65 cm	98 cm	1.2 mm	2.8 mm	3.5 mm
3.7 x 65	11302 BD2		 140° 140°	0°	90°	65 cm	93 cm	1.5 mm	3.7 mm	4.5 mm
5.2 x 65	11301 BN1		 140° 140°	0°	110°	65 cm	93 cm	2.3 mm	5.2 mm	5.5 mm

Accessories included in delivery:

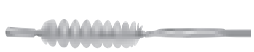


11025 E

13242 XL



11301 CF



27651 A/B

29100

11301 CD

10309/10310

11301 CE

27677 A	**Case**
11025 E	**Pressure Compensation Cap,** for ventilation during gas sterilization
13242 XL	**Leakage Tester,** with bulb and manometer
11301 CF	LIPP **Tube Holder,** for intubation fiberscopes
27651 A	**Cleaning Brush,** flexible, long, for working channel diameter 1.2 mm, working length 150 cm
27651 B	**Cleaning Brush,** flexible, round, outer diameter 3 mm, for working channel diameter 1.8 – 2.6 mm, length 100 cm
29100	**Plug,** for LUER-Lock connector for cleaning, **black, autoclavable,** package of 10
2x 11301 CD	**Irrigation Adaptor,** for machine cleaning, reusable, for fiberscopes
11301 CE	**Suction Valve,** for single use, package of 20
10309	**Bronchoscope Insertion Tube,** size 4, with integrated mouthpiece, for single use, sterile, insertion length 85 mm, made from EVA, package of 10
10310	**Same,** size 2, insertion length 65 mm

Intubation Fiberscopes

Eyepiece Versions

Accessories (included in delivery)									Add. Accessories	
Case	Pressure Compensation Cap	Leakage Tester	LIPP Tube Holder	Cleaning Brush	Plug	Irrigation Adaptor	Suction Valve	Bronchoscope Insertion Tube	Biopsy Forceps	Flexible Grasping Forceps
27677 A	11025 E	13242 XL	11301 CF	27651 A	29100	2x 11301 CD	11301 CE	10309 10310	11003 MA	11003 MB
27677 A	11025 E	13242 XL	11301 CF	27651 A	29100	2x 11301 CD	11301 CE	10309 10310	11003 MA	11003 MB
27677 A	11025 E	13242 XL	11301 CF	27651 B	29100	2x 11301 CD	11301 CE	10309	11001 KL	11002 KS

Optional Accessories:


11003 MA — **Biopsy Forceps,** flexible, oval, double action jaws, diameter 1 mm, length 110 cm


11003 MB — **Grasping Forceps,** flexible, double action jaws, diameter 1 mm, length 110 cm, for flexible bronchoscopes


11001 KL — **Biopsy Forceps,** flexible, spoon-shaped, round, double action jaws, diameter 1.8 mm, working length 120 cm


11002 KS — **Grasping Forceps,** flexible, alligator jaws, double action jaws, diameter 1.8 mm, working length 120 cm

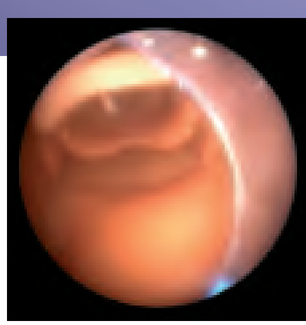
* **Please note that the accuracy of the ETT diameter may vary depending on the manufacturer's quality.**

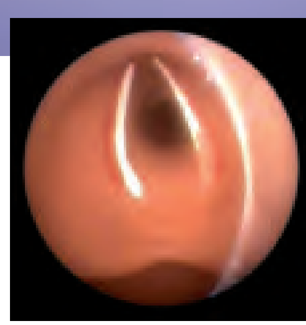
BONFILS **Retromolar Intubation Endoscopes**

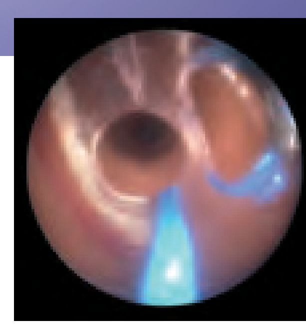
Eyepiece Versions

The expert instrument for multiple applications in airway management combines technical sophistication with utmost reliability

Unexpected difficult airways are always a challenge in airway management. With the BONFILS intubation endoscope and its versatile intubation techniques, this situation can be brought back to a controlled status. The endotracheal tube is guided into the trachea under direct vision and the possibility of simultaneous application of oxygen provides more safety. Moreover, KARL STORZ offers a solution to meet the most stringent hygiene requirements – the autoclavable SILVER LINE.





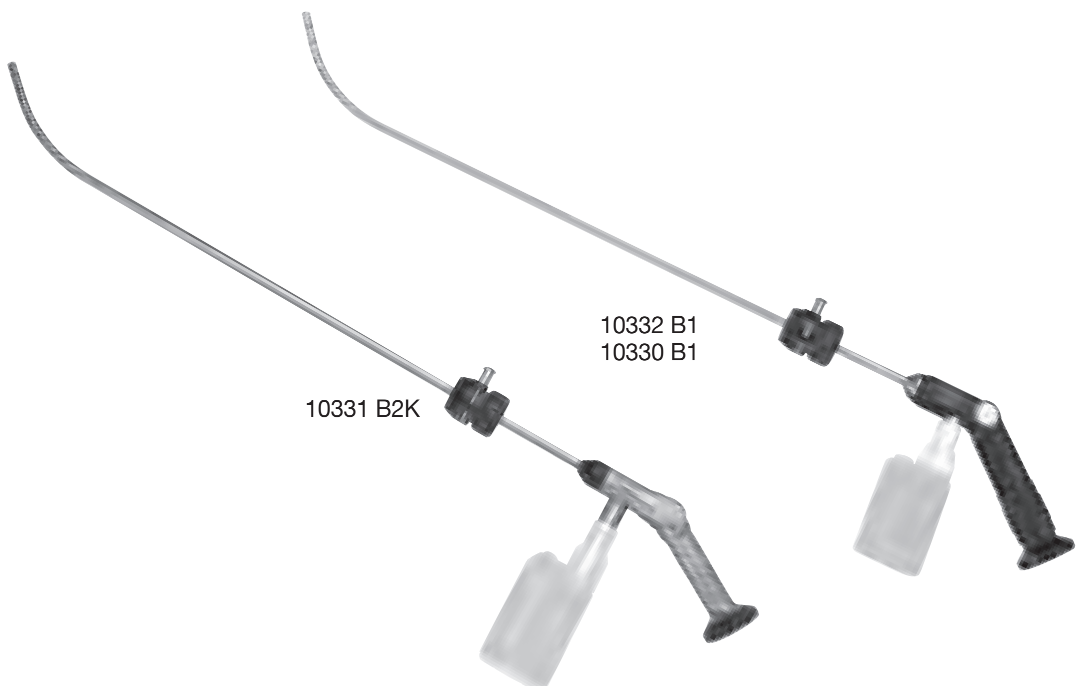


BONFILS **Retromolar Intubation Endoscopes**

Eyepiece Versions

Special Features:

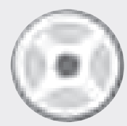
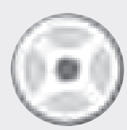
- **SILVER LINE – autoclavable**
- **Particularly suitable for the unexpected difficult airway**
- **Use in the case of minimal mouth opening (> 1 cm) possible**
- **Introduction of the tube under visualization: What you see is what you get!**
- **Continuous O_2 flow via tube adaptor between tube and instrument**
- **One-person intubation possible**
- **Connect and intubate – thanks to the mobile LED "Power of Light" light source**
- **Quick and easy cleaning**
- **Suitable and validated for the following low-temperature reprocessing methods up to bis max. 60 °C: manual/machine cleaning and disinfection, sterilization with Steris® AMSCO VPRO 1, Sterrad® (50S, 100S, 200S, NX, 100NX) and EtO gas; High-Level Disinfection (HLD) acc. to US standards**
- **Recommended for video-assisted intubation with C-CAM® to C-MAC® monitor**



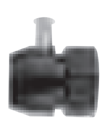
	10332 B1	BONFILS **Retromolar Intubation Endoscope,** outer diameter 3.5 mm, for ETT 4 – 5.5 mm, usable sheath length 35 cm, distal bending 40°, with movable eyepiece, including Tube Holder 10332 BA for tube fixation and O_2 application
NEW	10331 B2K	BONFILS **Retromolar Intubation Endoscope, autoclavable,** outer diameter 5 mm, for ETT > 5.5 mm, usable sheath length 40 cm, distal bending 40°, with movable eyepiece, with Tube Holder 10331 BA for tube fixation and O_2 application
	10330 B1	BONFILS **Retromolar Intubation Endoscope,** outer diameter 5 mm, for ETT > 5.5 mm, usable sheath length 40 cm, distal bending 40°, working channel diameter 1.2 mm, including Tube Holder 10331 BA for tube fixation and O_2 application

BONFILS **Retromolar Intubation Endoscopes**

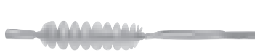
Eyepiece Versions

Intubation Endoscopes	Order No. Eyepiece		Distal bending
BONFILS **3.5 x 35**	10332 B1		
BONFILS **5 x 40**	10330 B1		
BONFILS **5 x 40**	10331 B2K		

Accessories included in delivery:



10332 BA/10331 BA



27651 AE

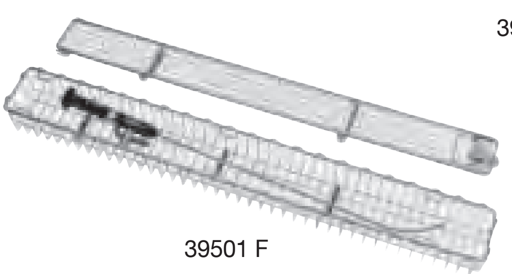
27677 BM	**Case,** internal dimensions (w x d x h): 490 x 290 x 85 mm
27677 C	**Plastic Case,** without inserts, internal dimensions (w x d x h): 480 x 285 x 80 mm
10332 BA	**Tube Holder for ETT,** with O_2 application connection, inner diameter 3.5 mm
10331 BA	**Tube Holder,** inner diameter 5 mm
27651 AE	**Cleaning Brush,** for Intubation Endoscope 10330 B1

BONFILS **Retromolar Intubation Endoscopes**

Eyepiece Versions

Angle of view	Working length	Total length	Working channel diameter	Distal tip outer diamter	Recommended ETT diameter as of*	Accessories (included in delivery)		
						Case	Tube Holder	Cleaning Brush
90°	35 cm	52 cm	–	3.5 mm	4 mm	27677 BM	10332 BA	–
110°	40 cm	52 cm	1.2 mm	5 mm	5.5 mm	27677 C	10331 BA	27651 AE
110°	40 cm	54 cm	–	5 mm	5.5 mm	27677 BM	10331 BA	–

Optional Accessories:



39501 F

39501 F

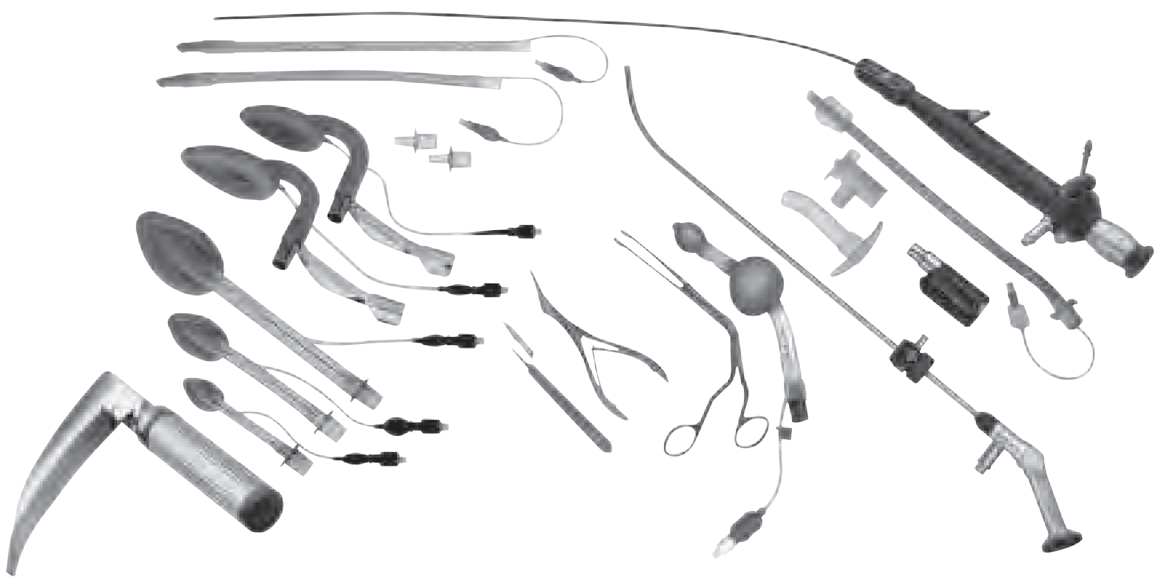
Wire Tray for Cleaning, Sterilization and Storage of one rigid **BONFILS endoscope,** including holder for light post adaptors, silicone telescope holders and lid, external dimensions (w x d x h): 570 x 80 x 52 mm

* **Please note that the accuracy of the ETT diameter may vary depending on the manufacturer's quality.**

LIPP/GOLECKI **Airway Management Set**

Basic Set

Recommended Set for Difficult and Standard Intubation



11300 B3 LIPP/GOLECKI **Airway Management Set,** for the difficult airway including:

Intubation Fiberscope, 3.7 mm x 65 cm
BONFILS **Retromolar Intubation Endoscope,** 5 x 40, **autoclavable**
Battery Light Source LED for Endoscopes
Mask Adaption "MAINZ Adaptor", blue, package of 5
Laryngeal Tube, size 4
Laryngeal Tube, size 3
Spiral Tube, size 6, for single use
Bronchoscope Insertion Tube, size 4
Laryngeal Mask, standard, reusable, size 1
Laryngeal Mask, standard, reusable, size 2
Laryngeal Mask, standard, reusable, size 4
Intubation Laryngeal Mask, reusable, size 3
Intubation Laryngeal Mask, reusable, size 4
Laryngeal Mask Tube, diameter 7 mm
Laryngeal Mask Tube, diameter 7.5 mm
LMA Tube Stabilizer
MAGILL **Forceps,** length 25 cm
Scalpel, for single use, package of 10
COTTLE **Nasal Speculum,** blade length 55 mm, length 13 cm
DÖRGES **Emergency Laryngoscope Blade,** cold light, universal size
Handle Sleeve, ISO 7376
Battery Insert, with 2 Batteries 121306 S and Xenon Lamp 8546 XA
Case

Intubation Set -C22-, ULM **Model** *NEW*

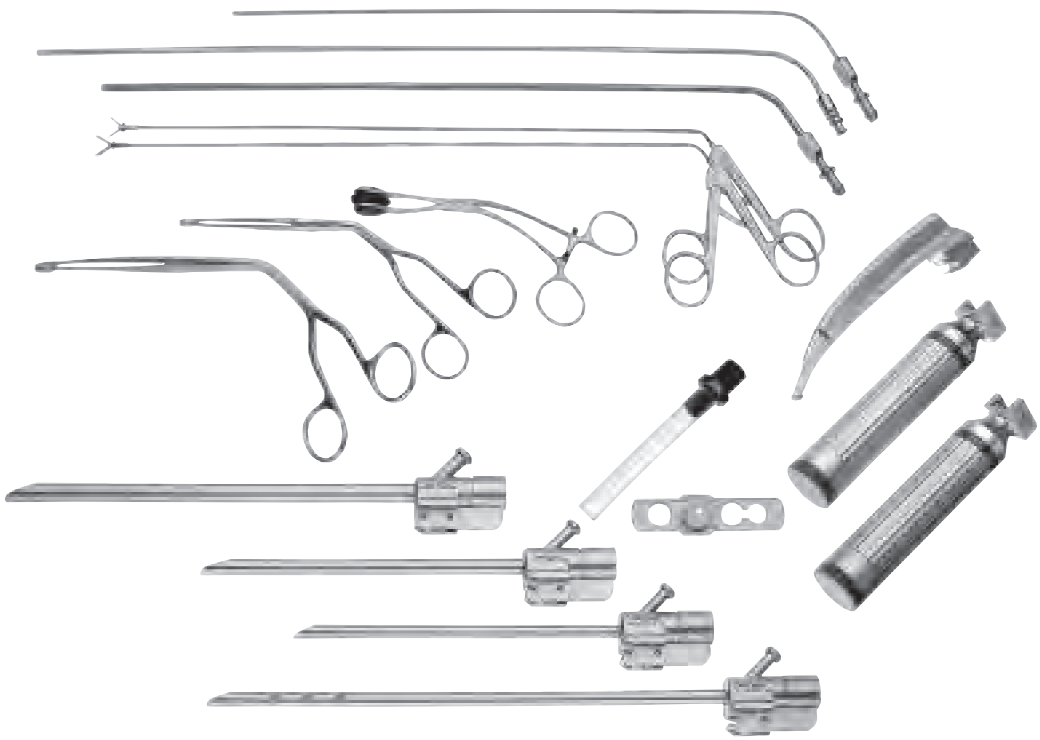
Basic Set

8400 B **Intubation Set -C22-,** ULM model
including:
BOEDEKER-DÖRGES **C-MAC® Video Laryngoscope,** MAC #3
BOEDEKER-DÖRGES **C-MAC® Video Laryngoscope,** MAC #4
C-MAC® Video Laryngoscope D-BLADE
C-MAC® Pocket Monitor Set
Charging Unit, for C-MAC® pocket monitor
Protective Cap
Handle Sleeve, ISO 7376
DÖRGES **Emergency Laryngoscope Blade,** cold light
Battery Insert Set LED, with cap
Bag for Intubation Set -C22-, ULM model
MAGILL **Forceps,** modified by BOEDEKER

8402 YE **Bag for Ulm Intubation Set -C22-,** made of water-resistant and sturdy material, washable, including two compartments with several holding facilities for C-MAC® video laryngoscope blades with C-MAC® pocket monitor and conventional laryngoscopes, for use with C-MAC® Pocket Monitor 8401 XD, C-MAC® video laryngoscopes and conventional laryngoscopes

Emergency Tracheobronchoscopy Set
Basic Set

Recommended Set for Difficult and Standard Intubation



10330 F **Emergency Tracheoscope Set**
including:
Emergency Bronchoscope, size 6, length 30 cm
Emergency Tracheoscope, size 9, length 25 cm
Emergency Tracheoscope, size 7, length 20 cm
Emergency Tracheoscope, size 5, length 20 cm
FLUVOG **Adaptor**
Adaptor for Ventilation
DÖRGES **Emergency Laryngoscope Blade,** cold light, universal size
2x **Handle Sleeve,** ISO 7376
2x **Battery Insert,** with 2 Batteries 121306 S and Xenon Lamp 8546 XA
Xenon Lamp, package of 6
Forceps, for peanuts and soft foreign bodies
Forceps, alligator, for hard foreign bodies
MAGILL **Forceps,** length 20 cm
MAGILL **Forceps,** length 25 cm
YOUNG **Tongue Seizing Forceps**
Suction Tube, diameter 3 mm, length 35 cm
Suction Tube, diameter 4 mm, length 35 cm
Suction Tube, diameter 5.5 mm, length 35 cm
Case

Battery Light Source LED BRITE LITE

Accessories for Intubation Fiberscopes and Endoscopes

Special Features:

- **Battery light source with extremely high light intensity >100 lm / > 150 klx**
- **Available as battery and rechargeable version**
- **Absolute white light due to LED technology**
- **Special light focus allows optimal light adjustment at the endoscope connector**
- **LED provides up to 50,000 hours lifetime**
- **Burning time of 120 min**
- **Waterproof, fully immersible for cleaning and disinfection (11301 D1/D3)**

11301 D1/D3/DE/DF

11301 DG

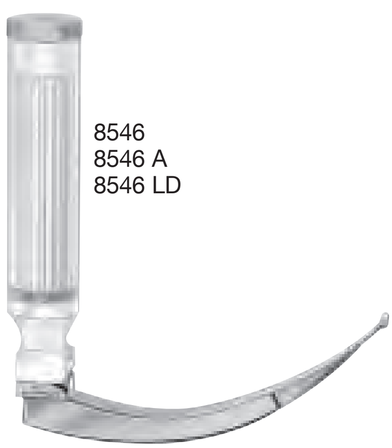
11301 D1	**Battery Light Source LED for Endoscopes,** with fine screw thread, brightness > 100 lm / > 150 klx, burning time > 120 min, weight approx. 150 g, waterproof and fully immersible for manual cleaning and disinfection, with 2 Photo Batteries 121306 P
11301 D3	**Same,** with coarse thread
121306 P	**Photo Battery,** lithium, 3 V, CR 123 A
11301 DE	**Battery Light Source LED for Endoscopes,** rechargeable, with click connection, brightness > 110 lm / >150 klx, color temperature 5500 K, lithium-ion batteries, charging time 60 min, burning time at 100% brightness 40 min, weight approx. 150 g ready for use, **suitable for wipe disinfection**
11301 DF	**Same,** with fast screw thread
11301 DG	**Charging Unit,** for 11301 DE/11301 DF, for two LED battery light sources, with fixed integrated power supply and adaptor for EU, UK, USA and Australia, power supply 110 – 240 VAC, 50/60 Hz, **suitable for wipe disinfection**
11301 DH	**Holder,** for Charging Units 11301 DG, 8546 LE and 8401 XDL

MACINTOSH **Laryngoscope Blades**

Cold Light, with Replaceable Fiber Optic Light Carrier

Special Features:

- **KARL STORZ blades and handles meet the highest cleaning and hygienic standards**
- **Chromium-plating gives the laryngoscope blades a compact, smooth surface; edges are rounded, thus preventing the formation of microcracks, fission or sharp edges which can harbour germs**
- **Handles are not knurled (problematic concerning hygiene), instead have an ergonomic shape and smooth surface.**
- **Handles can be supplied with LED "BRITE LITE" power system with > 50.000 lux and Li-Ion rechargeable batteries.**
- **The KARL STORZ laryngoscope blades are the only such products currently commercially available that are autoclavable and show no noticeable reduction in light intensity, even after several hundred cleaning cycles**.**
- **The Xenon lamps in the fiberoptic light carriers generate a neutral white light which is 30 – 40% brighter than standard halogen light.**
- **Laryngoscopy blades and handles comply with the ISO 7376 standard.**
- **On request, additional markings can be etched on the laryngoscope/handle free-of-charge (such as, e.g., "1-83-2/Case" or „Christoph 77/Rucksack")**



8546
8546 A
8546 LD

8541 AA-E

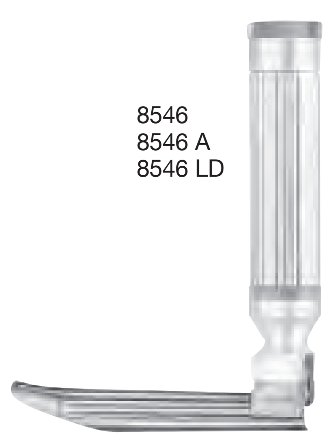
**) MJL BUCX, HM de GAST, J VELDHUIS, LH HASSING, A MEULEMANS, A KAMMEYER: The effect of mechanical cleaning and thermal disinfection on light intensity provided by fibrelight Macintosh laryngoscopes. Anaesthesia 58: 5, 461-465 (2003).

8541 AA	MACINTOSH **Laryngoscope Blade,** size 5
8541 A	**Same,** size 4
8541 B	**Same,** size 3
8541 C	**Same,** size 2
8541 D	**Same,** size 1
8541 E	**Same,** size 0

MILLER **Laryngoscope Blades**

Cold Light, Fiber Optic Light Carrier Incorporated

8537 A	MILLER **Laryngoscope Blade,** size 4
8537 B	**Same,** size 3
8537 C	**Same,** size 2
8537 D	**Same,** size 1
8537 E	**Same,** size 0



8546
8546 A
8546 LD

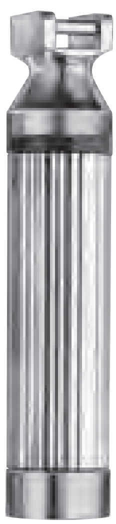
8537 A-E

Handles with LED Light Source

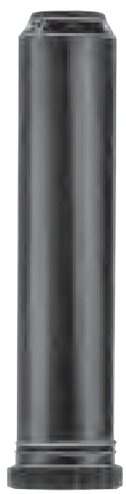
for Cold Light Laryngoscope Blades

Special Features:

- **Rechargeable lithium-ion batteries**
- **Extremely bright LED of more than 50 lm/> 100 klx**
- **Absolute white light due to LED technology (5500 K)**
- **Small handle with photo battery**
- **Special lens system allows optimal light adjustment at the blade connector**
- **LED provides a lifetime of more than 50,000 hours**
- **Burning time up to 240 min at 100% brightness**
- **Charging via inductive technology**
- **ISO 7376 compatible**



8546



8546 LD1

8549 LDX

8548

8548 LDX1

8546 — **Handle Sleeve,** ISO 7376, **autoclavable,** length 12 cm, for use with Battery Inserts 8546 A, 8546 LD, 8549 LD and cold light laryngoscopes

8546 LD1 — **Battery Insert, rechargeable,** length 12 cm, for Handle Sleeve 8546, **with high-power LED,** 56 lm/> 100 klx, lithium-ion battery insert, burning time at 100% brightness 240 min, charging via Inductive Charging Unit 8546 LE

NEW 8549 LDX — **Battery Insert Set LED,** length 12 cm, for Handle Sleeve 8546 and cold light laryngoscopes, **with high-power LED,** > 56 lm/ >100 klx, burning time at 100% brightness > 120 min

including:

Battery Insert, high-power LED

2x **Battery,** Mignon-Cell, LR 06, 1.5 V

Cap

8548 — **Handle Sleeve,** ISO 7376, length 6 cm, **autoclavable,** for use with Battery Insert Set 8548 LDX

8548 LDX1 — **Battery Insert Set,** length 6 cm, for Handle Sleeve 8548, **with high-power LED,** > 56 lm/> 100 klx, burning time at 100% brightness > 120 min

including:

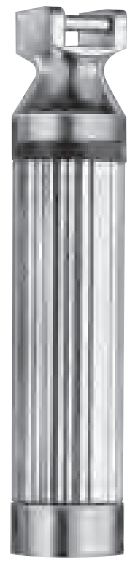
Battery Insert, high-power LED

Photo Battery, CR 123 A

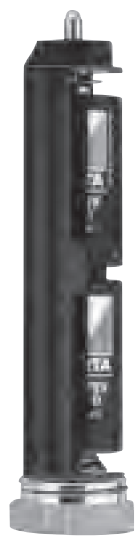
Cap

Handles with Xenon Light Source

for Cold Light Laryngoscope Blades



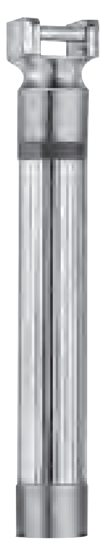
8546



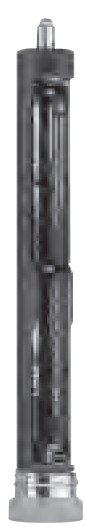
8546 A

8546	**Handle Sleeve,** ISO 7376, **autoclavable,** length 12 cm, for use with Battery Inserts 8546 A, 8546 LD, 8549 LD and cold light laryngoscopes
8546 A	**Battery Insert,** length 12 cm, with 2 Batteries 121306 S and Xenon Lamp 8546 XA
121306 S	**Batteries,** Baby-Cell, LR 14, for Battery Inserts 8544 A and 8546 A, package of 2
8546 XC	**Xenon Lamp,** 2.5 V, for Battery Inserts 8546 A, 8547 A and 8547 B, package of 6

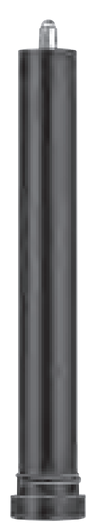
Especially suitable for use with blades sizes 0 and 1



8547



8547 A



8547 B

8547	**Handle Sleeve,** ISO 7376, length 12 cm, **autoclavable,** for use with Battery Inserts 8547 A and 8547 B
8547 A	**Battery Insert,** length 12 cm, including 2 Batteries 121306 KS and Xenon Lamp 8546 XA
121306 KS	**Batteries,** Mignon-Cell, LR 06, 2 Batteries 121306 K, for Battery Inserts 8545 A, 8547 A and Battery Insert Set High-Power LED 8549 LD
8547 B	**Rechargeable Battery Insert,** length 12 cm, for Handle Sleeve 8547, with Xenon Lamp 8546 XA, charging via Inductive Charging Unit 8546 LE
8546 XC	**Xenon Lamp,** 2.5 V, for Battery Inserts 8546 A, 8547 A and 8547 B, package of 6

Inductive Battery Charger

for rechargeable Laryngoscope Handles

Special features:

- **No open contacts**
- **No corrosion and contact problems**
- **No voltage peaks**
- **Batteries can be charged with or without handle sleeve, sterile packaging**
- **For use with LED handles**
- **Compatible with previous models**

8546 LE

8546 LE	**Inductive Charging Unit,** for two battery inserts (8546 LD, 8544 B, 8545 B, 8547 B), with fully integrated mains adaptor and power adaptor for EU, UK, USA and Australia, power supply 110 – 240 VAC, 50/60 Hz, suitable for wipe disinfection
8546 R	**Reduction Sleeve,** for Battery Inserts 8545 B and 8547 B, only
11301 DH	**Holder,** for Charging Units 11301 DG and 8546 LE

Notes: