



## Annotated Bibliography

The annotated VBM Bibliography gives you an overview of research results and publications on the following topics. Should you require additional references, please do not hesitate to contact the VBM team.

Laryngeal Tube	Page 2 – 5
Cuff Pressure Management	Page 6 – 8
Intubation Aids	Page 9 – 11
Cricothyrotomy	Page 12 – 14
Pelvic Sling	Page 15 – 17
Tourniquet	Page 18 – 19

# / Laryngeal Tube

## Introduction

The Laryngeal Tube was introduced to the market in 1999. Over the years, the Laryngeal Tube has undergone many changes. The current model of the LTS-D was launched in 2014. All sizes have a drain tube and thus make the LTS-D a 2nd generation supraglottic airway device. The two cuffs of the LTS-D have shown in various studies that they can achieve high leakage pressures. This has made the Laryngeal Tube a valuable aid in aerosol reduction. In combination with a breathing filter the LTS-D produced the most effective aerosol reduction in a study. If the Laryngeal Tube is used in the context of cardiopulmonary resuscitation, the tube can be inserted without interrupting chest compressions. After successful placement, chest compressions can be performed without interruptions, which leads to a reduction of the so-called "no-flow time".

## Overview Paper

*C.H.R. Wiese, "Tipps und Tricks zum Larynx-Tubus", Rettungsmagazin, Juli/August 2020, pp 46-50.*

This overview paper has presented important facts about the LTS-D, as well as its advantages and disadvantages in detail. The author sees as advantages, e. g. the simple insertion that can be carried out without any aids. The atraumatic insertion when used correctly is also considered an advantage. In addition, the Laryngeal Tube has a large drain tube (18 Fr for sizes 3, 4 and 5) and the stomach can thus be emptied quickly. This leads to an optimisation of the patient's oxygenation. The correct use of the LTS-D and its monitoring after placement was described as well as the importance of cuff pressure management to avoid possible complications. The author described the re-intubation to an endotracheal tube with the Laryngeal Tube in place as a unique feature.

## Cardiopulmonary Resuscitation

*C.H.R. Wiese et al., "Influence of airway management strategy on "no-flow-time" during an "Advanced life support course" for intensive care nurses – A single rescuer resuscitation manikin study" BMC Emerg Med, vol. 8, 4, 2008.*

Wiese and colleagues were able to show with their work that the so-called "no-flow time" in special training scenarios on the resuscitation manikin could be significantly reduced by using the Laryngeal Tube compared to bag-mask ventilation. The time requirements of the European Resuscitation Council (ERC) were met 96% of the time when using the Laryngeal Tube compared to only 30% when using bag-mask ventilation. In a subjective evaluation, the participants of the study preferred ventilation via the Laryngeal Tube vs. bag-mask ventilation.

*H. Wang et al., "Effect of a Strategy of Initial Laryngeal Tube Insertion vs. Endotracheal Intubation on 72-Hour Survival in Adults With Out-of-Hospital Cardiac Arrest – A Randomized Clinical Trial" JAMA, 320(8) pp. 769-778, 2018.*

The authors of this multicentre study investigated the initial success in securing the airway and looked at 72-hour survival in relation to the method used to secure the airway. A total of 3000 patients were included in the primary analysis. The use of the Laryngeal Tube versus endotracheal intubation was compared. The first attempt success rate was 90.3% for the Laryngeal Tube versus 51.6% for endotracheal intubation. The Laryngeal Tube also showed a clear superiority in 72-hour survival. The rate here was 18.3% of patients compared to 15.4% of patients ventilated via an endotracheal tube.

*M. Maignan et al., "Impact of laryngeal tube use on chest compression fraction during out-of-hospital cardiac arrest. A prospective alternate month study" Resuscitation, vol. 93, pp. 113-117, 2015.*

This prospective multicentre study investigated the "Chest Compression Fraction = CCF", i.e. the time (in percent) in which chest compressions are performed during resuscitation, with regard to possible changes in CCF when using a Laryngeal Tube or bag-mask ventilation. The use of the Laryngeal Tube showed a CCF of 75% compared to 59% with bag-mask ventilation.

### Pediatric Patients

*B. Scheller et al., "Laryngeal tube suction II for difficult airway management in neonates and small infants" Resuscitation, vol. 80, pp. 805-810, 2009.*

In this study, the LTS II was observed in 10 cases of securing the airway in neonates and infants < 6 months. The LTS II was inserted with a 100% success rate, especially when other airway securing techniques failed. The drainage tube was described as a potential advantage, allowing relief of the stomach. The authors recommend the LTS II as a first choice device when securing the airway by direct laryngoscopy has failed or is difficult due to anatomical malformations.

*S.G. Chandrakar et al., "Comparison of the laryngeal tube suction II and proSeal LMA in pediatric patients, undergoing elective surgery" Saudi Journal of Anesthesia, vol. 49, no. 3, pp. 152-161, 2017.*

Chandrakar and colleagues investigated the use of the Laryngeal Tube (LTS II) and the LMA ProSeal™ (PLMA) in planned surgical procedures in children aged 2-5 years in a randomised, prospective study. The success rate for the first attempt was the same for both SADs at 90%. However, the oropharyngeal leakage pressure (OLP) was significantly higher for the LTS II than for the PLMA, at 25.18 cmH<sub>2</sub>O. The authors described the LTS II as a safe alternative for short surgical procedures and the better device due to the higher oropharyngeal leakage pressure.

### Traumatological Patients

*S.G. Weilbacher et al., "Konventionelle Intubation und Larynxtracheotomie bei Halswirbelsäuleninstabilität - Änderungen der Dural-sackweite am unfixierten humanen Körperspender" Der Anaesthesist, vol. 49, no. 3, pp. 152-161, 2019.*

This paper compared conventional intubation vs. the Laryngeal Tube for securing the airway in cases of cervical spine instability. The study was performed on 6 unfixed human cadaver models. The orotracheal intubation was performed using a Macintosh blade size 3, a commercial stylet and a Magill endotracheal tube ID 7.5 mm. The Laryngeal Tube used was the LTS-D, size 4 and was inserted according to the manufacturer's recommendations. In the unfixed human cadaver model with combined atlantooccipital dislocation and atlantoaxial instability, insertion of the Laryngeal Tube resulted in a smaller change in dural sac width compared to conventional intubation and could therefore also be advantageous in the living patient.

*J. Schauble et al., "Larynxtracheotomie beim Traumapatienten - Geeignetes Hilfsmittel für die primäre Atemwegssicherung und Ventilation bei Erstversorgung und RTH-Transport?" Notfall Rettungsmed, vol. 6, no.10, pp. 432-434, 2007.*

This case report impressively showed that the Laryngeal Tube is a very good aid in the management of the difficult airway and made adequate ventilation of the patient possible without any problems.

### Anatomical / Physiological Characteristics

H.V. Genzwuerker et al., "The Laryngeal Tube: A New Adjunct For Airway Management" *Prehospital Emergency Care*, vol. 4, pp. 168-172, 2000.

A prototype of the Laryngeal Tube (LT) was tested in this study. For this purpose, the LT was inserted 10 times each into an ALS manikin by 50 doctors and nurses. In 478 cases (95.6%), correct placement and sufficient ventilation were achieved on the first attempt. The average time for correct placement was 27.15 seconds. The LT is placed blindly and requires a minimum mouth opening of only 23 millimetres.

S.G. Eismann et al., "Impact of the laryngeal tube as supraglottic airway device on blood flow of the internal carotid artery in patients undergoing general anaesthesia" *Resuscitation*, vol. 138, pp. 141-145, 2019.

The authors of this study investigated the influence of ventilation via a Laryngeal Tube on blood flow in the internal carotid artery. A total of 21 patients were included in the study. The authors found no impairment of blood flow in the internal carotid artery.

### Leakage Pressure / Cuff Pressure

S.G. Russo et al., "Erweiterte Indikationen der Larynxmaske - Wo liegen die Limitationen?," *AINS - Anästhesiologie • Intensivmedizin • Notfallmedizin • Schmerztherapie*, vol. 49, no. 3, pp. 152-161, 2014.

This paper investigated the extended indications of laryngeal masks. The leakage pressures of supraglottic airway devices available on the market were also considered. The Laryngeal Tube LTS-D shows the highest oropharyngeal leakage pressure (OLP) as well as the highest hypopharyngeal leakage pressure (HLP). OLP and HLP are responsible for sealing through the supraglottic airway aids towards oral/nasal and towards the gastrointestinal tract, respectively.

M. Kriege et al., "Evaluation of the optimal cuff volume and cuff pressure of the revised laryngeal tube "LTS-D" in surgical patients", *BMC Anesthesiology*, vol. 17, no. 19, pp. 17-19, 2017.

This prospective study investigated the optimal cuff pressure of the LTS-D in the context of short, ophthalmological surgery. A total of 60 patients were included in this study. After insertion, the cuffs of the LTS-D were blocked according to the manufacturer's instructions with the supplied 100 ml syringe and the cuff pressure was adjusted afterwards with a cuff pressure gauge. A cuff pressure < 60 cmH<sub>2</sub>O resulted in an adequate seal and made sufficient ventilation possible. If the cuff pressure is set to < 50 cmH<sub>2</sub>O, intolerable leakage is possible. After blocking the cuffs with the supplied 100 ml syringe, the cuff pressure must be adjusted to the recommended value (< 60 cmH<sub>2</sub>O) with a cuff pressure gauge.

### Re-intubation

R. Schalk et al., "Umintubation mithilfe des C-MAC-Videolaryngoskops - Durchführung bei Patienten mit schwierigem Atemweg und einliegendem Larynx-tubus" *Der Anaesthesist*, vol. 61, no. 9, pp. 777-782, 2012.

In this paper, re-intubation to an endotracheal tube with the Laryngeal Tube in place was described in 20 patients. The Laryngeal Tube was unblocked after sufficient oxygenation and moved to the left corner of the mouth. Laryngoscopy was performed using a videolaryngoscope, and the tube was inserted into the trachea using an intubation aid. The Laryngeal Tube was removed only after successful placement and positional control in accordance with general guidelines with a positive result. The authors described a problem-free re-intubation in 95% of the patient collective.

*L. Klein et al., "Technique for Exchanging the King Laryngeal Tube for an Endotracheal Tube" Academic Emergency Medicine, vol.23, no. 3, p. e2, 2016.*

This paper describes another technique of re-intubation from the Laryngeal Tube to the endotracheal tube. The authors used a videolaryngoscope and an intubation aid for the re-intubation. In contrast to other techniques, visualisation using a videolaryngoscope is performed with the Laryngeal Tube in place with inflated cuffs. Only when the glottis became visible, the cuffs of the Laryngeal Tube were deflated and the trachea was intubated with the intubation aid. The endotracheal tube, which was railroaded on the intubation aid, was then inserted into the trachea via this. The authors describe the great advantage of this method as the possibility to quickly reinflate the cuffs of the Laryngeal Tube and to ventilate the patient again via this if the attempt of endotracheal intubation failed. The re-intubations were performed with different videolaryngoscopes and with Macintosh- and hyperangulated blades.

In addition to this technical paper, a video demonstrating this technique is freely available.

### Infectious Diseases / Aerosol Reduction

*M. Ott et al., "Exploration of strategies to reduce aerosol-spread during chest compressions: A simulation and cadaver model" Resuscitation, vol. 152, pp. 192-198, 2020.*

The Corona pandemic prompted the authors of this study to investigate how effective aerosol reduction can be achieved during airway protection and subsequent ventilation in order to minimise the risk of infection for the personnel deployed. Using a modified manikin as well as body donors, the authors were able to show that the Laryngeal Tube LTS-D in combination with a breathing filter already attached before insertion, achieved the most effective aerosol reduction. This is certainly an important finding not only in the context of the Corona pandemic. Besides SARS-CoV-2, there are other human pathogens that are transmitted by aerosols or droplets.

### Education and Training

*C. Jänig et al., "Vergleich des Fertigungsniveaus in der Anwendung des Larynx-tubus und der Beutel-Masken-Beatmung durch Pflegekräfte im 1-Jahres-Intervall nach Erstausbildung", Notfall Rettungsmed, 22, pp. 394-401, 2019.*

The authors trained over 300 nurses inexperienced in securing the airway in the correct use of the Laryngeal Tube and bag-mask ventilation as part of a BLS training course. After one year, both techniques were used again. This time, however, without prior demonstration or theoretical instruction. Placement success and time as well as application problems were recorded by means of a data collection questionnaire. The results showed that after one year, the use of the Laryngeal Tube had a lower success rate and required more time to place. The authors concluded that exercises with the Laryngeal Tube should ideally be performed every six months.

*C. Länkimäki et al., "Feasibility of a laryngeal tube for airway management during cardiac arrest by first responders", Resuscitation, 84, pp. 446-449, 2013.*

The authors of this paper trained 300 first responders (volunteer firefighters) in the use of the Laryngeal Tube in out-of-hospital cardiac arrest. The training consisted of a 30-minute lecture on basic airway management and a movie on the correct use of the Laryngeal Tube. This was followed by skills training on an airway manikin. Emergency physicians and paramedics supervised the training. Each participant had to demonstrate at least two successful applications on the manikin. During the subsequent 36-month study period, the Laryngeal Tube was used in 64 cases. In 46 cases, placement was successful on the first attempt, and in another 13 cases on the second attempt. The mean time for correct insertion was 23.1 s. Based on the results, the authors concluded that the Laryngeal Tube can be used by first responders after theoretical and practical training and that it enables adequate ventilation.

# / Cuff Pressure Management

## Introduction

VBM has been dedicated to cuff pressure management since 1981. With the Control Inflator, the first cuff pressure gauge from VBM came onto the market. In the last 40 years, the product range of devices for cuff pressure management has been continuously expanded and optimised. Today, there are different cuff pressure gauges as well as an electronic Cuff Controller for continuous monitoring and maintenance of the recommended cuff pressure for the respective airway protection. Unfortunately, cuff pressure management is not given the necessary attention in the prehospital as well as in the hospital. Hagberg and Benumof, in their book "Hagberg and Benumof's Airway Management", refer to cuff pressure as the most neglected parameter in monitoring of an artificial airway. There is no better way to describe the problem of cuff pressure management.

## Overview Paper

*C.H.R. Wiese, T. Semmel, "Messungen des Cuffdrucks", Rettungsmagazin, März/April 2021, pp 50-54.*

The authors of this overview paper began by giving an overview of the data on cuff pressure management. Already more than 50 years ago, the first papers were published that drew attention to the problem of excessively high cuff pressures with endotracheal tubes. According to the authors, massively swollen tongues after the use of the Laryngeal Tube led to increased attention to cuff pressure management. In addition to a brief description of the anatomy of the affected structures, the authors described consequences of excessively high cuff pressures. The review ends with a presentation of comprehensive cuff pressure management.

*R. Schalk, "Präklinische Sorgfaltspflicht beim Cuffdruckmanagement" Med Klin Intensivmed Notfmed, vol. 111, pp. 737-742, 2016.*

Triggered by a series of publications on problems in airway management after the use of the Laryngeal Tube, the author dealt in his review with the problems arising from incorrect cuff pressure management. In addition to anatomy and physiology, the pathophysiology was also described. Different types of cuffs and materials were described as well as the equipment available on the market for monitoring and adjusting the cuff pressure. In addition, clear advice was given on the correct management of cuff pressure.

## Physiology / Pathophysiology / Pathology

*R. D. Seegobin, G. L. van Hasselt, "Endotracheal cuff pressure and tracheal mucosal blood flow: endoscopic study of effects of four large volume cuffs" British Medical Journal, vol. 288, pp. 965-968, 1984.*

As early as 1984, the authors investigated the influence of the cuff pressure of endotracheal tubes on the perfusion of the tracheal mucosa. A total of 40 patients were examined. Endotracheal tubes from different manufacturers with an inner diameter of 8.5 mm were used for this purpose. At cuff pressures  $\geq 30$  cmH<sub>2</sub>O, the investigators found a deterioration in the perfusion of the tracheal mucosa; at cuff pressures  $\geq 50$  cmH<sub>2</sub>O, there was no more perfusion.

*J. Brimacombe et al., "Pharyngeal Mucosal Pressure and Perfusion - A Fiberoptic Evaluation of the Posterior Pharynx in Anesthetized Adult Patients with a Modified Cuffed Oropharyngeal Airway" Anesthesiology, vol. 91 pp. 1661-1665, 1999.*

The authors of this paper investigated the influence of blood flow to the pharyngeal mucosa after insertion of pharyngeal airway devices. A modified oropharyngeal airway with cuff (COPA tube) was used for this purpose. The results of the study were pressure measurements and the acquisition of digital images using fibre optics. The authors found a deterioration of mucosal blood flow in the posterior pharynx as soon as a mucosal pressure of 34 cmH<sub>2</sub>O was present. This pressure correlated with a COPA cuff pressure of 40 cmH<sub>2</sub>O.

V. Thiruvengkatarajan et al., "Cranial nerve injuries with supraglottic airway devices: a systematic review of published case reports and series" *Anaesthesia*, vol. 70 pp. 344-359, 2015.

In this paper, case reports or case series on cranial nerve injuries due to the use of supraglottic airway devices were systematically reviewed. Common complications after insertion of a supraglottic airway device are sore throat, mucosal lesions, hoarseness and dysphagia. Cranial nerve injuries are less frequent but associated with more severe complications. Causes include incorrectly selected sizes of supraglottic airway device, incorrect placement, poor insertion technique, patient positioning and excessive cuff pressure. Injury to the recurrent laryngeal nerve resulted in high morbidity. In the worst case, a tracheostomy became necessary.

### Cuff Pressure Monitoring

M. Hensel et al., "Digital palpation of the pilot balloon vs. continuous manometry for controlling the intracuff pressure in laryngeal mask airways" *Anaesthesia*, vol. 80, pp. 805-810, 2009.

This is one of many papers that have investigated the ability to determine the correct cuff pressure of airway devices using palpation. Like the other papers, this paper shows that it is impossible to determine the cuff pressure by palpation of the pilot balloon, regardless of training and professional experience. Participants in this study had cuff pressures more than double the intended values when palpation was used. The authors of this study concluded that the palpation method is not an alternative to the use of a manometer to determine the correct cuff pressure.

A. V. Fritz et al., "Detrimental Effects of Filling Laryngotracheal Airways To Excessive Pressure (DEFLATE-P): a quality improvement initiative" *BMC Anesthesiology*, vol. 20, pp. 1-6, 2020.

In order to determine how often postoperative complications occur due to the use of cuffed airway devices, the „DEFLATE-P“ initiative was launched. An educational programme was then developed and implemented. As part of the training programme, anaesthesia staff were made aware of complications caused by excessive cuff pressures and shown how to avoid them by using cuff pressure measuring devices. The use of cuff pressure monitors reduced the incidence of postoperative complications.

M. Hensel et al., "Kontinuierliche Cuff-Druck-Messung bei Larynxmaskennarkosen - Eine obligatorische Maßnahme zur Vermeidung postoperativer Komplikationen" *Anaesthesist*, vol. 65 pp. 346-352, 2016.

The authors of this study introduced continuous measurement of cuff pressure as mandatory monitoring for all laryngeal mask anaesthesia. The aim of the study was to investigate the influence of this measure. The necessary data were taken from the anaesthesia protocols and an additional postoperative questionnaire. This was also used to determine patient satisfaction with the anaesthetic procedure performed. Before the introduction of continuous cuff pressure measurement, 36% of the patients complained about postoperative complaints. With the use of continuous monitoring, this was only the case in 12% of patients. Based on the data from the study, the authors call for continuous cuff pressure measurement in all laryngeal mask anaesthesia.

### Ventilator-associated pneumonia (VAP)

L. Lorente, et al., "Continuous endotracheal tube cuff pressure control system protects against ventilator-associated pneumonia" *Critical Care*, vol. 18, pp. 1-8, 2014.

This prospective observational study compared the effect of continuous versus intermittent cuff pressure monitoring on the prevention of VAP in patients ventilated for more than 48 hours. Cuff pressure was monitored intermittently in 134 patients and continuously in 150 patients. Patients with continuous monitoring of cuff pressure and the use of an endotracheal tube with integrated subglottic suctioning were less likely to develop VAP. The authors of the study concluded that the use of continuous cuff pressure monitoring and a special endotracheal tube can help prevent the occurrence of VAP.

G. Asgarpur, M. Deja, "Infektionsprävention in der Intensivstation – die Top-5-Maßnahmen" *Krankenhaushygiene up2date*, vol. 12, no.3 pp. 239-257, 2017.

Respiratory infections caused by invasive ventilation are the most frequent cause of device-associated nosocomial infections. In order to contain this so-called ventilator-associated pneumonia (VAP), a bundle of measures was presented. In addition to scoring-guided analgesia to reduce the duration of ventilation, subglottic suctioning, aseptic mouth rinses and selective bowel decontamination in special patient groups, cuff pressure control is also recommended. Properly adjusted and monitored cuff pressure can prevent microaspirations.

Z. Wen, et al., "Is continuous better than intermittent control of tracheal cuff pressure? A meta-analysis" *Nursing in Critical Care*, vol. 24, no.2 pp. 76 - 82, 2019.

For this paper, a systematic meta-analysis of randomised controlled trials (RCTs) was conducted to assess intermittent and continuous cuff pressure measurement for the prevention of VAP. In the end, seven RCTs with a total of 970 ventilated patients could be included in the meta-analysis. The occurrence of VAP was less frequent in the included studies when the cuff pressure was measured continuously. There was no difference between intermittent and continuous cuff pressure measurement with regard to duration of ventilation, length of stay in the intensive care unit and mortality.

### Prehospital

J.H. Peters, N. Hoogerwerf, "Prehospital endotracheal intubation; need for routine cuff pressure measurement?" *Emerg Med J*, vol. 30, pp. 851-853, 2013.

The authors reviewed the HEMS database for cuff pressure measurements after prehospital intubation by paramedics. When patients were endotracheal intubated by ground ambulance staff, the cuff pressure of the endotracheal tube was not checked in any case. The reason for this is the lack of a cuff pressure measuring device on the ground-based rescue equipment. After the arrival of the rescue helicopter, the cuff pressure of the already intubated patients was checked by the staff of the helicopter. Only a very small number of the patients intubated by the ground ambulance staff had a cuff pressure of less than 30 cmH<sub>2</sub>O. Due to the potential danger of serious damage from too high a cuff pressure, but at the same time a simple and inexpensive measure to monitor the cuff pressure and set it to the correct value, the authors call for the routine use of cuff pressure measurement. For this purpose, they demand that the respective rescue vehicles be equipped with cuff pressure measuring devices.

Bassi M. et al., "Endotracheal Tube Intracuff Pressure During Helicopter Transport" *Annals of Emergency Medicine*, vol. 56, pp. 89-93.e1, 2010.

This study investigated the influence of different flight altitudes of a rescue helicopter on the cuff pressure of endotracheal tubes. Over a period of 12 months, the cuff pressure was measured and documented before the start of the helicopter and when the maximum flight altitude was reached. As the flight altitude increased, so did the cuff pressure. After reaching the cruising altitude of the helicopter, 98% of the 114 patients included in the study showed a cuff pressure  $\geq 30$  cmH<sub>2</sub>O, 72%  $\geq 50$  cmH<sub>2</sub>O and in 20% the cuff pressure was even  $\geq 80$  cmH<sub>2</sub>O. Based on these results, the authors call for the cuff pressure to be checked before and during the flight and to be adjusted accordingly.



# / Intubation Aids

## Introduction

Intubation devices have a long history. The first report on the successful use of a so-called “gum elastic bougie” for the care of a patient with a difficult airway was published in 1949 by Sir Robert Macintosh, the inventor of the laryngoscope blade named after him. The first industrially manufactured intubation aid came onto the market in 1973. Unfortunately, even in this field the terms to be used are not standardised, so that there are many names for intubation aids and some of them are also used synonymously. Therefore, it is not surprising if someone asks for an “Eschmann rod” or a “bougie”, but the aid has a completely different name. But they have one thing in common, they can all be very helpful in controlling a difficult airway.

## Guidelines

J.L. Apfelbaum et al., “2022 American Society of Anesthesiologists Practice Guide-lines for the Management of the Difficult Airway” *Anesthesiology*, vol. 136, pp. 31-81, 2022.

The current ASA guideline recommends the provision and use of intubation aids to better manage a difficult airway.

A. Timmermann et al., “German guideline for prehospital airway management - S1-Leitlinie: Prähospitales Atemwegsmanagement (Kurzfassung)” *Anästhesi Intensivmed*, vol. 60, pp. 316-336, 2019.

The S1 german guideline recommends the use of intubation aids when using videolaryngoscopy and strongly curved videolaryngoscope blades. The intubation aids should be adaptable to the curvature of the blades.

A. Higgs et al., “Guidelines for the management of tracheal intubation in critically ill adults” *British Journal of Anaesthesia*, vol. 120 pp. 323-352, 2018.

The authors of this guideline recommend the use of an intubation aid if the view of the glottis is difficult (C&L 2b or 3a). Furthermore, the use of intubation aids is recommended when using videolaryngoscopes with hyperangulated blades. For a planned extubation, the authors recommend the use of a tube exchanger.

## “First-Pass Success”

C. Nkoulou et al., “Comparing S-Guide® and Gliderite® time to Assist Video laryngoscopic Intubation in Patients with Simulated Difficult Airways: A Single-Blinded Randomized Prospective Study” *Turkish Journal of Anaesthesiology & Reanimation*, vol. 450, pp. 86-93, 2022.

The authors of this randomised, prospective, single-blinded study compared the use of the S-Guide with that of the Gliderite (Verathon) in a simulated difficult airway scenario. A difficult airway was simulated in 50 patients using rigid cervical collar after obtaining informed consent. The airway was then secured using a videolaryngoscope and the randomised intubation aid. The time to glottic identification and the time to inflate the cuff of the endotracheal tube were the same for both intubation aids. When considering the total intubation time, the airway was secured on average 7 seconds faster in patients using the S-Guide. In addition, there was also less contact with the arytenoid cartilage when using the S-Guide.

*S. Jaber et al., "Effect of the use of an endotracheal tube and stylet versus an endotracheal tube alone on first-attempt intubation success: a multicentre, randomised clinical trial in 999 patients" Intensive Care Med, vol. 47, pp. 653-664, 2021.*

The authors of this randomised multicentre study hypothesised in advance that the use of intubation aids can increase the success rate for intubation on the first attempt. Thirty-two intensive care units participated in the study; allocation to the respective procedure was randomised. The first study objective was successful intubation on the first attempt using an intubation aid. The proportion of patients with complications related to endotracheal intubation was the second study objective, and serious complications such as trauma caused by endotracheal intubation were also investigated. A total of 999 patients were included in the study, 501 of whom were intubated using an intubation aid. In 78.2% of the patients, the first intubation attempt was successful. In patients intubated without an intubation aid, the first attempt was successful in only 71.5%. The complication rate due to endotracheal intubation was almost the same in both groups.

*B. Driver et al., "The Bougie and First-Pass Success in the Emergency Department" Annals of Emergency Medicine, vol. 70, pp. 473-478.e1, 2017.*

This retrospective observational study assessed intubation success on the first attempt using an intubation aid in an emergency department. A total of 543 cases were assessed. An intubation aid was used in 435 intubations. First attempt success with the use of an intubation aid was 95% compared to 86% success rate when no intubation aid was used. The authors conclude that the use of an intubation aid increases the success rate of the first intubation attempt and that the use of an intubation aid can be helpful in the emergency department.

### Pediatric Patients

*N. Komasa et al., "Utility of a Gum-Elastic Bougie for Difficult Airway Management in Infants: A Simulation-Based Crossover Analysis" BioMed Research, vol. 2015, pp. 1-5, 2015.*

This simulation-based crossover study investigated intubation success on the infant ALS simulator in different scenarios. Fifteen anaesthetists with more than 5 years of work experience participated in the study. The ALS simulator represented a 3-month-old infant. Intubations were performed using direct laryngoscopy and a size 1 Miller blade. The uncuffed endotracheal tube used had an internal diameter of 3.0 mm. The manikin was fixed to a table top with tape so that movement of the manikin through the laryngoscopy could be avoided. Participants had to secure the infant's airway using endotracheal intubation in three different scenarios. The results of the study led the authors to conclude that the use of an intubation aid can shorten intubation time and increase the success rate.

### Prehospital

*A.J. Latimer, et al., "Routine Use of a Bougie Improves First-Attempt Intubation Success in the Out-of-Hospital Setting" Annals of Emergency Medicine, vol. 77, pp. 296-304, 2021.*

This prospective observational study in a pre-post design compared the success rate for intubation on the first attempt 18 months before and 18 months after the introduction of a new SOP for endotracheal intubation by American paramedics using an intubation aid in the prehospital setting. During the control phase, 823 patients were intubated by paramedics, and during the intubation aid phase, 771 patients were intubated. An increase in the success rate of 7% could be demonstrated with the use of an intubation aid. A differentiated analysis of the documented Cormack & Lehane scores (C&L) showed even more significant increases in success rates, especially for C&L 3 and 4.

### Re-intubation

*K.W. Dodd et al., "Endotracheal intubation with the King Laryngeal Tube in situ using a video laryngoscopy and a bougie: A retrospective case series and cadaveric crossover study" The Journal of Emergency Medicine vol. 52, pp. 403-408, 2017.*

The authors of this study demonstrated that successful re-intubation from a Laryngeal Tube to an endotracheal tube using an intubation device with the Laryngeal Tube still in place is 100% possible on the first attempt.

### Case Reports

*M. Zuercher et al., "Combined use of Ventrain and S-Guide for Airway Management of Severe Subglottic Stenosis" Turkish Journal of Anaesthesiology & Reanimation, vol. 47, pp. 238-241, 2019.*

The authors of this case report impressively describe the life-saving use of the S-Guide in combination with the Ventrain® (Ventinova Medical) in a patient with severe tracheal stenosis. The patient had been complaining about increasing dyspnoea and shortness of breath during physical exertion for several months. Radiological and subsequent endoscopic examination diagnosed tracheal stenosis with a diameter of 7 mm over a length of 11 mm. The tracheal stenosis was located 95 mm above the carina. After placement of the S-Guide through the stenosis, the patient was ventilated through it using Ventrain® during the entire procedure.

*X. Combes et al., "Emergency gum elastic bougie-assisted tracheal intubation in four patients with upper airway distortion" CAN J ANESTH, vol. 51, pp. 1022-1024, 2004.*

The use of an intubation aid and the "hold-up technique" led to successful endotracheal intubation in four cases. In all patients, neck surgery (e.g. thyroidectomy) or a chemical burn in the pharynx had led to the subsequent occurrence of dyspnoea and a critically reduced oxygen saturation. A laryngoscopic view of the glottic structures was impossible and thus intubation attempts were unsuccessful. Only the use of intubation aids made successful reintubation possible..

# / Cricothyrotomy

## Introduction

„Cannot intubate – cannot oxygenate“ (CICO) situations occur when all efforts to oxygenate the patient using facemask, supraglottic airway device (SAD) and tracheal intubation have failed. Different techniques can be used to perform a cricothyrotomy. Which technique is used depends on the training and experience of the operator as well as the material available. Unfortunately, as in many other areas of medicine, the terminology regarding the different cricothyrotomy techniques is not standardised. A relatively new but already widely used abbreviation is eFONA. eFONA stands for „emergency Front Of Neck Access“. This term refers to emergency access at the front of the neck. This abbreviation is used for this annotated bibliography.

## Overview Paper

*T.M. Price, E.P. McCoy, "Emergency front of neck access in airway management", British Journal of Anaesthesia (Education), vol. 19(8), pp 246-253, 2019.*

This overview paper includes epidemiological data on emergency front-of-neck access (eFONA). It describes the anatomy, cricothyroid membrane identification techniques and basic access techniques. The approach is based on the Difficult Airway Society (DAS) algorithms, education and training follows the Vortex approach.

*S. Mohr, M. Göring, J. Knapp, "Notfallkoniometrie – chirurgisch oder doch Punkti-on?", Notfall Rettungsmed, vol. 22, pp. 111-123, 2019.*

German-language overview paper of cricothyrotomy. In addition to a brief look at the anatomical structures, various cricothyrotomy techniques (e.g. catheter-over-needle – Quicktrach II, Seldinger technique – Surgicric III) are described and compared. The procedure for the „rapid four-step technique“ is described step by step and illustrated in pictures. In addition, the authors give an overview of the ready-to-use emergency cricothyrotomy kits available on the market at the time of writing, sorted by technique.

*X. Onrubia, G. Frova, M. Sorbello, "Front of neck access to the airway: A narrative review", Trends in Anaesthesia and Critical Care, vol. 22, pp. 45-55, 2018.*

This comprehensive overview paper highlights the techniques, principles, problems and discussions surrounding the concept of access to the front of the neck. The anatomy itself, the identification of the anatomical landmarks, different techniques and necessary devices, success rates and complications of the different approaches, as well as the discussion of which technique is useful, complete this overview paper.

## Anatomical Facts

*K. Dover, T.R. Howdieshell, G.L. Colborn, "The Dimensions and Vascular Anatomy of the Cricothyroid Membrane: Relevance to Emergent Surgical Airway Access", Clinical Anatomy, vol. 9, pp. 291-295, 1996.*

In this paper, the dimensions of the cricothyroid membrane were determined on 15 body donors. The body donors were six females and nine males. The age of the body donors ranged from 70 to 92 years. The width of the cricothyroid membrane was measured at three different points. In addition to the width and height of the cricothyroid membrane, the vasculature in the vicinity of the cricothyroid membrane was also examined. In 14 body donors, it was found that a branch from the thyroid artery ran transversely in the upper third of the cricothyroid membrane. According to the authors' measurements, this area is the widest part of the cricothyroid membrane.

*N. Navsa, G. Tossel, J.M. Boon et al., "Dimensions of the neonatal cricothyroid membrane – how feasible is a surgical cricothyroidotomy?" Pediatric Anesthesia, vol. 15 pp. 402-406, 2005.*

The authors of this paper examined 27 neonatal cadavers with an average height of 44.89 cm and an average body weight of 2.05 kg. After careful dissection, the dimensions of the cricothyroid membrane were collected and documented by two examiners independently of each other using a digital measuring device. The authors found an average width of the cricothyroid membrane of 3.03 mm and a height of 2.61 mm. From this they concluded that the cricothyroid membrane of a newborn is too small for the use of even the smallest tracheal tube.

*S. Gulsen et al., "Clinically Correlated Anatomical Basis of Cricothyrotomy and Tra-cheostomy", J Koeran Neurosurg Soc, vol. 47 pp. 174-179, 2010.*

In this paper, the anatomical structures of the anterior neck were examined with regard to a cricothyrotomy or tracheostomy. For this purpose, the investigators had 40 fresh body donors available. The 29 male and 11 female body donors had an average age of 42 years. The trachea and larynx as well as the surrounding anatomical structures were examined and the respective dimensions measured and documented. A cricothyrotomy or tracheostomy was then performed. The authors concluded that the performance of both a cricothyrotomy and a tracheostomy can be performed with few complications if the operators have a comprehensive knowledge of the anatomy of the neck.

### Epidemiology

*C.V. Rosenstock et al., "Emergency surgical airway management in Denmark: a cohort study of 452461 patients registered in the Danish Anaesthesia Data-base", British Journal of Anaesthesia, vol. 17 (S1), pp. i75-i82, 2016.*

In this cohort study, data from the Danish Anaesthesia Database from June 2008 to March 2014 were analysed regarding the management of a difficult airway including emergency surgical airway. The authors were able to identify a cohort of 452.461 adult patients who received general anaesthesia and endotracheal intubation. Of these, 27 patients required an emergency surgical airway. This corresponded to an incidence of 0.06 per 1.000 patients. In ENT patients, the proportion was disproportionately higher at 1.6 per 1.000 patients.

*A. Timmermann et al., "Präklinisches Atemwegsmanagement in Norddeutschland – Individuelle Kenntnisse, Vorgehen und Ausrüstung", Anaesthesist vol. 56, pp. 328-334, 2007.*

This paper presents the results of a survey of emergency physicians working in Northern Germany regarding their experience and knowledge of airway management. A total of 606 of the 677 questionnaires returned were included in the evaluation. Almost 50% of the emergency physicians surveyed stated that they had no practical knowledge of performing cricothyrotomy.

### Education and Training

*N. Chrimes, A. Higgs, A. Rehak, "Lost in transition: the challenges of getting airway clinicians to move from the upper airway to the neck during an airway crisis", British Journal of Anaesthesia, vol. 125, pp. e38-e46, 2020.*

Technical and psychological factors were blamed by the authors for the challenge of performing emergency access. A training concept developed by the authors should help to make the decision for an eFONA quickly and to carry out the eFONA consistently afterwards.

### Technique

J. SS Ti, et al., *“Impact of “Can’t Intubate Can’t Oxygenate” CICO kit ergonomic design on timed responses of participants in simulated CICO crises: A randomized, crossover pilot study”*, *Tasman Medical Journal*, vol. 3, pp. 45-51, 2021.

CICO situations are rare but life-threatening situations. Several factors are responsible for poor survival in a CICO situation. One factor identified by the authors of this pilot study is the availability and accessibility of the material. As a result, the authors were able to show that design and ergonomics of cricothyrotomy sets can have an influence on the success rate of the cricothyrotomy.

### Pediatric Patients

C. Gernoth, *“Der invasiv-chirurgische Atemweg bei Säugling und Kind”*, *Elsevier Emergency*, vol. 1, pp. 20-26, 5/2020.

In this overview paper, the value of the invasive surgical airway in infants and children was discussed, although the exact incidence of CICO situations in children is not known. Anatomical features of the child’s airway were presented according to age. In particular, the dimensions of the cricothyroid ligament played a special role. The different techniques of the invasive surgical airway were described and their execution was also illustrated in parts.

L. Koers et al., *“The emergency paediatric surgical airway - A systematic review”*, *Eur J Anaesthesiol*, vol. 35, pp. 558-565, 2018.

The authors of this paper conducted a literature search in order to be able to make a recommendation for best practice in an emergency surgical airway in children based on the available literature and after evaluating the research. A total of 5 studies were identified. However, their evaluation made a recommendation impossible due to a lack of evidence regarding best practice. According to the authors, further studies are needed.

# / Pelvic Sling

## Introduction

Pelvic slings are a non-invasive treatment method for severe pelvic trauma. After correct application, the intrapelvic volume can be reduced and bleeding can be possibly controlled. The first applications of pelvic slings were published in 1999. However, it took a while before the use of the pelvic sling became the standard of care for patients with suspected pelvic trauma. Even today, the correct application of a pelvic sling sometimes proves to be problematic. VBM is trying to counteract this with the current Pelvic Sling. Markings on the inside of the Pelvic Sling can help to make correct positioning easier.

## Overview paper

*U. Schweigkofler, "Beckengurt - warum, wann und wie präklinisch einsetzen", Elsevier Emergency, 02/2020, pp 46-51*

The epidemiology of pelvic trauma is presented in this paper, as well as the reason for the high mortality of patients with pelvic ring fractures. Pelvic slings are suitable for initiating hemorrhage control and thus also a positive influence on blood coagulation already in the prehospital phase. The author explains the mechanism of action leading to bleeding control through the use of a pelvic sling. Practical tips on the correct application of the pelvic sling as well as a decision algorithm for the application of a pelvic sling complete this work.

## Effectiveness of Pelvic Slings

*U. Schweigkofler et al., "How effective are different models of pelvic binders: results of a study using a Pelvic Emergency Simulator" European Journal of Trauma and Emergency Surgery, Online first (May 26, 2020), pp. 1-9, 2020.*

In this simulation study, three different pelvic slings were tested for their effectiveness in stabilising and compressing the posterior pelvic ring. The study found that reduction of intrapelvic volume by internal rotation of the lower extremities must precede application of a pelvic sling. A subsequent correctly applied pelvic sling can thus lead to effective bleeding control. In this study, the ventilated cuffs of the VBM Pelvic Sling led to a significant increase in the achievable pressure effect on the posterior pelvic ring.

*E. Esmer et al., "Einfluss der externen Beckenstabilisierung bei hämodynamisch instabilen Beckenfrakturen" Unfallchirurg, vol. 120 pp. 312-319, 2017.*

In this study, the data of the TraumaRegister DGU® from the years 2002 to 2011 were retrospectively evaluated. Patients with a pelvic injury severity of AIS 4 or 5 as well as a systolic blood pressure  $\leq 100$  mmHg and a preclinical shock index  $> 1$  were included. The Tile classification could not be used as it was not included in the datasets. Only patients with isolated pelvic trauma were included in the evaluation in order to be able to evaluate the influence of external compression of the pelvis on the prognosis of patients with complex pelvic ring fractures. The mortality of patients with external pelvic stabilisation was 19.1%, whereas 33.3% died in the group of patients who did not receive pelvic stabilisation. The authors concluded that the use of external pelvic stabilisation in haemodynamically unstable pelvic fractures can lead to a reduction in mortality in these patients.

### Examination Technique and Treatment

*U. Schweigkofler et al., "Diagnostics and early treatment in prehospital and emergency-room phase in suspicious pelvic ring fractures" European Journal of Trauma and Emergency Surgery, vol. 44, pp. 747-752, 2018.*

The aim of this prospective, multicentre observational study was to determine the current diagnostics in patients with suspected unstable pelvic fracture. A total of 254 patients from 12 different clinics were included in this study. In 95 cases, an unstable pelvic fracture was present by definition. Of these, a type B fracture was confirmed in 46 patients and a type C fracture in 49 patients. Mechanical stability testing was performed in 61% of patients. The sensitivity was 31.6%, the specificity 92.2%. Only in 18 patients was the pelvis actually mechanically unstable. However, a total of 166 patients were treated with a pelvic sling. Even though the examination of mechanical stability was performed much less frequently, this did not influence the initial treatment. The authors concluded that the application of a pelvic sling should be performed at the earliest possible time based on the present mechanism of injury and other clinical signs to reduce the risk of severe pelvic bleeding.

*T. Lustenberger et al., "The Reliability of the Pre-hospital Physical Examination of the Pelvis: A Retrospective, Multicenter Study" World Journal of Surgery, vol. 40, pp. 3073-3079, 2016.*

The authors of this study investigated the incidence of unrecognised pelvic injuries in prehospital settings. A total of 11,062 patients were included in the study. In 7,201 patients (65.1%), the pelvic injury was diagnosed on admission to hospital. Of these, 3,178 pelvic injuries were not recognised in the prehospital setting; 40.5% were type B fractures and 32.3% were type C fractures. Due to the unrecognised pelvic injuries and the potential consequences for the patient, the authors concluded that the use of a pelvic sling should be considered in the prehospital setting regardless of the examination results.

*M.J. Gardner et al., "Internal Rotation and Taping of the Lower Extremities for Closed Pelvic Reduction" J Orthop Trauma, vol. 23, pp. 361-364, 2009.*

This article describes the so-called „IRTOTLE“ technique. This technique is used to stabilise the pelvis in patients with distinct obesity in whom, for example, the application of a pelvic sling is impossible due to the patient's body dimensions. In order to use this technique, the lower extremities of patients in the supine position are placed under axial longitudinal traction and rotated inwards, resulting in a significant reduction of the intrapelvic volume. To maintain this position, the lower extremities are fixed above the knees and at the feet by means of a bandage. This technique may not be applicable in the case of lower limb injuries.

### Pediatric Patients

*A. Gänsslen, A. Weinberg, "CME - Zertifizierte Fortbildung - Kindliches Beckentrauma" Unfallchirurg, vol. 123, pp. 395-407, 2020.*

The authors of this CME article provide the reader with a comprehensive overview of pediatric pelvic trauma. In addition to the detailed epidemiological consideration of pelvic trauma in children, the mechanisms of injury in pelvic trauma and acetabular injury are also presented. The treatment of pediatric pelvic trauma largely relates to in-hospital care. In this context, the long-term consequences after pelvic trauma are also highlighted.



### Case Reports

G. Szalay et. al., "Stabilisierung instabiler Beckenfrakturen mittels pneumatischer Beckenschlinge im Schockraum" *Notfall Rettungsmed*, vol. 13, pp. 47-51, 2009.

A 58-year-old man was involved in a head-on collision as the driver of a passenger car. The rescue team found the patient somnolent. After being rescued from the vehicle, the patient was immediately endotracheally intubated and quickly transported to a hospital with suspected SHT, blunt thoracic and abdominal trauma as well as fractures of the pelvis and the left upper and lower extremities. The patient was transferred to the shock room in stable condition. Sonography revealed free fluid intra-abdominal and in the pelvis. The pelvis was stabilised by means of a pneumatic pelvic sling. The subsequent radiological examination showed a haematoma in the pelvis but no pelvic fracture. The joints of the sacroiliac joint and the symphysis also appeared regular. Nevertheless, stabilisation of the pelvis was maintained by means of a pelvic sling. Intraoperatively, a perforation of the urinary bladder as well as an avulsion of the prostate with rupture of the pelvic floor muscles and parenchymatous haemorrhage was seen. After completion of the laparotomy, a pelvic survey without a pelvic sling was performed to clarify the discrepancy between the CT findings and the clinical examination. Only then did an open book fracture with dislocation of the left sacroiliac joint and disruption of the symphysis become apparent.

# / Tourniquet

## Introduction

The history of the use of tourniquets to control bleeding goes back to the Middle Ages. The use of tourniquets in the operating theatre also has a long history, dating back to 1873. At that time, Esmarch described the use of a bandage made of rubber to achieve bloodless field in a limb. The first use of pneumatic tourniquets in surgery is attributed to Harvey Cushing in 1904.

VBM introduced a tourniquet in 1982, the second product in the company's history. Today, VBM has 40 years of experience in the development and manufacture of tourniquets and related accessories.

## Overview Paper

*T.E. McMillan et al., "Current concepts in tourniquet uses", Surgery, vol 38, pp. 139-142, 2020.*

The authors of this overview paper provide a broad insight into the use of tourniquets. In addition to a short historical excursus, the indications for the use of a tourniquet are presented as well as the relative contraindications. The choice of cuffs and general preparation are discussed. In particular, the application of the correct cuff pressure is discussed based on the AORN recommendation. The authors present strategies for deflating the cuffs after use and address possible complications with the use of tourniquets. Ultimately, the authors state, the surgeon's decision to use or not to use a tourniquet must be patient-specific.

*K. Kumar et al., "Tourniquet application during anesthesia: What we need to know?" Journal of Anaesthesiology Clinical Pharmacology, vol. 32 pp. 424-430, 2016.*

Kumar and colleagues provide a comprehensive knowledge base for the clinical use of tourniquets in this review. Besides a short excursion into the history of tourniquets, the different types of tourniquets are presented. The cuff pressure of pneumatic tourniquets and a look at the occlusion pressure of the extremities (AOP/LOP) are discussed in detail, as well as local complications that can occur through the use of tourniquets. The authors differentiate these into nerve injuries, damage to muscles and vessels, and injuries to the skin. Systemic effects, such as cardiovascular or hematological changes caused by tourniquet applications, are also presented. Absolute contraindications for the use of tourniquets do not exist, therefore the relative contraindications are described.

## Arterial Occlusion Pressure (AOP) / Limb Occlusion Pressure (LOP)

### Introduction

Arterial occlusion pressure (AOP) or limb occlusion pressure (LOP) is the lowest pressure of the tourniquet required to interrupt arterial blood flow distal to the tourniquet. Incidentally, both terms are used synonymously. There also seems to be disagreement about how to determine AOP or LOP. For some time now, the so-called „blood flow restriction (BFR)“ has also been used to support muscle building.

B. Tuncali et al., "Tourniquet pressure settings based on limb occlusion pressure determination or arterial occlusion pressure estimation in total knee arthroplasty? A prospective, randomized, double blind trial" *Acta Orthopædica et Traumatologica Turcica*, vol. 52 pp. 256-260, 2018.

The aim of this prospective, randomised, double-blinded study was to compare different methods for determining AOP and LOP in adult patients who had undergone total knee arthroplasty. 93 patients could be included in the study. Tourniquet cuff pressure based on estimation of AOP is comparable to that of LOP determination. However, less time was needed to set the cuff pressure, which was also lower in comparison.

Z. Zeng et al., "Blood-Flow-Restriction Training: Validity of Pulse Oximetry to Assess Arterial Occlusion Pressure" *International Journal of Sports Physiology and Performance*, vol. 14 pp. 1408-1414, 2019.

In this study, a crossover design was chosen to compare two different methods for determining LOP. In 94 subjects, LOP was determined by Doppler ultrasound or by pulse oximetry in both the upper and lower extremities. In this study, pulse oximetry was found to be reasonably accurate for determining LOP in the upper limb, but rather unsuitable in the lower limb.

### Guidelines

"Guidelines for Perioperative Practice: Pneumatic Tourniquet (NEW)", <https://aornguidelines.org/guidelines/content?sectionid=173719470&view=book>, 2020.

The American Association of periOperative Registered Nurses (AORN) has published this guideline since 1984. The current revised version was published in 2020 and is valid until 2025. The guideline is intended to provide peri-operative teams with a common thread for the safe use of pneumatic tourniquets. The recommendations are based as far as possible on the available evidence.

"Guidelines for Best Practices for Safe Use of Pneumatic Tourniquets", <https://www.ast.org/webdocuments/ASTGuidelineSafeUseofPneumaticTourniquets/2018>, (accessed Feb. 17, 2022).

This guideline is published by the American Association of Surgical Technologists (AST). This guideline, published in 2018, is also intended to support the user in the use of pneumatic tourniquets. Like the AORN guideline, it is based on current evidence.