

# The role of tracheal tube introducers and stylets in current airway management

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Received: 29 December 2015 / Accepted: 12 April 2016  
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**Abstract** Tracheal tube introducers and stylets are highly successful devices for the management of various airway scenarios. Their first-line use is advocated in many difficult airway algorithms. Although they have been used for decades, the shape and design of introducers and stylets as well as their patterns of use are constantly evolving. Our purpose is to provide the clinician with an update on these different devices. We performed a systematic literature search from 2005 until May 2015, without language restrictions. The two authors independently retrieved all studies with the keywords “bougie”, “gum elastic bougie”, “stylet”, “airway management”, “tracheal tube introducer” and “extubation catheter”. Our search did yield mostly observational and retrospective studies with small case numbers. The data was synthesized into a narrative review to provide the clinician with an update on the characteristics, indications and techniques of use as well as the dangers of different intubation aids. Today, numerous tracheal tube introducers and stylets exist with different indications, ranging from general to specific situations. Anesthetists should be familiar with the different devices, their characteristics and indications in order to use the right device at the right time in the right way.

**Keywords** Intubation · Bougies · Stylets · Difficult intubation · Intubation aids

## 1 Introduction

The management of patients with a difficult airway can lead to severe injuries [1, 2] and life threatening complications [2, 3]. Whenever the tracheal inlet cannot be visualized adequately by direct laryngoscopy, two simple and effective techniques are available: firstly, the preforming and directing of the endotracheal tube (ETT) anteriorly with the help of a stylet [4], and secondly, the blind insertion of a soft-tip tracheal tube introducer (TTI) followed by railroading an ETT over it [5]. As both TTIs and stylets are proven to be highly successful devices for the management of difficult airways, their early use is recommended in many guidelines [6, 7]. Although not originally designed for airway exchange [8–10] or for extubation [11], TTIs have been specifically modified and are increasingly used for these purposes. Finally, TTIs and stylets combine well with new techniques such as video laryngoscopy [12–14]. As a consequence, numerous different modifications of the original devices as well as newly developed introducers and stylets are available on the market.

We aim to provide the clinician with an update on the characteristics, indications, techniques of use and dangers of different intubation aids.

## 2 Methods

The two authors independently conducted a systematic literature search in MEDLINE and EMBASE, including randomized controlled trials and reviews from 2005 up

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until May 2015, in human subjects and without language restrictions. Search keywords were “bougie”, “gum elastic bougie”, “stylet”, “airway management”, “tracheal tube introducer”, “intubation aid”, “extubation catheter”. In addition to the randomized controlled trials and reviews retrieved by the search, case reports and series were included if deemed appropriate, especially in the section on complications related to TTIs. We identified 396 articles, of which 17 were removed due to duplication. 323 articles were rejected after having read the title or the abstract. 56 articles were read in full text, after which 19 were rejected, as not specifically evaluating tracheal tube introducers or stylets. The retrieved 37 articles were appraised by both authors. The data was synthesized into a narrative review to provide the clinician with an update on the characteristics, indications, techniques of use and dangers of different intubation aids.

## 2.1 Bougies

### 2.1.1 Tracheal tube introducers

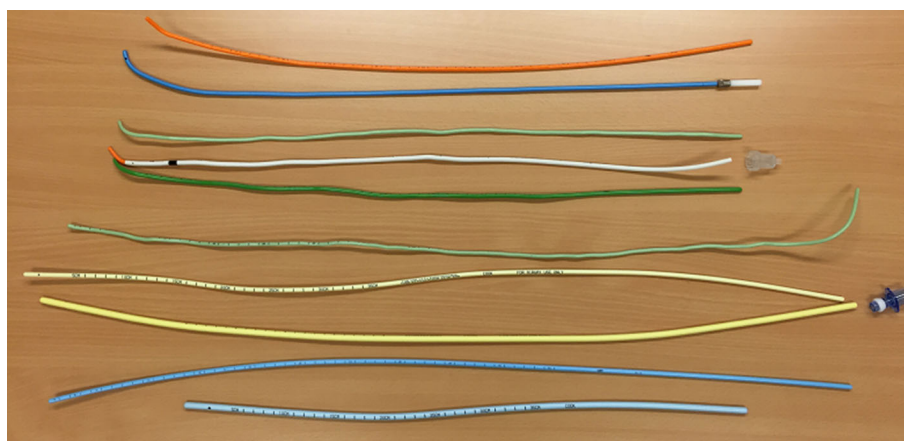
Amongst the characteristics which will affect the choice of a specific TTI in a clinical situation are its size, length, structure, stiffness, single-use versus reusable, shape, type of distal end (angulated/coudé or straight), soft versus hard tip and full versus hollow core. Figure 1 show a selection of commonly used TTIs.

**2.1.1.1 Eschmann-type tracheal tube introducers** Sir Robert Reynolds Macintosh is credited with inventing the first TTI in 1949 [15]. As his device was a modification of a urethral dilatation catheter, it was named “Gum Elastic

Bougie”, a term that has survived even if today’s TTIs are no longer elastic nor made of gum nor used in a “bougie” fashion. Based on Macintosh’s description, P.H. Venn designed the first purpose-made introducer in the 1970s, which was subsequently manufactured by the British company Eschmann under the name “Eschmann introducer” [16]. Today, Eschmann-type introducers are 600 mm long with an outer diameter of 5 mm, fitting ETTs of size 6 or larger. The distal tip is angled at 40°. A polyester coating conveys a certain stiffness and flexibility at the same time and makes it easy to insert and withdraw. Eschmann-type introducers will retain a new shape when bent (memory effect [17]). These devices are produced by several companies (Portex®, VBM®, Cook®).

The Eschmann TTI is passed through the vocal cords under full or partial vision or even blindly. The angled tip facilitates its passage into anterior airways and should provide tactile feedback—firstly so-called “clicks” as the introducer bounces over the tracheal rings and secondly the “hold-up sign” as it impacts on smaller airways and eventually coughing if the patient is not paralyzed [5]. Once the introducer is in place, an ETT is railroaded over it, after which the TTI is withdrawn. There are also reports describing how TTIs can facilitate the insertion of laryngeal mask airways [18, 19]. While the original introducer was sterilized and re-used, modern introducers are mostly single-use, for example the Portex bougies (Smiths medical Intl Ltd, Kent, UK) or the VBM introducer (VBM Medizintechnik GmbH, Sulz a. N, Germany). Pediatric sizes Eschmann-type tracheal tube introducers can be found, allowing railroading of tubes size 4 and up.

The “traffic-light bougie” is a recently developed prototype which is color-coded to indicate its depth of



**Fig. 1** Different tracheal tube introducers and connectors. Legend (from top to bottom). Eschmann introducer, VBM. Frova intubating introducer, Cook Medical. Muallem Endotracheal Tube Stylet (METTS), VBM. S-Guide with universal connector, VBM. Muallem Endotracheal Tube Introducer (METTI), VBM. Rivier Airway

Introducer, VBM. Cook Airway exchange introducer 14Fr, Cook Medical. Cook Airway exchange introducer 8Fr with Rapi-Fit adaptor, Cook Medical. Tube exchanger, VBM. Aintree intubation Catheter, Cook Medical

insertion and prevent airway trauma from advancing it too far [20]. The green zone indicates a safe depth of insertion (<21 cm), yellow indicates possible contact with the carina and red warns of a high risk of impact with distal airway structures. The reliability of these markings, however, has been questioned [21].

**2.1.1.2 Introducers with distal angled tip and inner O<sub>2</sub> lumen** The Frova intubating introducer (Cook Critical Care, Bloomington, Indiana, USA) has been described by some as the “gold standard” to aid for difficult intubation [22]. Its length of 650 mm is close to that of the Eschmann-type introducers, but its tip is angled at 65° instead of 40° for better sliding under the epiglottis. Pediatric models are available in different lengths and sizes, for size 3 ETTs onwards. Made of polyethylene, the Frova catheter has some memory effect. It was designed stiff enough to transform a straight force applied at the proximal end into an anterior-upward movement at the tip of the instrument, so that an impact of the Frova against the inter-arytenoid notch should result in an upward-anterior shift towards the tracheal inlet [23]. In addition to facilitating intubation, the Frova introducer can provide oxygenation. Once the proximal end is adapted to an oxygen source, oxygen can be insufflated through the inner lumen. The distal end has additional sideports for conventional or jet ventilation.

A 2009 survey amongst English airway providers showed that the Eschmann and Frova were the sole introducers available in 39 % of the departments, while numerous other devices were present, even some described as “inappropriate” [22].

**2.1.1.3 Other tracheal tube introducers** In different introducers the polyester core was replaced by a metal one in order to enhance the memory effect. For example, the METTS [24] (Muallem ET Tube Stylet, VBM Medizintechnik GmbH, Sulz a. N, Germany) combines a relatively stiff metal core with a flexible pre-formed soft tip. It is available in both adult and pediatric sizes for ETTs as small as 3.5 mm. The slightly longer METTI [25] (Muallem ET Tube Introducer, VBM Medizintechnik GmbH, Sulz a. N, Germany) with a length of 800 mm serves for both difficult intubation and tube exchange. All these introducers are single-use.

### 2.1.2 Airway exchange catheters (AEC)

These catheters have been designed to be introduced through an ETT, a laryngeal mask or an intubating laryngeal mask and maintaining access to the airway after extubation. A strategic stepwise approach is recommended for tube exchange, starting with optimizing blood oxygenation, followed by inserting the AEC in the existing

ETT under continuous glottis viewing [26], airway removal and railroading of the new ETT over the exchange catheter.

**2.1.2.1 Straight exchange catheters with O<sub>2</sub> lumen for tracheal tube exchange** The Cook airway exchange catheter [27] (Cook Critical Care, Bloomington, Indiana, USA) is a single-use 800 mm hollow catheter with a proximal O<sub>2</sub> connector and distal sideports to allow emergency oxygenation. Its straight tip is blunt, soft and flexible for easy passage through an ETT. Centimeter markings guide the depth of insertion. Different sizes exist, allowing placement of ETT size 3 onward for all ranges of age [28]. The VBM tube exchanger is an existing alternative available for ETT sizes 4 or more (VBM Medizintechnik GmbH, Sulz a. N, Germany, <http://www.vbm-medical.com/products/airway-management/stylets-introducers-tube-exchangers/>. Assessed March 3 2016).

**2.1.2.2 Straight exchange catheters with lumen for fiberoptic bronchoscope** The Aintree Intubating Catheter [29] (Cook Critical Care, Bloomington, IN, USA) is a single use, straight, flexible device with a proximal oxygen connection and a blunt, fenestrated end to ensure sufficient airflow. The large inner diameter of 4.7 mm allows the insertion of a fiberoptic bronchoscope, leaving the controllable distal tip uncovered. As it fits through a supraglottic airway device, it can also serve as a bridge towards intubation [30–32]. Development of this device was pursued with the ideal of permitting an unhurried fiberoptic intubation, starting from a position of airway control with the laryngeal mask and proceeding without the need to relinquish this control during the procedure [29]. The Aintree, which is loaded over the fibrescope, is inserted into the laryngeal mask airway. Glottis, tracheal rings and carina are visualized as the fibrescope passes caudally. The fiberoptic bronchoscope is withdrawn and the laryngeal mask removed, leaving the Aintree catheter in the trachea. Using a laryngoscope, a size 7 ETT or larger ETT is rail-roaded over the Aintree catheter, which is removed at the end of the procedure. Besides being a primary intubation tool, the Aintree is useful for bronchoscopy-guided tube exchange.

### 2.1.3 Extubation catheters

Following the publication of the different guidelines for management of the difficult airway and intubation, there was a statistically significant reduction in airway claims arising from injury at induction of anesthesia [33]. Nowadays, it is increasingly recognized that post-extubation airway failure is frequent and potentially life-threatening. Indeed, the predefinition of a failed-extubation strategy with possible use of an airway exchange catheter is

recommended by relevant societies such as the ASA and the DAS [7, 34]. However, in a recent audit, up to 30 % of airway failures were related to extubation [3], especially in patients who had been intubated for longer periods of time. The Cook staged extubation set (Cook Critical Care, Bloomington, IN, USA) contains a kink-resistant nitinol wire of 1450 mm length as well as an 830 mm long, hollow reintubation catheter. Before removal of an ETT, the soft and thin nitinol wire is placed through the vocal cords where it is well tolerated and can be left in place as long as necessary. Should the airway become compromised, the reintubation catheter is threaded over the wire and emergency oxygenation can rapidly be installed via its distal side ports. Finally, a new ETT can be railroaded over the catheter.

## 2.2 Stylets

Stylets are inserted into the ETT prior to intubation. The distal extremity of the stylet should come to lie before the Murphy eye, while the proximal end should be hooked onto the ETT connector. The stylet inside the ETT can then be pre-formed as the airway situation requires, often with an angle not exceeding 35° and an otherwise straight-to-cuff shape [35]. This “hockey stick technique” leaves the end of the ETT free for manipulation [36] or specific tube movement [37]. During intubation, as soon as the vocal cords are passed, the stylet should be removed to prevent airway injury. Figure 2 show a selection of existing stylets.

### 2.2.1 Metal core stylets

Standard stylets are metal rods with a malleable core and a soft, low friction coating for easy sliding (for example, the Portex stylets, Smiths medical International Ltd, Kent, UK). They are available in different lengths and diameters, for multi-use or single use. In many hospitals, these devices are often recommended for rapid-sequence inductions and for intubations in the prehospital setting [38, 39].

Over recent years, the stylet-aided shape of an ETT is increasingly combined with videolaryngoscopic visualization of the vocal cords. For this purpose traditional stylets seem to have similar success rates than specifically customized stylets, for example the GlideRite® stylet designed for the GlideScope videolaryngoscope [40].

### 2.2.2 Plastic stylets

The Schroeder directional stylet [41] (Parker articulating stylet Flex-It™) is a disposable plastic stylet that is inserted into the ETT without any pre-bending. The tube curvature is then modified during intubation by pushing a lever with the thumb. Due to its flexibility, it can be used

for oral or nasal intubation [42, 43]. As no studies have proven a benefit on success rate or diminished tracheal intubation attempts, these types of stylets have not gained widespread use.

## 3 Complications

After decades of use in many clinical scenarios, tracheal tube introducers and stylets have shown to be lifesaving devices [44, 45], while their strengths and weaknesses depend mainly on their characteristic (Table 1). Case reports and series describe that tube introducers may cause serious problems and significant morbidity, if not mortality. The most frequent complications are of mechanical nature. As they are more rigid, stylets and single-use introducers seem to be associated with higher complication rates than multiple-use introducers [46]. For example, a complication rate of up to 5 % has been reported with the Frova introducer [47]. Introducer-related mechanical complications include pharyngeal [48] and tracheal bleeding or perforation [49], bronchial rupture [50], alveolar hemorrhage [51] and hemopneumothorax [52]. Similarly, stylets have caused palatal or tonsillar perforation [53–55]. Device fractures with intratracheal and pulmonary migration of sheared stylet parts have been reported [56–58]. Airway exchange catheters have equally been shown to cause tissue damage on insertion or while administering oxygen, especially if inserted to deeply into the bronchial tree [59] in an animal model.

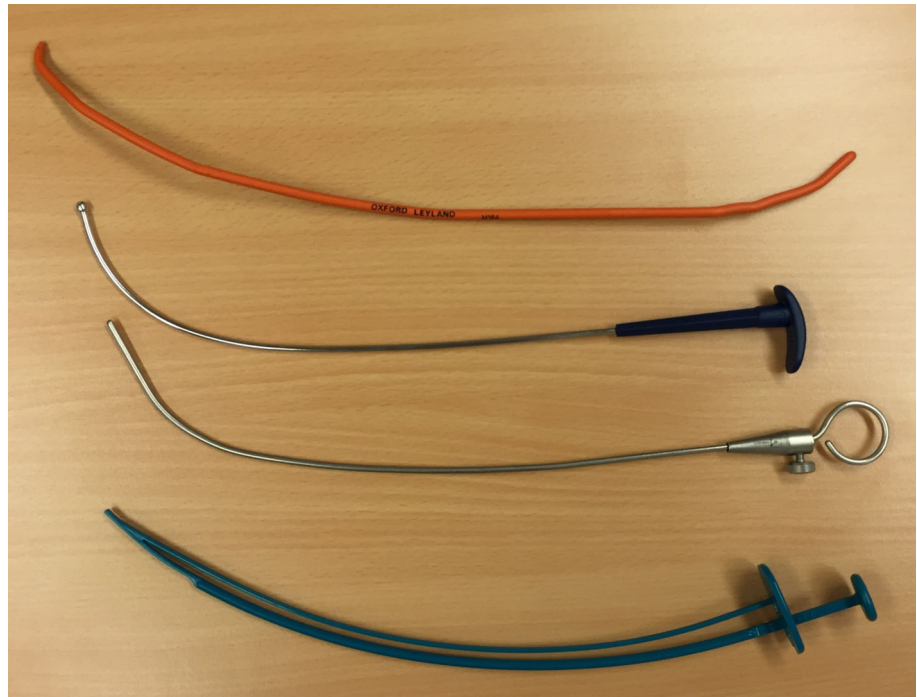
While re-useable devices seem safer to handle, they may be the source of pathogenic microorganisms [60–62]. There is realistic concern, however, that single-use devices may be less effective, while a clinically relevant transmission of infection by stylets or introducers has not been confirmed.

## 4 The ideal intubation aid

As of today, the ideal intubation aid does not exist. Such a device should be inexpensive, readily available, single use, easy to store and transport and straightforward to handle. It should be firm enough to maintain its shape after bending (memory effect), but soft enough so as not to cause airway trauma. Its tip should be soft and curved for easy (blind) positioning under the epiglottis and should provide visual feedback of proper placement. In addition, it should allow emergency oxygenation. The ideal introducer should also be compatible for use with video-assisted laryngoscopy and allow movement of the tube’s extremity under direct visualization [37].

Several promising prototypes are currently being evaluated and will have to be assessed in clinical studies.

**Fig. 2** Different stylets. Legend (from *top to bottom*). Oxford Leyland stylet. Gliderite stylet, Verathon. Metallic stylet, Centre Hospitalier Universitaire Vaudois, Lausanne. Parker articulating stylet



**Table 1** Main characteristics of tracheal tube introducers and stylets

Purpose	Type of introducer	Example
Intubation	(a) ETT stylets	Gliderite <sup>®</sup> , VBM malleable Stylet <sup>®</sup>
	(b) Tracheal tube introducers	Eschmann bougie, METTI <sup>®</sup>
Intubation and oxygenation	(a) Introducers with distal angled tip and O <sub>2</sub> lumen	Frova introducer <sup>®</sup>
	(b) Straight introducers with lumen for fiberoptic bronchoscope	VBM Introducer <sup>®</sup> Aintree catheter <sup>®</sup> VBM Intubation catheter <sup>®</sup>
ETT exchange	Straight introducers with O <sub>2</sub> lumen	Cook airway exchange catheter <sup>®</sup> VBM tube exchanger <sup>®</sup>
Staged extubation	Staged extubation wire and staged reintubation catheter	Cook staged extubation set <sup>®</sup>

## 5 Conclusion

In cases of difficulty in visualization of the tracheal inlet, every effort must be pursued to guide the tracheal tube between the vocal cords while minimizing time and injury. The early use of tracheal tube introducers and stylets is advocated in airway management guidelines and knowledge of specific characteristics, indications, techniques and complications must be known in order to maximize success.

**Financial disclosure** Sina Grape and Patrick Schoettker do not have any external funding.

### Compliance with ethical standards

**Conflict of interest** Patrick Schoettker has participated in the development of the VBM S-Guide, Malleable Intubating Guide ([www.vbm-medical.com](http://www.vbm-medical.com)).

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