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The miracle of parted Red Sea: not any stick but Moses' one

> [21] Then Moses stretched out his hand over the sea, and all that night the Lord drove the sea back with a strong east wind and turned it into dry land. The waters were divided, [22] and the Israelites went through the sea on dry ground, with a wall of water on their right and on their left.
>
> Exodus 14:21–22 [1].

Moses, leading Israelites away from Egypt, rose his hands with the holy stick parting the water of Red Sea and succeeded escaping the chariots and cavalry led by the Pharaoh himself (Exodus, 17: 5–7) [1]. Nowdays scientists provide different explanation (obtained through computer simulation) for the "miracle", hypothesizing that the water parting phenomena was a combination of winds and tides [2].

In this issue of Trends in Anaesthesia, Dr. Agarwal and Dr. Gupta describe a case report of unexpected difficult intubation solved with use of a tracheal introducer, and ending up in some (uneventful) complications due to introducer-related tracheal injury [3]. They metaphorically address the issue to Moses' choice, between the Egyptian devils, related to having to use an adjunct to secure this difficult to manage airway and the Red Sea deep water, related to the possible complications associated with the use of tracheal introducers.

In this editorial we are going to discuss important points relevant to the efficient and safe use of tracheal introducers.

Difficult airway management and failed/difficult intubation remain challenging even in experienced physicians' hands. Although relatively rare, the potential for patient harm is quite significant [4]. To deal with these airway management challenges, a number of devices and techniques have been suggested in various international airway management guidelines [5]. One simple and effective airway management device has maintained its relevance over a number of years and is included in almost all of the guidelines – this unique device is a bougie, also named tracheal introducer (TI).

Since the introduction of the original *gum elastic bougie* by Professor Macintosh and of its evolution by Dr. Venn, the so-called *Eschmann guide* has been used for years, passing through phases of variable enthusiasm and today living a kind of *second youth*, due to their expanded use, including use for extubation [6], as an adjunct to videolaryngoscope guided intubation [7,8] for emergency front of neck access (eFONA) [9,10], use in pediatric patients [11], and occasionally with supraglottic devices [12,13]. Many studies are giving more precise figures about their use, performance and success rates [14,15].

The hidden face of the moon is represented by the potential for airway trauma related to use of bougies. This is a consequence of a combination of intrinsic trauma potential of any variably stiff device inserted into the airway and insufficient education and training in their use. A large variety of complications have been described, and airway trauma similar to the one reported by Agarwal and Gupta [3] can occur in up to 5% [16]. The extent of the bougie-related airway trauma varies from blood staining of the bougie tip to the severe life-threatening airway trauma such as tracheal, pharyngeal and esophageal perforations [17], haemothorax [18], pneumomediastinum, subcutaneous emphysema [19] and pneumoperitoneum [20]. Other complications of bougie use, such as slicing in airways [21] (especially if used with double-lumen tubes [22,23]), or retaining-valve mechanism in simulated eFONA scenario [24] have also been reported.

Sir Isaac Newton stated that *error is in the artist, not in the art*, and this quote is probably very true when considering complications associated with bougie use, as many of them seem to come from an imprudent or uneducated use. Nevertheless, some complications could be avoided following some easy rules, as in large part suggested by the same report from Drs. Agarwal and Gupta [3], with their "ten commandments" (as the holy Decalogue that God gave to Moses for human beings) for safe bougie use (Table 1).

Although very similar in appearance (hollow or solid plastic rods with curved coude tip), bougies differ significantly in their performance characteristics. They have a coude tip that varies in length and angle, the bougies also vary in length, outer diameter, material, markings, stiffness, and *memory*; some come with a reinforced or stiffer structure or a stiffening removable cannula, some are particularly soft and with variable shaping possibility, some are designed for single use (vast majority of the currently available introducers) and one that can be used up to five times (*Eschmann guide*). All these characteristics unavoidably condition and affect performance. Traditionally the Eschmann guide is used as the reference point against which all currently available bougies are tested as this bougie has been researched the most and has a proven record of high efficiency and low airway trauma potential.

The transition towards single use bougies (due to new materials and the need for disposable instruments) has introduced new devices with different performance (lower, in average, when compared to *Eschmann guide*, except for Frova TI [27]) and higher complications rate (mostly described for stiffer single-use bougies). Most of the currently available single use bougies have not been tested for effectiveness or airway trauma potential. It appears that much of the reported airway trauma was associated with the stiffer single use bougies, and very few with the re-useable Eschmann bougie. The crucial point is that there is a strong need for knowledge of the device we are using, and awareness that not all bougies are performing the same.

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Table 1

	TI Decalogue from Argwal and Gupta [3]	Editorial comments
1	Gently advance the tracheal tube introducer and TT.	Respect TI use indications (up to CL3a) and gather experience in easy cases.
2	Use of other introducers like the FROVA intubating introducer which do not need eliciting any of the signs for correct introduction	There is no evidence for this statement. Not all TIs are the same, in terms of shape, materials, tip shape (all factors affecting performance) with different success rates. CO2 detection is theoretically feasible using hollow TI (i.e.Frova) [25]
3	Avoid the hold-up sign or, if used, retract the tracheal introducer a few centimetres after the distal hold-up sign before railroading the tracheal tube over the introducer.	Do not use the hold-up sign and advance the bougie to no further than 22–25 cm from the incisors. Cautious and gentle advance of the TI and of the TI-ET assembly is advised.
4	Use of only the click sign to ascertain the position of the introducer.	When elicited, tracheal clicks are reliable sign of tracheal placement. However, clicks are not always present and may be influenced by the bougie tip design.
5	The click sign is apparent in adults and older children if the introducer is correctly placed in the trachea.	See above comment. The only certainty of correct position comes from direct view of TI/ET passage between vocal cords and capnographic trace during ventilation
6	A CT scan done pre-operatively can also be used to measure the distance to the carina, and thus guide the depth the introducer can go in. Improve the tracheal tube's angle of insertion over the introducer by moving soft tissues out of the way with the laryngoscope; using a video laryngoscope is beneficial as everyone can observe the ease with which the tube may slide in and determine which maneuver might be helpful in case of difficulty.	Although reviewing a CT scan may be useful we are not aware of the evidence backing this statement. Remember anatomical distances and landmarks, and never push any TI deeper than 22–25 cm from incisors. Facilitate ET passage with laryngoscope in place (videolaryngoscope allowing shared view), using rotational movements or retracting ET and sliding it again the bevel oriented posteriorly.
7	Minimise the risk of introducer migration by having an assistant 'stabilise' the introducer while advancing the TT into the trachea;	This stands the common-sense scrutiny.
8	Limit the number of tracheal intubation attempts as recommended by the current airway management guidelines.	Prioritize oxygenation and consider any available opportunity to avoid fixation errors, including option to wake up the patient (if feasible).
9	Use evaluated standard devices, i.e., avoid introducers that can be more harmful for tracheobronchial mucosa (e.g. those with a metal core).	Rely on evidence from literature and experience with your device, as TI and their performance vary significantly.
10	If an injury is suspected after intubation, a diagnosis can be made with tracheobronchoscopy, followed by a chest CT scan if needed.	Conservative treatment should be a multidisciplinary decision [26]. A safe extubation strategy is recommended. Source and site of damage should be carefully sought and endoscopically documented.

As a consequence, a prudent approach is mandatory: whichever the bougie, it should never be advanced deeper than 22–25 cm from superior incisors; the tracheal-clicks, if felt are reliable sign of bougie's tracheal placement. Nevertheless, theoretically, different introducer tip designs might result in no clicks even with bougie in correct position, so caution is advised when relying on this sign to confirm tracheal placement. Currently there are no specific data on this issue.

Distal hold-up, on the other hand, is more likely to be associated with airway trauma especially if stiffer single-use bougies are used [28]. If on one hand hold-up sensitivity is 100%, on the other we might ask is it worth eliciting this sign when potential for trauma is so high. We know that certainty of correct bougie position comes only once the endotracheal tube is in, and we read on monitor repeated and morphologically normal capnograph trace. To use religious terminology, the hold-up sign is theologically un-useful.

When using a stiffer bougies, similar to the Portex (Minneapolis, USA) bougie used in Agarwal and Gupta case report [3], then bougie advance has to be gentle, with visual control if possible and respecting the correct indication: laryngoscopy views 1, 2 and 3a, remembering that when faced with views 3b and 4 bougies are not likely to be effective (and thus their use discouraged). Epiglottis view (complete or at least a large part of it) is important as anatomical landmark of glottic position: as we push the bougie blindly towards the glottis entrance, sliding below the epiglottis keeping the bougie advance midline is likely to aid tracheal placement and minimise the risk of airway injury.

Keeping a (video)laryngoscope in situ throughout bougie-assisted intubation is advisable, to improve the views, to favour TI/ET passage and enlarge the working space (i.e. dislodging the tongue). An elegant and ergonomic opportunity favoring these recommendations could be represented by the handling mode of the bougie. Fig. 1 shows the so-called *Italian grip* and the *kiwi grip* proposed in USA by Dr. Levithan [29] (Fig. 1). The *Italian grip* allows bougie's safe and probably more sensitive handling, freedom to orientate and to move towards upper airway. Based on our experience (MS and GF) this grip is likely to shorten intubation time and reduce the need for additional operator, providing an intrinsic safety limit to the depth of bougie insertion represented by the two fingers holding the bougie at the established safety mark of 22–25 cm. Releasing the two holding fingers will immediately make the tube free to advance over the bougie, with no need of further manipulation of the bougie-ET assembly, with reduction of potentially traumatic movement of the bougie tip inside the airway. This recommendation is based on personal experience (MS and GF) and has not been evaluated fully, representing a further opportunity for future research.

Other debate is ongoing about whether to shape the bougie prior to placement or not. In Driver's study [14], operators were given a freedom to shape the bougie (documented in 7% of cases) according to their preference and no other instructions on the method of bougie use were given.

Ideally, when coupled to a "line-of-sight principle" based device such as Macintosh, the TI should be moderately bent accordingly to airway natural curvature (especially for limited laryngeal views), or particularly for some specific bougie (such as Frova TI) maintained in a linear shape so to maximize benefit of the "direction of force" principle [30]. It needs to be curved whenever coupled to a hyperangulated blade videolaryngoscope [31], so to follow airway anatomy and blade design.

Videolaryngoscopes improve the ability of anesthetists to see the glottis. It can be argued that this might reduce the need for bougies, taking account that they can't provide adequate ventilation in paralysed apnoic patients [32].

Although videolaryngsocopes are established devices claimed to improve laryngoscopy view and intubation success, they can also fail even in expert hands.

A large population study from Aziz and coworkers [33] exploring rescue techniques used by anaesthetists after failed conventional direct laryngoscopy, found that, when used as a rescue, videolaryngoscopy failed in around 8%. In a small number of such failures, airway was secured stepping back to the use of a bougie with Macintosh laryngoscope.

Evidence seems to suggest that intubation duration and success rate are improved in one third of videolaryngoscope guided intubations when bougie is used as an adjunct [34]. This can be explained

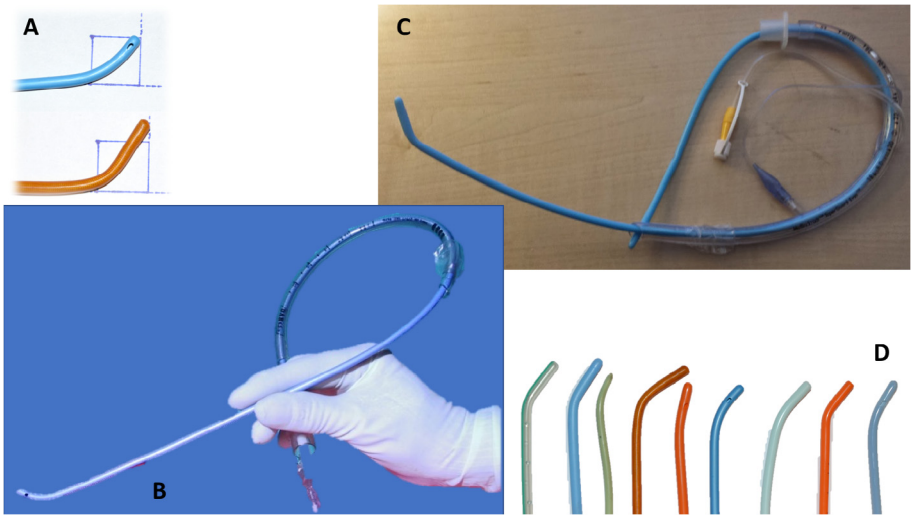

Fig. 1. Bougies comparison; A: difference between the (coudè) tips of the Frova Introducer (Cook Medical, USA), blue and curved compared with the Eschmann guide (Smiths Portex, USA), orange and angled. Both tips are referenced above a 2 × 2 cm square. B: the *Italian grip*; notice the proximal end of tube/bougie free. C: the *kiwi grip* (Dr Baker and Dr. Levithan); notice the proximal end of bougie caught in the tube's Murphy's eye. D: Tracheal bougies from the market: differences in shapes and materials.

with smaller outer diameter of a bougie when compared to the outer diameter of the tracheal tube, resulting in safer, easier and smoother airway instrumentation and tracheal placement, due to the relative working-space gain.

All previous considerations highlight the concept that a wise and gentle use of a bougie with Macintosh laryngoscope can parallel and perhaps surpass videolaryngoscope guided intubation success rate [35].

A direction of research and teaching is probably the possible mutual benefit of combining older and newer devices, the bougie improving videolayngoscopes' performance and videolaryngoscopes reducing bougie-related trauma. Recent observational study show an incidence of Frova (Cook Medical, USA) related trauma to be 0.8%, which appears to be definitively smaller if compared to a reported 5.5% incidence of trauma when it was used with Macintosh laryngoscope [7].

To summarize, the best actual evidence strongly supports the use of bougies with either direct and indirect laryngoscopy, providing that physicians are educated in their use, prudent and aware that not all bougies are the same.

As a simple device, any bougie requires simple rules to follow, and it always need to be part of an airway plan. In the assumption that unique target of any airway management strategy is always patients' oxygenation [36]. In any case, whichever the bougie or the (video)laryngoscope, depth of insertion is a crucial point, representing a *commandment* which cannot be violated.

There is a strong call and need for a bougie related research, from case reports to large randomized controlled studies, in order to better assess the role of these useful and effective deices in airway management, to provide clear messages, to differentiate devices' performances and to identify features of the ideal bougie, giving physicians the decisional tool to choose the best introducer for critical airways.

Research in the field of Anaesthesia, Critical Care, Pain Medicine, is moving forward new techniques and devices, pushing boundaries of disciplines to unexpected directions and techniques [35,37,38], but a correct approach should include thinking about future, looking at present and not forgetting the past. Keeping in mind that often the simpler is better.

In reference to Agarwal and Gupta case report [3], we would like to underline the point that not any stick would have been equally performing to part the Red Sea: independently on the debate between science and religion, the waters parted either because of the stick's specific characteristics (still partly unexplored, as for tracheal introducers) and mostly because of trust, faith and experience in Moses's hands handling it.

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None.

Conflict of interest

MS research and development and pre-clinical testing of the LMAProtector™. Paid Consultancy with Teleflex Medical, Dublin, Ireland. Patent owner (no royalties), paid consultancy with DEAS, Castelbolognese, Italy.

IH Trialed equipment for clinical use and training, travel and accommodation funding to give lectures from Medtronic, Fanin, Storz Medical, Cook Medical and Ambu.

GF inventor of Frova Introducer (Cook Medical, Bloomington, IN, USA), Percutwist (Teleflex Medical, Ireland – royalties), Easycric (Teleflex Medical, Ireland – royalties), Cricotrainer (VBM Medizintecnik, Germany – no royalties), Tracheostomy Cannula exchanger (DEAS, Castelbolognese, Italy – no royalties).

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