REVIEW ARTICLE

The Difficult Intubation: A Review of the Recent Literature.

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Although perhaps simple in appearance, tracheal intubation by direct laryngoscopy is in fact a complex skill requiring training and experience for its mastery. It is an essential skill for anaesthetists, as well as other physicians and emergency care personnel who work in intensive care environments or in the operating room. This paper provides a general review of the difficult intubation by focusing on the following areas: 1) physical factors involved in causing an airway to be difficult; 2) how a difficult airway can be recognized before intubation is attempted; 3) specialized instrumentation and techniques that aid in successful completion of a difficult intubation; 4) level of skill required, or degree of training needed to be better equipped to deal with a difficult airway.

INTRODUCTION

The vast majority of tracheal intubations are performed without complications and can be referred to as "easy" intubations. However, various predisposing factors of an airway can make tracheal intubation difficult. If such "difficult airways" are not recognized before attempts at tracheal intubations are made and specialized equipment is not on hand to aid in the intubation, severe complications with potentially drastic consequences may arise. Indeed, it has been estimated that inability to successfully manage airways has been responsible for as many as 30% of deaths totally attributable to anaesthesia (1). In addition, approximately 33% of all malpractice lawsuits brought against anaesthetists in the United States are related to complications of managing airways, which resulted in hypoxic brain damage or outright death in the majority of cases (2). Therefore, it is important to be able to identify and manage difficult airways.

DEFINING THE DIFFICULT AIRWAY

During the normal intubation using a laryngoscope, the vocal cords can be visualized readily and the endotracheal tube easily placed in the trachea. However, during the difficult intubation, the cords may not be seen and problems may be encountered in placing the tube. The American Society of Anaesthesiologists' Task Force on Management of the Difficult Intubation offers that "a difficult airway is defined as the clinical situation in which a conventionally trained anaesthesiologist experiences difficulty with mask ventilation, difficulty with tracheal intubation, or both." (4) Other physicians have found this defintion too vague to be of any practical use (5).

The American Society of Anaesthesiologists also provide a useful distinction between difficult laryngoscopy and difficult intubation. The former is defined as a failure to visualize any portion of the vocal cords with conventional laryngoscopy. The latter is defined as requiring three or more attempts to achieve proper tube placement, or requiring a time of more than ten minutes to achieve proper tube placement from the beginning of the first attempt using direct laryngoscopy (4).

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PHYSICAL FACTORS INVOLVED IN THE DIFFICULT INTUBATION

It has been observed that the difficult airway represents a complex interaction between patient factors, the clinical setting and the skill level of the practitioner (4). However, it is arguably the patient factors that are most noteworthy, since these may potentially have predictive value in pre-procedure recognition of the difficult airway. Such patient factors can generally be categorized into (a) anatomical, (b) physiological and (c) pathological categories.

(a) Anatomical factors

There are a variety of anatomical factors that determine the ease of intubation. The most significant in terms of predictive value are described by Benumof (1). First, the size of the tongue in relation to the oral cavity is important, since a larger tongue is more difficult to manipulate while performing laryngoscopy. Second, the amount of atlanto-occipital joint extension achievable is crucial, since greater extension results in greater ease of tongue displacement with the laryngoscope, and a better line of sight to the trachea. Third, the amount of mandibular space is important as it determines how much room the practitioner has to sweep the tongue out of the way and establish a clear view of the vocal cords.

Other anatomical factors which make intubation difficult include an anteriorly-placed larynx, oversized or protruding upper incisors, a prominent beard, and any congenital abnormalities of the upper airway (6). Age (40-59 years old) and male gender have also been reported as statistically significant risk factors (7).

Aside from the obvious smaller proportions, the airways of young people are complicated by several important anatomical differences that make intubation more challenging in children than adults. These include a large occiput, a large tongue, a high-positioned larynx (at the C3 level whereas in adults it is usually at the C4 to C5 level), anteriorly-slanting vocal cords, a narrow cricoid ring, and an overall funnel-shaped larynx (as opposed to the cylinder-shaped larynx of adults) (8).

(b) Physiological factors

Pregnancy is perhaps the most significant physiological factor contributing to difficulty in airway management. It has been found that the incidence of failed intubations in obstetrics is as much as five to eight times higher than that of general surgery (9,14,15). Pilkington and colleagues (10) suggest that pharyngeal edema due to fluid retention during pregnancy may contribute slightly and that a tendency to abandon intubation very early for pregnant women at any sign of difficulty, including after only a single failed event, would inflate the failure rate (10).

Obesity is another important physiological factor (6,7,11,12). Intuitively, this may be due to the large tongue, greater mass of oropharyngeal tissue, and the typical short, thick neck observed in an obese patient. However, Bond (13) found no correlation between difficulty visualizing the larynx and obesity, the latter being determined by body mass index (BMI) rather than weight alone. Nonetheless, the obese patient poses different challenges for the anaesthetist, including difficult mask ventilation and rapid desaturation, which make induction of anaesthesia particularly hazardous to overweight patients (13).

(c) Pathological factors

There are numerous pathological or disease conditions that can complicate intubation. Some, such as diabetes and arthritis, cause stiffness of the joints. If the cervical spine is involved then atlanto-occipital joint extension may be compromised, thereby imposing difficulty on vocal cord visualization and tube placement (16). Infectious conditions, such as pharyngeal infections, epiglottitis and pneumonia, may cause soft tissue swelling. Tumours and abscesses of the airway and mediastinum often place extreme limitations on airway access (17). Fibrotic scarring or extreme sensitivity of the skin of the face and neck area from burns, trauma, or previous surgery may also pose challenges (1).

Inherited and chronic medical conditions may also increase the potential for difficult intubation (17,18). For example, a recent study found that critically ill patients displayed a high frequency of complications in airway management, as 8% of these patients were difficult intubations. In addition, a high mortality rate (15%) was associated with tracheal intubations in patients with systemic hypotension (18).

RECOGNITION OF THE DIFFICULT AIRWAY BEFORE INTUBATION IS ATTEMPTED

As many of the aforementioned physiological and pathological conditions are recognized before anaesthesia induction, they are rarely responsible for anaesthesia-related disastrous outcomes, such as death or brain damage from hypoxia (1). It is the unexpected difficult intubation that provides the greatest challenge to anaesthetists and emergency care personnel. In order to minimize the number of these, several researchers have devised simple pre-operative assessments based on certain anatomical measurements that offer varying degrees of accuracy in predicting the prospective difficulty of a given intubation.

One of the best known is the Mallampati test, a simple visual test that can be performed quickly at the bedside (19). The patient is classified based on the relative ability to visualize the faucial pillars, soft palate and uvula (19). The patient must sit upright with the head in a neutral position, the mouth open as wide as possible and the tongue extruded as far as possible. The resultant classification is summarized in Table 1, with class IV representing the most difficult intubation.

Table 1: *Classification of airways based on the Mallampati test (19)*

Class	*Criteria*
I	soft palate, uvula and faucial pillars all visible
II	soft palate, fauces and part of uvula visible
III	soft palate visible with or without base of uvula
IV	none of soft palate or uvula visible

Although this test has achieved considerable popularity among clinicians and other caregivers, it has some limitations. Some feel that the Mallampati test has poor sensitivity, with subjective bias that makes it extremely susceptible to variation among different observers (10,20-23). Furthermore, the effects of patient posture and phonation also cause variations in test results (24). On the other hand, Frerk (25) found that the Mallampati test has poor specificity. The test predicted a large number of difficult intubations (81%) but it also gave a high number of false positives. The specificity was markedly improved by modifying the Mallampati test to include a measurement of the patient's thyromental distance, with 7cm or less being a predictor of difficulty (25). Savva (23) has demonstrated that sternomental distance is even more sensitive and specific than thyromental distance and may also be a good indicator of maximum head extension. Similarly, Delilkan (26) has recommended a measure of the level of the mentum relative to the inferior occipital prominence at maximum head extension.

Wilson and colleagues (11) have designed a somewhat more complex test based on weight, head and neck mobility, jaw mobility, extent of receding mandible and extent of incisor protrusion. Although it has higher inter-observer correlation (Ref. 21), this test has been criticized for its poor sensitivity.

Although the accuracy of each of these tests has been shown to be less than 100%, no single predictive test can offer 100% sensitivity and specificity (14,23,25). However, the combined use of two of these simple tests improves the sensitivity and specificity (25). Bellhouse and Dore (27) have shown that by using a multi-factorial assessment method based on reduced atlanto-occipital extension, reduced mandibular space and increased anterior-posterior thickness of the tongue, 100% predictive accuracy in difficult airway assessment can be achieved.

EQUIPMENT AND TECHNIQUES WHICH AID IN THE DIFFICULT INTUBATION

Regardless of whether a difficult airway is predicted prior to the start of an intubation, it is inevitable that special equipment or a specialized technique will be necessary for successful completion of the procedure. A wide variety of intubation techniques is available.

The bougie

One of the older techniques, which has been touted by many as being the first method of choice in handling a difficult intubation, involves the use of a flexible introducer known as a "bougie" (10). The bougie is inserted into the trachea with direct laryngoscopy. One of the bougie's unique qualities is that even if the view of the trachea is not optimal, one can feel the bougie skipping lightly over the cartilaginous tracheal rings, indicating a successful intubation. The endotracheal tube is then advanced over the bougie for proper placement in the trachea. The bougie is then removed. Confirmation of correct placement of the tube into the trachea can be achieved using the usual methods of auscultation and end-tidal CO_2. Bougies have also been shown to be useful in maintaining airway access during extubation, which is particularly useful when reintubation is anticipated in patients with a history of difficult intubation (29).

The Augustine Guide™

A newer device that acts to guide the endotracheal tube into position is the Augustine Guide™ (AG) (30). This instrument is a molded piece of plastic that fits into the glottis in a lock-and-key manner. The AG is a device that allows for blind intubation, i.e., without visualization of the vocal cords and without special positioning of the head and neck. Prior to beginning the intubation, the endotracheal tube is fitted onto the AG and a special stylet is threaded through the lumen of the tube. The stylet is hollow, with several holes in its distal end and a syringe attached to its proximal end. The patient's mouth is opened, a bite-block inserted between their right molars, and the AG-tube-stylet unit is inserted in his/her glottis. The stylet is advanced slightly and placement in the trachea is confirmed by aspirating free air with the syringe. The endotracheal tube is detached from the AG and advanced over the stylet into the trachea. The stylet is removed and tube placement confirmed as described above.

A study by Carr and Belani (31) indicates a success rate of 94% for AG intubations in anaesthetized, paralyzed patients. They found no correlation between Mallampati class and difficulty in intubation. Although the presence of a maxillary overbite or mandibular micrognathia caused an increased requirement for repositioning of the guide, they did not result in a higher failure rate in these patients (31). However, there may be false-positive air aspiration in the presence of esophageal intubation or heavy secretions from the trachea may occlude the holes at the tip of the stylet, thus preventing confirmation of placement in the trachea (30).

Laryngoscopes

There are a number of laryngoscope designs that have been developed over the past several decades, all for the purpose of increasing the ease of endotracheal intubation (32). Some designs have proven to be quite innovative. For example, the incorporation of a mirror or prism onto the Bellhouse blade allows for indirect visualization of the vocal cords (33). Other laryngoscope designs, such as the Bullard laryngoscope, use fibreoptics to allow a direct view of the vocal cords with minimal manipulation of the head and neck, thus making many difficult intubations much easier (34).

A more recent laryngoscope, referred to as the "levering laryngoscope," has a hinged tip at the distal end of the blade under the control of a lever at the proximal end of the laryngoscope handle. This device functions in the same manner as a conventional laryngoscope and, therefore, does not require any special training for its use (36). Like a conventional laryngoscope, the tip of the blade is placed between the base of the tongue and the epiglottis but the use of the lever will move the tip forward to allow direct visualization of the larynx (36).

Laryngeal mask airway

The laryngeal mask airway (LMA) does not require visualization of the larynx for its placement and has a success rate of approximately 95% (37). While it provides an adequate airway for ventilation and oxygenation, the LMA does not effectively prevent aspiration of regurgitated stomach contents in anaesthetized patients (38). However, the structure and functional positioning of the LMA allows a 6 mm cuffed endotracheal tube to be safely passed down its lumen and properly positioned in the trachea (39). This facilitation of blind intubation by the LMA is a valuable aid in difficult intubations and prevents aspiration of regurgitants.

Magnet-guided intubation

The use of a powerful magnet to guide a steel stylet through the glottic opening and into the trachea is another technique for tube placement (40). Once the stylet is correctly placed, the endotracheal tube can be simply advanced over it into the trachea. This technique is especially useful in the presence of blood and secretions when visualization of the larynx is poor.

Tactile digital intubation

Tactile digital intubation was first described over 200 years ago (see ref. 48). This technique is rarely used except in emergencies or when proper intubating equipment is not available. The epiglottis is palpated with the middle finger of the practitioner's non-dominant hand. The dominant hand is then used to advance the endotracheal tube along the non-dominant hand's fingers into the trachea as the index and middle fingers of the non-dominant hand guide the tip (46,48). Confirmation of proper tube placement can be determined as described above.

Blind intubation

Perhaps one of the simplest techniques described to date was reported by VanElstraete and Remy (41). They successfully performed a blind intubation using nothing more than the endotracheal tube itself. The cuff was first inflated with 15 mL of air and the tube was advanced gently until slight resistance was felt as the inflated cuff made contact with the vocal cords. The cuff was then deflated and the tube advanced into the trachea. A follow up study by VanElstraete and colleagues (42) has confirmed that this method is an effective blind intubating technique.

The fibrescope

The fibrescope, or flexible fibreoptic bronchoscope, is a more technologically advanced instrument that is regularly used to manage difficult airways (43). The flexibility of the fibrescope allows it to be dextrously manipulated through the upper airway under direct vision. The lubricated fibrescope itself acts as a guide over which the endotracheal tube can be guided into the trachea (44). Fibreoptic intubation is seen as a favourable intubation technique that can be used for both routine and difficult procedures as it is relatively atraumatic and requires little manipulation of the head and neck. In addition, it can be performed on both the anaesthetized and awake patient. However, the fibrescope is an expensive piece of equipment and its use is relatively difficult to master. Furthermore, airway trauma with an excess amount of blood or secretions will prove difficult for fibreoptic intubation (43) or a critical upper airway narrowing due to edema or a tumour (45) may make fibrescopy more difficult.

The lightwand

An instrument that employs trans-illumination of the soft tissues of the neck, but does not rely on visualization of the cords, is the lighted-stylet or "lightwand." The rigid stylet is placed inside the lumen of the flexible wand, which is in turn placed inside the lumen of the endotracheal tube and together they are affixed to the handle. The stiffness of the stylet allows the apparatus to be guided into the glottic opening (46). Once through the glottis, the stylet is retracted and the pliable wand-and-tube unit can be guided into the trachea. Verification of placement within the trachea occurs when a bright, well-defined, circumscribed glow is seen through the skin below the thyroid prominence (46). The wand is then removed and the tube kept in place, followed by confirmation of the tube placement.

The lightwand has been demonstrated to be extremely effective in intubating patients with difficult airways (47) and is a much cheaper instrument than the fibrescope. It is also a relatively simple technique to master compared to fibreoptic intubation. However, it should be used with extreme caution in patients with upper airway trauma or airway tumours, since visualization of the trans-cutaneous glow in the upper airway is often not possible in these instances.

Other noninvasive techniques

Recently two very different, highly technological instruments have been introduced to assist in difficult intubations. Kawana and colleagues (49) described using three-dimensional computed tomography of the pharynx and larynx to aid intubation of two patients whose airways were distorted anatomically from previous surgery. Broomhead *et al.* (50) described the use of a cuirass ventilator called the Hayek oscillator to ventilate a patient with a history of failed fibreoptic intubation. They claimed this as being a "major advance for upper airway surgery," since there is no need to use a tracheal tube with the Hayek oscillator. Reports of the use of these two very innovative and technological interventions are anecdotal at present and the efficacy and cost of these procedures must be assessed with controlled studies.

Retrograde intubation

Several invasive procedures are also available to aid the placement of a tracheal tube. Retrograde intubation or trans-laryngeal-guided intubation involves entering the trachea percutaneously below the oropharynx, and then passing a guide cephaladly into the oropharynx, over which the endotracheal tube can be accurately guided into the trachea. This technique is especially useful for airway management of patients with anatomic abnormalities or cervical injuries as well as in emergent situations where other techniques have failed or when no other equipment is available (48). Retrograde intubation has been shown to be associated with a complication rate of less than 1% (52). The vast majority of these are minor and self-limiting in nature, consisting mostly of bleeding and subcutaneous emphysema (51).

Tracheostomy

The tracheostomy is almost exclusively reserved for emergent cases, especially those involving blunt laryngeal trauma (53). However, in general medicine it is performed most commonly for ventilator-dependent patients who have had prolonged periods of endotracheal intubation (54). The establishment of a tracheostomy is a surgical procedure (53). In the emergency setting, the need for a tracheostomy should be recognized early so that prompt surgical consultation and appropriate intervention can be carried out. The expediency of the procedure, coupled with its low morbidity, cause it to remain an important technique in emergency airway control (55).

Trans-tracheal jet ventilation

Occasionally a tracheostomy may not be possible in an acute setting due to lack of equipment, proper conditions or time. In such cases, trans-tracheal jet ventilation (TTJV) may be an alternative, provided an appropriate high pressure oxygen source with proper connections is available (1). In addition to being quicker, easier, and safer than a tracheostomy (56), TTJV has been shown to provide adequate air supply for indefinite periods in patients for whom a tracheostomy replacement has proven difficult (57).

PREPARATION FOR THE DIFFICULT INTUBATION: REQUISITE SKILLS AND TRAINING

Each of the previously described techniques does not adequately deal with a difficult airway if the practitioner has not acquired the skills necessary to perform them. Some techniques are easier to learn than others but it is essential that at least several are mastered so that a difficult intubation may be performed successfully regardless of the circumstances or the available technology. This is especially true for professionals who may find themselves in a difficult situation with little assistance available, such as paramedics or rural general practitioner (GP) anaesthetists. Indeed, it has been suggested that at a minimum, all GP anaesthetists should have a twelve month training period in anaesthesia (58) and be proficient in the use of introducers (guides), angulated blades, and the laryngeal mask airway (59).

The more technological methods are essential skills for anaesthetists. Although fibreoptic-guided endotracheal intubation requires much effort and practice, it is probably the most widely used piece of technology. However, despite the amount of training, the number of techniques and accumulated experience, there will still be patients who remain "impossible" to intubate. It is John McIntyre (32) who offers the ultimate piece of wisdom when he says: " it is the user who determines the usefulness of the instrument. Examine your patient, understand laryngoscopes, learn how to use them." Perhaps an appropriate addendum to this axiom is: "know when an alternative is required and have the necessary equipment and skills on hand so that difficulty does not unnecessarily lead to failure."

ACKNOWLEDGEMENTS

The author would like to thank Dr. Orlando Hung, Dept. of Anaesthesiology, QEIIHSC for his helpful suggestions regarding revisions and references.

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