Lighted Stylet Tracheal Intubation: A Review

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Historical Perspectives

Tracheal intubation is older than the recognized history of general anesthesia itself. In the late 18th century, The Royal Humane Society of London used tracheal intubation for resuscitating the near-drowned. Approximately 100 years later, MacEwan (1) performed a digital tracheal intubation in an awake patient before a chloroform and air general endotracheal anesthetic for the resection of a tongue tumor, and in 1928, Magill (2) incorporated blind nasal tracheal intubation as a part of a general anesthetic. Although laryngoscopes were invented in the 19th century, tracheal intubation under direct visualization was greatly enhanced by the development of a special laryngoscope blade by Macintosh (3) in 1943.

The first reported use of a lighted stylet used to facilitate intubation came in 1957 when (by now Sir Robert) Macintosh (4) described an 18-inch illuminated tracheal tube introducer, which was designed to stiffen the tube and better illuminate the cords by supplementing the light of the laryngoscope. Berman (5) described a similar device in 1959 and said it was useful “when the fickle light of the laryngoscope has gone out at the most inopportune time.” In the same year, Yamamura et al. (6) described a light bulb-tipped wire that was inserted into the tracheal tube before blind nasal intubation in awake patients. The tube position was then determined by the medial transillumination of the external throat and neck.

In 1977, Foster (7) used a transilluminating fiberoptic bundle to facilitate tracheal intubation in a young child with trismus, and Ducrow (8), in the following year, used a flexible surgical light (Flexi-lum™, Concept Corporation, Clearwater, FL) to achieve the same end by first passing a guide (two plastic suction catheters connected end-to-end) into the trachea followed by passage of the tracheal tube over the guide. In correspondence to the latter article, Rayburn (9) commented that the Flexi-lum™ could be positioned inside the tracheal tube, thereby shortening the intubation sequence and claimed that the technique, nicknamed “lightwand intubation,” had been used for some years at the Brooke Army Medical Center.

Development of Commercial Devices

The Flexi-lum™ was originally designed for intraarticular illuminations in orthopedic surgery. Its use as a tracheal intubation device ended after a serious complication in which the distal bulb became detached and had to be retrieved from the patient’s right lower lobe bronchus (10). In this case, the Flexi-lum™ had been reused after sterilizing and repeated handling and may have had a weakened bulb/stylet connection. The Tube-Stat™ (Xomed, Jacksonville, FL) evolved from the Flexi-lum™ in the mid1980s and included a sleeve surrounding the bulb designed to prevent bulb loss; however, the smallest tracheal tubes that could be fitted over the Tube-Stat™ were 5.5-mm internal diameter (ID), limiting their use in pediatric practice to children over six years.

Current lightwands are largely fiberoptic in design and have either external or internal light sources (Figure 1). Most have addressed the demand for pediatric options. The Imagica™ (Fiberoptic Medical Products, Allentown, PA) lighted stylet can accommodate tubes as small as 2.5-mm ID and requires an external light source. The light source serves as the handle for the Anesthesia Medical Specialties (AMS; Santa Fe, CA) stylet which comes in adult and pediatric sizes and is stiff enough to maintain its shape. The pediatric stylet was developed after Krucylak and Schreiner (11) altered an adult stylet by grinding the distal brass bulb away to allow passage of a 3.5-mm ID tracheal tube. The Trachlight™ (Laerdal, Armonk, NY), also with an internal light source/handle, has a retractable stylet which allows for good stiffness but subsequent flexibility once the stylet is withdrawn. This improved on earlier models in which “because of the rigidity of the wand portion of the device, the tracheal tube was frequently dislodged from the glottic opening while withdrawing the light wand” (12). It also has a connector clamp which allows for securing of the tube
during intubation. The Trachlight™ is now provided with three stylets which are reusable and will accommodate tracheal tubes from ID size 2.5–10 mm.

Newer devices have been developed that use transillumination or transmission of sound, in combination with other intubating guides. The AMS shuttle combines a lighted stylet with a fiberoptic scope (Fiberlightview™, Anesthesia Medical Specialties). This combination is intended to provide transillumination and internal visualization of the larynx either directly or on a screen. No published trials at Children’s Hospital of Philadelphia have demonstrated the utility of this approach, which, combined with direct laryngoscopy, has been termed “videointuboscopy” (13). Optical-audio feedback systems use the fine frequency discrimination of the human ear to direct the tube past the glottis (14). This technique relies on the principle that human hearing is more sensitive than visual detection and that therefore converting light intensity to an audio signal will enhance the changes in a visual signal. Aspects of several different commercial light-wands are summarized in Table 1.

**Comparative Trials and Studies**

*Learning the Technique*

Lighted stylet tracheal intubation requires practice, but is easily learned. Ellis et al. (15) found that intubator training in a cadaver laboratory and clinical experience influenced the speed of intubation, but not the success rate on the first attempt. In the first 25 attempts, the average time for a successful intubation was 42 seconds, and this time decreased to an average of 32 seconds for the second 25 attempts. Even early in the trial, all lighted stylet intubations were successful by the third attempt. Fisher and Tunkel (16) performed a videographic study of 125 children (mean age three years) who were tracheally intubated by anesthesia residents with little or no lighted stylet experience. They found an overall success rate of 83% and a 76% success rate in infants weighing <10 kg. Failures generally had one of two causes: either too large a tracheal tube was chosen or there was persistent vallecular or esophageal entry.

*Lighted Stylet Compared with Direct Laryngoscopy*

Many studies have been performed to compare lighted stylet technique with traditional methods of tracheal intubation (Table 2). Ellis et al. (15) were the first to show that lighted stylet intubation (Tube-Stat™) compared well with direct laryngoscopy by using a Macintosh blade. They found no time advantage in intubating the trachea in the traditional method nor was the use of a lighted stylet associated with a more frequent incidence of complications. In a trial comparing blind nasal with lighted stylet intubation, Fox et al. (17) found that both time to intubation (means 119.7 vs 37.9 seconds) and number of intubation attempts were significantly less in the latter group. These results are all the more impressive when one considers that three of the participants had not performed lighted stylet intubation before this study. Weis and Hatton (18) reported a case series of 253 patients in whom the lighted stylet had been used in a variety of clinical settings with much success. Two hundred fifty were successfully intubated by using the lighted stylet. The three failures occurred in grossly obese subjects. Twenty of these patients had been impossible to tracheally intubate by using direct laryngoscopy. The largest trial performed involved 950
Table 1. Commercial Lighted Stylets

<table>
<thead>
<tr>
<th>Product</th>
<th>Features</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tube-Stat™</td>
<td>Limited reuse bulb</td>
<td>Modestly bright</td>
<td>Inadequate length</td>
</tr>
<tr>
<td>Xomed, Jacksonville, FL</td>
<td>25 (oro), 33 (naso) cm</td>
<td>Appropriate stiffness</td>
<td>High failure rate</td>
</tr>
<tr>
<td></td>
<td>Cost approx. $30</td>
<td></td>
<td>No infant stylet</td>
</tr>
<tr>
<td>Lighted Intubation Stylet</td>
<td>Limited reuse bulb</td>
<td>Bright light</td>
<td>Adult stylet too long and of inadequate stiffness</td>
</tr>
<tr>
<td>Aaron Medical, St. Petersburg, FL</td>
<td>Adult, pediatric, nasal</td>
<td>Pediatric size (4.0-4.5-mm ID minimum)</td>
<td>No infant stylet</td>
</tr>
<tr>
<td>Imagica Fiberoptic Lighted Stylet</td>
<td>Variable size fiber bundles</td>
<td>Brightness adjustable</td>
<td>Need separate light source</td>
</tr>
<tr>
<td>Fiberoptic Medical Products, Allentown, PA</td>
<td>Rheostat controlled light source</td>
<td>2.5-mm id, adult sizes with appropriate stylets</td>
<td>Difficult to control and too flexible</td>
</tr>
<tr>
<td></td>
<td>Cost approx. $90+ disposable sleeve</td>
<td>Can augment light output of metal stylets (AMS)</td>
<td></td>
</tr>
<tr>
<td>Trachlight™</td>
<td>Reusable light-flashes after 30 s</td>
<td>Very bright light</td>
<td>Expensive</td>
</tr>
<tr>
<td>Laerdal, Armonk, NY</td>
<td>Retractable stylet adult, child, infant</td>
<td>Good stiffness which can be removed with stylet retraction</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cost approx. $300 handle + $50 for reusable wand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fiberoptic Lighted Intubation Stylet</td>
<td>Reusable, metal jacketed fiber bundle</td>
<td>Light appropriate for children</td>
<td>Light inadequate for many adults</td>
</tr>
<tr>
<td>Anesthesia Medical Specialties, Santa Fe, CA</td>
<td>33 cm adult, 21 cm pediatric</td>
<td>Reusable, thin diameter adult pediatric 3.5-mm ID</td>
<td>Light can be too bright for infants</td>
</tr>
<tr>
<td></td>
<td>Cost approx. $75 for handle and stylet ($35 for stylet alone)</td>
<td>Fiberoptic bundle for endoscopic visualization</td>
<td>Fragile switch but can be replaced</td>
</tr>
<tr>
<td>The Shuttle™</td>
<td>Adult 33 cm, pediatric 21 cm (3.5 mm ID)</td>
<td>Potential for visualization of laryngeal structures</td>
<td>Unreliable visualization through fiberoptic bundle caused by encroachment of soft tissues</td>
</tr>
<tr>
<td>Anesthesia Medical Specialties, Santa Fe, CA</td>
<td>Cost approx. $925</td>
<td>Ease of use similar to AMS Fiberoptic lighted intubation style</td>
<td>Very expensive</td>
</tr>
</tbody>
</table>

Prices are given in US $. approx. = approximate, ID = internal diameter, AMS = American Medical Specialties.
patients comparing Trachlight™ with direct laryngoscopy, noting time to intubation in both groups, difficult intubation predictors such as the Mallampati score, success rate, and complication rate (19). The success rates were comparable for the two groups; however, the time to intubate was significantly shorter in the Trachlight™ group.

**Prediction of Ease of Intubation**

Traditional methods of estimating degree of difficulty in achieving tracheal intubation under direct laryngoscopy may not apply when a lighted stylet approach is undertaken. Ainsworth and Howells (20) evaluated the use of the Tube-Stat™ on 200 patients who also

### Table 2. List of Clinical Trials of Lighted Stylet Intubation

<table>
<thead>
<tr>
<th>First author (Ref)</th>
<th>Year</th>
<th>n</th>
<th>Comparison</th>
<th>End points</th>
<th>Outcome (LS/conventional)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ellis (15)</td>
<td>1986</td>
<td>100</td>
<td>Tube-Stat™ versus Macintosh3</td>
<td>1. T(i) 2. N(i) 3. Trauma 4. Arrhythmias 5. Coughing</td>
<td>1. 37 ± 13/33 ± 9s 2. 72%/98% 3. 23%/18% 4. 14%/2% 5. 26%/41%</td>
<td>1. &gt;0.05</td>
</tr>
<tr>
<td>Friedman (23)</td>
<td>1997</td>
<td>40</td>
<td>Fiber-optic ITS-510 versus MAC3</td>
<td>1. ΔMAP (induction-intubation) 2. ΔHR (induction-intubation) 3. T(i) 4. N &gt; 5 PVC’s</td>
<td>1. 20/24/35 mm Hg 2. 27/25/25 bpm 3. 14 ± 6/15 ± 6/ 23 ± 8s 4. 23%/10%/17%</td>
<td>1. &gt;0.05</td>
</tr>
<tr>
<td>Fox (17)</td>
<td>1987</td>
<td>23</td>
<td>Flexi-lum™ versus blind nasal intubation</td>
<td>1. T(i) 2. N(i) 3. Trauma (epistaxis)</td>
<td>1. 3.7/119.7s 2. 1.1/3.1 3. 0%/70%</td>
<td>1. &lt;0.01</td>
</tr>
<tr>
<td>Knight (22)</td>
<td>1988</td>
<td>56</td>
<td>Flexi-lum™ versus MI2 versus MAC3</td>
<td>1. ΔMAP (induction-intubation) 2. ΔHR (induction-intubation) 3. T(i) 4. N &gt; 5 PVC’s</td>
<td>1. 20/24/35 mm Hg 2. 27/25/25 bpm 3. 14 ± 6/15 ± 6/ 23 ± 8s 4. 23%/10%/17%</td>
<td>1. &gt;0.05</td>
</tr>
<tr>
<td>Ainsworth (20)</td>
<td>1989</td>
<td>200</td>
<td>Tube-Stat™</td>
<td>1. C&amp;L 2,3,4 2. SS I,II,III,IV 3. N (failures) 4. Trauma</td>
<td>1. 5.9 ± 10.8/ 19.6 ± 23.7s 2. 92.3%/93.8% 3. 1.04%/2.76% 4. 2.08%/7.85%</td>
<td>1. &gt;0.05</td>
</tr>
<tr>
<td>Hung (19)</td>
<td>1995</td>
<td>950</td>
<td>Trachlight™ versus direct laryngoscopy</td>
<td>1. T(i) 2. N(i) 3. N (failures) 4. Trauma</td>
<td>1. 1.57 ± 10.8/ 19.6 ± 23.7s 2. 92.3%/93.8% 3. 1.04%/2.76% 4. 2.08%/7.85%</td>
<td>1. &gt;0.05</td>
</tr>
<tr>
<td>Hung (41)</td>
<td>1995</td>
<td>206</td>
<td>Trachlight™ in patients with h/o or anticipated difficult intubation</td>
<td>1. T(i) 2. N(i) 3. N (failures) 4. Trauma</td>
<td>1. 25.7 ± 20.1s 2. 79.1% 3. 0.97% 4. 15.55</td>
<td>No corr</td>
</tr>
<tr>
<td>Hung (41)</td>
<td>1995</td>
<td>59</td>
<td>Trachlight™ in patients with unanticipated difficult intubation</td>
<td>1. T(i) 2. N(i) 3. N (failures) 4. Trauma</td>
<td>1. 19.2 ± 13.5s 2. 84.7% 3. 0% 4. 39%</td>
<td>No corr</td>
</tr>
<tr>
<td>Berns (47)</td>
<td>1996</td>
<td>73</td>
<td>Tube-Stat™ versus Miller/Macintosh blade in children with cervical immobilization</td>
<td>1. T(i) 2. N(i) 3. N (failures) 4. Trauma</td>
<td>1. 2.2/1.5 2. 124.3 ± 77/70 ± 35s</td>
<td>1. &lt;0.01</td>
</tr>
<tr>
<td>Friedman (23)</td>
<td>1997</td>
<td>40</td>
<td>Fiber-optic ITS-510 versus MAC3 in outpatient setting</td>
<td>1. ΔMAP (induction-intubation) 2. ΔHR (induction-intubation) 3. Sore throat (ss3)</td>
<td>1. -1/5 mm Hg 2. 6/7 bpm 3. 0%/32%</td>
<td>1. &gt;0.05</td>
</tr>
<tr>
<td>Hirabayashi (24)</td>
<td>1998</td>
<td>40</td>
<td>Trachlight™ versus Macintosh</td>
<td>1. T(i) 2. ΔMAP (induction-intubation) 3. ΔHR (induction-intubation) 4. Coughing</td>
<td>1. 22 ± 11/24 ± 11s 2. 25 ± 21/ 23 ± 19 mm Hg 3. 16 ± 14/ 16 ± 15 bpm</td>
<td>1. &gt;0.05</td>
</tr>
</tbody>
</table>

**Notes:**

- **n** = number of subjects in trial, **T(i)** = time for intubation, **N(i)** = number of attempts for successful intubation, **N(i) 1st** = the percentage success rate for first time intubation, **LS** = lighted stylet, **MI2** = Miller 2, **MAC3** = Macintosh3, **nq** = significance not quoted, **sig** = significance claimed (for the figure in brackets) but level not quoted, **C&L** = Cormack&Lehane grade of laryngoscopy, **SS** = success score (1 = success at 1st attempt, II = success after 5 attempts, III = success after multiple attempts within 1 min, IV = failure to intubate within 1 min), **ss3** = severity scale 3, i.e., “more severe than a cold”, **NA** = not applicable, **ΔMAP** = change in mean arterial pressure (induction-intubation), **ΔHR** = change in heart rate (induction-intubation).
were scored for ease in laryngoscopy by using the Cormack and Lehane (21) classification. They found that 87.5% of the patients were successfully intubated on the first attempt by using a lighted stylet, 99% were tracheally intubated within three attempts, and that there was no correlation in the number of attempts to the Cormack and Lehane (21) score. In a series of 950 patients, Hung et al. (19) found there was no correlation between the time to intubate and any of the airway prediction variables in the Trachlight™ group. This contrasted with the direct laryngoscopy group in which some of the airway variables, such as the Mallampati score and the circumference of the neck, did correlate with the time to intubate the trachea.

**Sympathetic Stimulation During Intubation**

Laryngoscopy and endotracheal intubation are both intensely stimulating procedures and are associated with varying degrees of sympathetic activity which may be detrimental in patients with coexisting conditions, such as coronary artery disease, elevated intracranial pressure, and asthma. Several groups have investigated the possibility that lighted stylet intubation may result in less stimulation than direct laryngoscopy and may offer some protective effects from sympathetic hyperactivity. A study that compared two direct laryngoscope blades, the Macintosh 3, and the Miller 2, with lighted stylet intubation showed no significant difference in hemodynamic changes among the three groups (22). There was a tendency for the lightwand group to have lower arterial blood pressures (means, 110 mm Hg for lighted stylet versus 128 mm Hg for Macintosh 3) and slower heart rates (95 bpm for lighted stylet versus 108 bpm for Macintosh 3) at intubation. However, the findings did not reach significance with only 56 patients in the study and were confounded by the different levels of experience of the laryngoscopists. The speed of intubation in the lighted stylet group compared favorably with the direct laryngoscopy groups, so that the authors concluded that the lighted stylet facilitated tracheal intubation is no worse than traditional methods at producing sympathetic stimulation. More recently, Friedman et al. (23) studied 40 subjects receiving either rigid laryngoscopy (Macintosh 3 blade) or lightwand intubation as part of a standardized outpatient general anesthetic. Heart rate and blood pressure changes during intubation were recorded, although the arterial blood pressures were only measured every minute by using a noninvasive cuff. As with Knight et al.’s (22) study, there was no statistical hemodynamic difference between the lighted stylet and the direct laryngoscopic intubation technique. Only patients of ASA physical status I and II were recruited into this trial, and the numbers were quite small. Finally, in a study with 40 patients who had continuous invasive blood pressure measurement, Hirabayashi et al. (24) showed no significant maximal heart rate and blood pressure changes during tracheal intubation. There was no difference in the time taken to achieve tracheal intubation. As with the previous two studies cited, no power analysis was included in the methodology. Despite the failings of these studies, it appears that lighted stylet tracheal intubation, if performed in the same time as direct laryngoscopy, should not incur greater hemodynamic instability. Larger studies would elucidate if there was any advantage to the use of lighted stylet intubation in special cases, e.g., patients with hypertension, coronary artery disease, and increased intracranial pressure.

**Complications and Safety**

Friedman et al. (23) compared the morbidity of tracheal intubation using direct laryngoscopy versus lighted stylet in an outpatient setting by means of a follow-up telephone call by a blinded investigator 16–24 hours postoperatively. Patients were questioned about the presence and severity of sore throat, hoarseness, and dysphagia. The lightwand group had a significantly lower incidence of all three complications and less severe cases of hoarseness and sore throat. In Hung et al.’s (19) large comparative trial, the oropharynx of each patient was inspected for signs of mucosal bleeding, dental trauma, and lacerations. After extubation, a blinded recovery nurse asked the patients about dry throat, sore throat, or hoarseness. There was a significantly lower incidence of traumatic events and fewer postoperative sore throats in the lighted stylet group.

One concern that has been raised when using a lighted stylet is the possibility of heat damage to the tracheal mucosa during prolonged intubation attempts. This is one of the reasons why the manufacturers of the Trachlight™ have designed the bulb to flash on and off after 30 seconds of being continuously on. (The other quoted reason is to remind the intubator that the patient has now been apneic for 30 seconds and may need reoxygenation.) Nishiyama et al. (25) investigated the possibility of mucosal damage by using the Trachlight™ in a cat model, with histological examination performed by a blinded pathologist, the control being tracheal mucosa in contact with a tracheal tube for one hour. They measured the temperature at the tip of the Trachlight™ and found that it reached $55^\circ \pm 6^\circ$C at the time of the first blink and $103^\circ \pm 10^\circ$C after 10 blinks (250 seconds in total). There were no macroscopic signs of burn injuries in any of the cats. Histologically, although there was moderate neutrophil and lymphocyte infiltration in
both the Trachlight™ and the control specimens, there were no significant differences between the two sides. These findings suggest that there is little risk of burn injury from the clinical use of the Trachlight™, although the authors do concede that there may be interspecies variation and that the hour allowed in the study between insult and fixation may not have been long enough to cause histological changes. This issue is only of concern where there is a bulb at the tip of the stylet, e.g., Trachlight™, but in models where the light is fiberoptic transmission of the light in the handle, e.g., AMS, there will be no heat at the tip.

**Techniques**

**I. Basic**

The distal end of the stylet should be lubricated with silicon spray or a water-based surgical lubricant and the tracheal tube loaded onto it. Excessive lubricant, which spreads to the proximal end of the tracheal tube, loosens the junction between the tube and its 15-mm connector. For most devices, the tube connector should be removed before loading and then reconnected once tracheal intubation is complete. This facilitates unimpeded delivery of the tracheal tube over the distal bend of the stylet. With the Trachlight™ this action is not necessary because 1) a connector bracket is designed to hold the tube in place on the stylet and 2) the retractable inner stylet is withdrawn before advancing the tracheal tube, obviating any resistance at the distal end. The connector must be placed in a routine location so that one remembers its whereabouts when the tracheal tube is in place and ready to be connected to the breathing circuit. When properly loaded, the tip of the stylet should remain just inside the tracheal tube. A rubber stopper is useful to prevent the tube’s riding up the stylet and exposing the potentially damaging rigid stylet tip to oropharyngeal, laryngeal, or tracheal structures.

The stylet is then shaped, bending it 3–6 cm from the distal end to a 90°–120° “hockey-stick” formation. For a cuffed tracheal tube this would be just proximal to the cuff. The bend should be made at approximately the base of the tongue along the patient profile, such that the stylet tip is at the level of the laryngeal inlet when the proximal portion is situated in the oropharynx. This allows maximal light intensity to be directed along the anterior neck wall, producing a well circumscribed light first at the level of the hyoid and then distally toward the suprasternal notch (Figure 2).

After the induction of anesthesia with or without neuromuscular blockade, the patient’s lungs are ventilated with 100% oxygen, and the head and neck are positioned to increase the success rate of lighted stylet intubation. An exaggerated sniffing position, used for direct laryngoscopy, is not required. For most patients, slight extension of the head will lift the epiglottis from the posterior pharyngeal wall and increase visibility of the superior anterior neck. For those with suspected cervical spine injuries, the head should be kept in a neutral position. In the obese or short-necked subjects, a roll under the shoulders may improve exposure of the neck and success rate. Some intubators dim the room lights at this point, although the advocates of Trachlight™ claim that 88% of intubations can be done with ambient light with or without shading of the neck (19). Iwama et al. (26) concluded that adequate transillumination through the pharynx in adults requires an ambient light intensity of <300 Lux but that an intensity <150 Lux is optimal.

Unlike traditional intubation with direct laryngoscopy, lighted stylet intubation is an ambidextrous technique in which the dominant hand controls the lightwand and the nondominant hand the airway. The operating table is lowered and the anesthesiologist approaches from the side or the head. In general, it is easier to control the whole unit of tube and lighted stylet if a pencil grip is used, combining both the handle and the tube. For oral intubation, the nondominant hand is used to open the mouth with the thumb placed against the mandibular molars while the opposing index finger is pressed against the ramus of the mandible; this hand should be kept as far lateral as possible to allow unobstructed midline placement of the lighted stylet. A firm anterocaudal jaw thrust elevates the epiglottis, improves tactile sensation, and facilitates intubation via gentle lighted stylet motions with the dominant hand (Figure 3).

The lighted stylet is introduced into the oropharynx from the side and brought into the midline following the midsagittal plane transecting the tongue. The tip of the lightwand should be passed under the tongue, and with gentle anterior traction, a bright well circumscribed circle of light at the level of the hyoid indicates that the tip lies in the vallecula (Figure 4). Gentle forward pressure may displace the epiglottis, allowing immediate tracheal intubation (Figure 5). If a bright red glow is seen off the midline, then the tip of the lightwand may lie in one of the pyriform fossae, and the unit should be withdrawn slightly and rotated back toward the midline. If resistance is felt preventing passage into the trachea, then the obstructing epiglottis may be circumvented by a series of rocking or scooping movements redirecting the tip to the thyroid prominence by using the light as a guide (Figure 6). A smaller tracheal tube may be indicated if resistance continues. Because of the lever-arm nature of the stylet, small movements of the hand will translate to larger movements at the tip. The light will remain continuously bright with successful tracheal intubation. Briefly losing the light and then recovering a glow in
the midline normally indicates esophageal intubation. This is especially true in infants and small children. The transient loss of light corresponds to passage behind the larynx, and the return of light results from transesophageal illumination. Intentionally placing the tube in the esophagus may aid recognition of tracheal intubation by acting as a baseline for comparison: the tube is slowly withdrawn from the esophageal inlet with gentle anterior traction until the light suddenly intensifies with the posterior displacement of the larynx. After careful withdrawal of the stylet following the contour of the oropharynx, the 15-mm adapter is reconnected and the tracheal tube placement is confirmed in the usual manner.

In infants and small children, the feel of the light-wand becomes just as important as the appearance of the light: a click is often felt when the tracheal tube/

**Figure 2.** The upper “glow” shows a well defined circle of light just below the hyoid and above the thyroid cartilage in the midline indicating an ideal position for passing the tip of the endotracheal tube between the vocal cords. From this point, the tube should be advanced easily off the stylet and into the trachea where its position will be confirmed by a cone-shaped light above the suprasternal notch (lower “glow”).

**Figure 3.** Oral tracheal intubation with a lighted stylet demonstrating jaw thrust with the nondominant hand and midline technique.

**Figure 4.** The glow demonstrated just as the lighted stylet passes the vocal cords. The initial circle of light just above the thyroid cartilage may change to a cone of light projecting caudally toward the suprasternal notch.

stylet is advanced past the epiglottis. Subglottic stenosis will hinder the passage of the tube off the stylet. When using a lighted stylet, it is generally easier to pass a slightly smaller tracheal tube than one with a maximal age-predicted diameter.
For nasotracheal intubation, the same principles apply with the following additions. The nasal passages must be prepared with a topical vasoconstrictor such as phenylephrine or oxymetazaline. The shape of the stylet should be prepared against the patient profile before insertion just as in the oral approach. The stylet will assume a more gentle J shape. Lubrication is especially important to ease the passage of the tracheal tube-stylet unit through the nose and to ease removal of the stylet from the tube.

II. Hybrid Techniques

Several tracheal intubation techniques have been developed by using the lighted stylet, many in combination with other anesthesia devices.

A. With Direct Laryngoscopy. Turning back to the original Macintosh lighted stylet technique (4), Biehl and Bourke (27) combined direct laryngoscopy with a lighted stylet in an unanticipated difficult laryngoscopy, claiming that the lighted stylet improved the laryngoscopic view and the transillumination assisted them in subsequently guiding the tube into the trachea. To minimize any obstruction in their view of the larynx, they threaded the Murphy eye of the endotracheal tube onto the stylet, which was then thought to be more maneuverable and less likely to cause trauma.

B. With Laryngeal Mask Airway. From its introduction into anesthesia, the laryngeal mask (LMA) has been a useful tool in the management of the difficult airway. One of the methods used to intubate via the LMA is to insert a gum elastic bougie through the grill of the mask and into the laryngeal inlet and then to thread the endotracheal tube over the bougie. This technique may be unreliable, however, as the bougie may track posteriorly and result in esophageal intubation. In an effort to selectively intubate the trachea, Asai and Latto (28,29) replaced the bougie with a Trachlight™ lighted stylet. They claimed a high first attempt success rate (80%) in passing the Trachlight™ wand into the trachea and reported no complications but could not reproduce this success rate when trying to pass the tracheal tube itself. Agro et al. (30) claimed a much higher success rate (100%) of tracheal intubation through an LMA using a Trachlight™ and noted that the crucial factor for success was only attempting intubation once the LMA was perfectly positioned, i.e., detection of a central point of light at the cricothyroid membrane with the Trachlight™ inserted within the LMA.

C. With Fiberoptic Scope. For the most challenging of airways, many practitioners elect awake fiberoptic intubation. This technique can be difficult, especially when obstructing anatomy or blood and secretions obscure the view. Lupien and Taylor (31) describe

Figure 5. A midsagittal view of the properly placed lighted stylet. Note that anterior mandibular traction pulls the base of the tongue and epiglottis forward facilitating easy and gentle stylet positioning.

Figure 6. A demonstration of the “rocking” or “scooping” motion often required to correctly position the stylet and advance the tracheal tube. The dashed figure shows and initial intubation attempt thwarted by the tube tip’s lodging in the vallecula. The intubator must “scoop” the tube and stylet posteriorly around the epiglottis into the laryngeal inlet as indicated by the arrows.
how they aided an oral fiberoptic intubation in a patient with two cervical fusions using a Flexi-lum™ that lay beside the fiberoptic scope in an orotracheal tube. Transillumination by the lighted stylet provided visual cues that helped the anesthesiologist position the fiberoptic scope and intubate the trachea in less than one minute.

D. Airway Introducer. The lightwand can also be positioned by using an airway introducer (Airway Intubator™), which was designed originally as an aid to blind oral intubation. This device prevents lateral movement of the tube and resists the tendency of the tube to pass posteriorly into the esophagus. Williams (32) claims that this device reduces lighted stylet intubation times and is more readily accepted by an awake patient.

E. Local Anesthesia. Although the basic technique described above involves patients who are anesthetized and paralyzed, the lighted stylet can also be used in the awake patient with local anesthesia. Topical anesthesia may be applied in the traditional ways with sprays and anesthetic soaked pledgets or via the tracheal-tube-stylet unit. Higgins and Wherry (33) attached an epidural catheter under the casing of a Surch-lite™ (Aaron Medical Industries, St. Petersburg, FL), which then allowed the anesthesiologist to inject lidocaine on patient inspiration after laryngeal transillumination.

F. Light-guided Retrograde Intubation. Retrograde intubation may be accomplished over a transtracheal flexible catheter which has been inserted percutaneously through the cricothyroid membrane and directed cephalad to exit the mouth. This technique can be modified to include the use of a lighted stylet placed at the tip of the endotracheal tube, which will then guide tube advancement over the catheter. Hung and Al-Qatari (34) used light-guided retrograde intubation in 27 patients who had cervical spine fractures or instability and reported a first and second time success rate of 81% and 19%, respectively.

Tracheal Tube Position

Transillumination of the airway by using a lighted stylet may not only facilitate tracheal intubation but may also confirm proper tube position. Mehta (35) studied 420 intubated adult patients by placing a lighted stylet in the lumen of the tracheal tube (the Heller device) such that the tip lay just proximal to the cuff. The maximal point of transillumination was seen just distal to the cricoid cartilage when the tracheal tube was ideally placed. If the overhead lights were dimmed and cricoid pressure was applied, Mehta found 81% of the transilluminations rated as excellent and 19% as good. This study included subjects of both Caribbean and Indian descent.

There is little margin for error in properly positioning tracheal tubes in the neonatal and pediatric intensive care populations. Traditional methods to confirm this placement include auscultation, palpation, and calculation based on patient size. Despite this, serial chest radiographs are routinely done in most intensive care units to confirm tube placement, incurring ionizing radiation and adding cost. Using a tracheal tube with a fiberoptic strand incorporated into the wall, Heller and Cotton (36) confirmed that transillumination compares well with radiography to confirm tube placement. When the tip of the tracheal tube lay in an ideal position radiographically, (i.e., at the level of the first thoracic vertebra) then the maximal intensity of the transmitted light was seen at the suprasternal notch. Investigating 33 tube placements in infants ranging from 600 to 3100 g, they found that the tube was positioned safely every time, and while this technique would not replace conventional radiography for documenting other features in the chest, it would obviate the need for serial chest radiographs simply to document tracheal tube position.

In a novel adaptation of the transillumination principle, Inoue (37) described a bronchial blocker attached to an endotracheal tube for use in thoracic surgery when one-lung ventilation was required. The blocker, which has a small light source mounted at its distal tip, remained retracted into the main body of the tube until the patient was laid lateral and the main bronchus to be blocked, exposed by the surgeon. The blocker was advanced into the main bronchus by using transillumination for proper positioning without the need for bronchoscopy.

Indications

The Difficult Airway

The difficult airway is possibly the most common indication for the use of the lighted stylet. Patients, who for a variety of reasons are unintubatable by direct or fiberoptic laryngoscopy, can often be intubated by using this method. The reasons for this seem to be the ability of a lighted stylet to negotiate acute oropharynx-tracheal angles, particularly in situations in which neck mobility is limited or contraindicated. An added advantage is that secretions are not an impedance as they can be in direct or fiberoptic laryngoscopy. In its practice guidelines for management of the difficult airway, the task force of the American Society of Anesthesiologists recognizes the value of lighted stylet intubation; the section titled “Techniques for Difficult Intubation” includes the lightwand (38). As with any technique, experience must be gained from intubating normal airways before it can be relied on for the difficult case.
**Adult Difficult Airways**

Holzman et al.’s (39) report in 1988 included four adult patients in whom a difficult intubation was anticipated but were easily intubated by using a lightwand. The airway diagnoses included hemifacial microsomia Type I, Pierre-Robin, postcervical surgery for scoliosis, and Duchenne’s muscular dystrophy.

In a series of 253 patients reported by Weis and Hatton (18), 20 patients were intubated by using a Tube-Stat™ successfully on the first attempt after being found impossible to intubate by using direct laryngoscopy. These 20 patients included 4 patients with complete temporomandibular immobility who were intubated nasally.

The lighted stylet can be inserted into the bronchial lumen of a double-lumen tracheal tube for placement in a patient with an anticipated difficult intubation requiring single-lung ventilation. It may be necessary to trim the length from the tube for the lighted tip to lie at the distal end (40).

In the largest series reported to date, Hung et al. (41) divided 265 patients into those with anticipated difficulty and those with unexpected difficult intubations, in whom the Trachlight™ was to be used. In all but two patients, tracheal intubation was successful with the Trachlight™, the vast majority on the first attempt. The failures were patients who were grossly obese.

**Pediatric Difficult Airways**

Holzman et al. (39) describe 31 patients who had a variety of difficult airway diagnoses and either known or anticipated difficult endotracheal intubations. Twenty-seven of these patients were aged 5–17 years. In all but one case, the trachea was intubated by using a lighted stylet in an average of 30–60 seconds, depending on the seniority of the clinician. Two patients needed repeated instrumentation by more than two anesthesiologists, and pharyngeal bleeding was noted in three patients.

Light wand intubation was limited to tracheal tubes 5.5-mm ID or more until Krucylak and Schreiner (11) reported the use of a fiberoptic lightwand to intubate an infant with hemifacial microsomia. The smaller size of the fiberoptic stylet permitted passage of a 3.5-mm tube.

Schreiner and Cook-Sather (42) and Schreiner and Rehman (43) describe the successful use of the lightwand in four difficult pediatric airways in which fiberoptic and direct laryngoscopy had failed. Two of the patients had hemifacial microsomia, one had congenital ankylosis of the temporomandibular joint, and the fourth had Pierre-Robin anomaly. In the last case, a “homemade” lighted stylet was described allowing passage of a 3.0-mm tracheal tube where direct laryngoscopy and a Trachlight™ prototype had failed. The lightwand consisted of a fiber bundle and a separate stylet with the rheostat-controlled stylet adjusted to maximize the differential between tracheal and esophageal placement. The same fiber bundle has been used to augment the light output of commercial lightwands for obese and for darkly pigmented patients.

**The Emergency Setting**

Although prehospital procedures, such as tracheal intubation and establishment of IV access, are sometimes controversial, especially when rapid transport could bring patients to more experienced physicians and better equipment, medical and paramedical personnel are often called on to secure a challenging airway in the field. Whereas direct laryngoscopy is preferable, lighted stylet intubation is an easily learned and reliable technique for emergency medicine and residents working in an urban mobile intensive care unit (44).

Hartman et al. (45) describe tracheal intubation using a modified lighted stylet technique in four patients with clenched jaws in whom nasal intubation was contraindicated. The lighted stylet was inserted behind the back teeth, the third molars either unerupted or previously extracted, as the cheek was retracted. The tip of the tracheal tube was then advanced toward the larynx in a paramedian approach and was guided by the typical transillumination.

Cervical spine injuries present a particular challenge for airway management, for the airway is likely to be obscured with blood and secretions, and the neck cannot be flexed nor the head extended to aid laryngoscopy. Lighted stylets may be useful under these circumstances, but should not be used if there is suspicion of a fracture of the larynx. Weis (46) claimed a 100% success rate in securing the airway by using lighted stylet intubation in 28 cervical spine cases and noted that the use of lighted stylet intubation was 1) not influenced by blood in the airway, 2) allowed administration of cricoid pressure, and most importantly, 3) kept the cervical spine in the neutral position. Despite intubators’ inexperience with lighted stylets, this mode of intubation compares favorably with direct laryngoscopy in children with cervical spine immobilization (47).

**The Austere Environment**

Faced with an obvious difficult tracheal intubation, many anesthesiologists favor fiberoptic visualization but, because of a lack of equipment or expertise, this may not be possible. At a medical relief mission hospital in Central America, Fox and Matson (48) were asked to anesthetize two children who had severe contractures of the face and neck secondary to burns. In one patient, the mandible was fixed to the anterior
chest wall by adhesions. The second patient had a small and inelastic mouth secondary to facial burns. Direct laryngoscopy for both tracheal intubations was predicted to be impossible. In both cases, by using modifications of the above basic technique, the tracheas were intubated with a lighted stylet in <20 seconds. These cases may have been managed equally successfully with fiberoptic bronchoscopy, but this would have meant the transport of expensive, delicate, and bulky equipment to the mission hospital. Lighted styles are far easier transported, maintained, and cleaned in such environments, which would include military hospitals dealing with wartime casualties.

Contraindications
There are few absolute contraindications to the use of the lightwand. The most prominent is the presence of an upper airway foreign body, tumor, polyp, retropharyngeal abscess, or other friable tissue along the intubation course. A trauma victim who may have sustained laryngeal injury should have direct visualization rather than blind intubation. Some consider a known difficult airway and a planned fiberoptic approach to be a relative contraindication, because a blind lightwand intubation attempt might cause bleeding which could make subsequent fiberoptic visualization of the larynx difficult. In our experience, however, gentle manipulation of the lighted stylet rarely disturbs tissue to the point of hemorrhage, and one or two attempts with this approach does not interfere with subsequent fiberoptic attempts.

Complications
Although lighted stylet intubation has been practiced for many years, there have been very few reported complications. There are two reported incidents of instrument disarticulation. In the first, the bulb from a Flexi-lum™ disconnected and lodged in the patient’s right lung lower lobe after intubation of an airway which had previously been treated with radiation for two carcinomas of the larynx (10). The bulb was immediately removed by using a fiberoptic bronchoscope, but the patient developed aspiration pneumonitis requiring a three-day course of intubation and mechanical ventilation. In the second case, the lightwand fractured at the junction of the handle and the stylet, which was attributed to insufficient stylet lubrication which caused unforgiving traction on withdrawal (49). No patient morbidity was noted. Manufacturers have since adapted their designs so that lightwands are sturdier and have integral bulbs or fiberoptic bundles.

Trauma to the upper airway after lighted stylet intubation is generally of a minor nature and includes bleeding, sore throat, hoarseness, and dysphagia. In Hung et al.’s (19) large study, these were less likely with a lighted stylet as compared with a direct laryngoscopic tracheal intubation. The most severe upper airway damage reported after lighted stylet intubation are two reported cases of arytenoid cartilage dislocation. In neither case was more than moderate difficulty reported in achieving the intubation (50,51), and in both cases the long-term outcome was good. Hoarseness after any tracheal intubation may be a sign of arytenoid subluxation and should be referred to an otorhinolaryngologist for evaluation and possible reduction under direct vision. Because arytenoid dislocation may occur with direct laryngoscopy and is similarly rare, it is impossible with the current data to determine whether use of a lighted stylet poses an increase in risk.

Conclusion
Lighted stylet intubation is a simple technique that is easily learned and could be valuable if tracheal intubation by using direct laryngoscopy is impossible. Unlike fiberoptic intubation, minimal preparation is needed when intubation must proceed with urgency. Lighted styles can be cleaned and sterilized readily and are easily transportable to unusual settings. The technique can be combined with other airway adjuncts and is useful in a variety of settings. At worst, the technique is as good as traditional laryngoscopy; at best and in experienced hands, it is quicker, more reliable, and better tolerated by the patient. With the right choice of stylet, it can be used for all sizes of patients and will not significantly increase department costs. It should be available in all anesthetic departments and taught to all trainees.

References
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