
Special Article

Laryngoscope design and the difficult adult tracheal intubation

J.W.R. McIntyre MRCS LRCP FRCPC

Clinical examination of a patient is very likely to reveal the factors making tracheal intubation difficult and thus increasing the likelihood of a traumatized temporo-mandibular joint or mouth. Although laryngoscopes and bronchoscopes incorporating fiberoptic visual devices are invaluable they are usually only employed for extremely difficult patients. Other laryngoscopes exist in a variety of designs and can be categorised according to the particular problem they address: (i) prominent sternal region, (ii) narrow space between the incisors, (iii) reduced intraoral space and, (iv) the anteriorly positioned larynx. An atraumatic tracheal intubation will be assisted if the laryngoscope blade to be used is selected on the basis of the anatomic difficulties prescribed by the patient. The Miller, Jackson-Wisconsin, Macintosh, Soper, Bizarri-Guffrida, and Bainton blades together with appropriate handles and fittings comprise a group from which selection can be made.

Many laryngoscopes have been designed since William MacEwan in 1878 passed a tube from the mouth into the trachea using his fingers as a guide.¹ The purpose has been to provide appropriate and rapid access to the trachea and minimize damage to teeth, temporo mandibular joints, and other vulnerable structures.

A laryngoscope consists of a handle joined by a folding fitting to a blade that incorporates arrangements for lighting. The blade comprises a fitting, spatula, beak and flange. The flange projects from the edge of the spatula and serves to deflect interfering tissues. In some models the flange is uniformly curved, in others it lies at right-angles to the spatula at first and then changes direction. This initial vertical piece and even the cross-

sectional height of a parabola-shaped piece is sometimes referred to as a step. Currently popular laryngoscope blades in the United States market are the Miller² (Figure 1), the Jackson-Wisconsin (Figure 2), and the Macintosh³ (Figure 3). In Canada the Macintosh blade is the most popular. All were designed approximately fifty years ago and during the subsequent period numerous new designs have been proposed. These address specific problems presented by patients that could be difficult to intubate⁴ and indeed some of the design changes might have rendered the blade more appropriate for routine use in the operating room as well. However, such attempts have been largely unsuccessful and the popularity of early blades remains.

Morbidity associated with tracheal intubation continues to occur⁵ and increasingly stringent standards of practice are demanded. The purpose of this presentation is to classify laryngoscopes according to the clinical problem that they particularly address and encourage the problem-oriented approach to laryngoscope selection, assuming that a laryngoscope or bronchoscope incorporating a fiberoptic visual device will not be used.

The Miller laryngoscope was described in 1941² and reference is not made here to medical literature before that date. Only subsequent designs have been included. Additional blades that apparently have not been documented by their designers in the medical literature and not readily available commercially although described by Dorsch and Dorsch⁶ are not included.

Problems presented by patients, with reference to laryngoscope design

Protruding sternal region

The handle of many straight-bladed laryngoscopes lies approximately 90 degrees to the blade. In the case of the blade curved throughout its length, such as that designed by Macintosh,³ the important feature is the 58 degree angle between the part of the blade initially inserted into the mouth and the handle.⁷ In either instance if the patient is obese, has a prominent sternum, or is in a body cast, use

Key words

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From the Department of Anaesthesia, University of Alberta, 8440 - 112 Street, Edmonton, Alberta T6G 2B7.

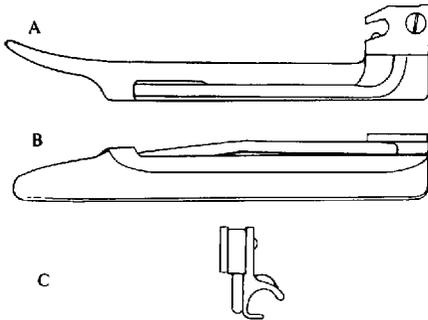


FIGURE 1 The Miller blade: A, side view; B, top view; C, fitting view.

General Caption for Figures 1 to 6.

A laryngoscope blade consists of fitting to the handle, spatula, beak and flange. The top is that part that appropriates the roof of the mouth. The bottom contacts the tongue. In side view the flange is seen nearest to the viewer. The fitting is viewed end-on as it would be seen by the anaesthetist after the blade had been positioned in the mouth.

of a conventional laryngoscope may be impossible and the application of cricoid pressure may be hindered. Such difficulties have been addressed by increasing the angle between the blade and the handle⁷⁻¹² and by offsetting the blade from the handle.⁹⁻¹³

Setting the handle more in line with the blade sacrifices the mechanical advantage of the 90 degrees angle and alters a pattern of use to which the anaesthetist is likely to have become accustomed. Ideally the ability to apply force should not play a role in modern tracheal intubation. However, if this is considered important, a simple and attractive solution has been to allow the angle to remain the same and halve the length of the laryngoscope handle.¹⁴

Narrow space between fully parted incisor teeth

In the late 1930's commonly employed laryngoscopes incorporated a blade that was a straight tube opened longitudinally at the right side and which might have a beak extending beyond the distal end. To facilitate insertion of the blade and its subsequent upward angulation Miller² flattened the flange thus reducing the height of the step (Figure 1). Subsequently other anaesthetists reduced the area of the flange even more or abolished it altogether, and reduced the height of the step.¹⁵⁻¹⁹ Other blades, straight and designed for direct lifting of the

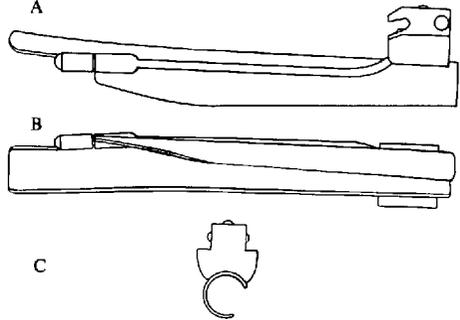


FIGURE 2 The Jackson-Wisconsin blade: A, side view; B, top view; C, fitting view.

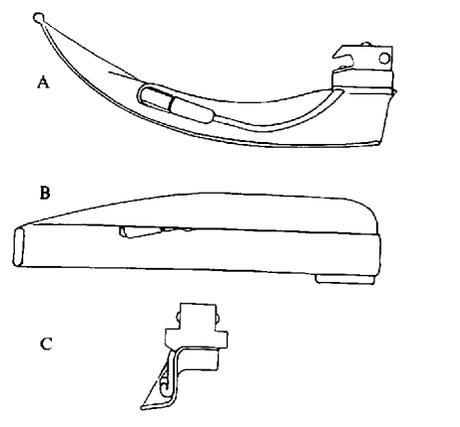


FIGURE 3 The Macintosh blade: A, side view; B, top view; C, fitting view.

epiglottis, have a reduced step and a flange which is reversed^{20,21} (Figure 4).

The reversed flange, reduced step, and some curvature throughout the length of the blade were believed to be attractive design features by many anaesthetists, particularly if the beak was designed for indirect lifting of the epiglottis.^{8,21,22} A comparison of the Macintosh⁵ (Figure 3) with the Bizarri-Guffrida blade²² (Figure 5) illustrates modification of the curved blade by reduction of the step.

Although reduction of the step is helpful, particularly as an aid to angulation of the blade in patients with

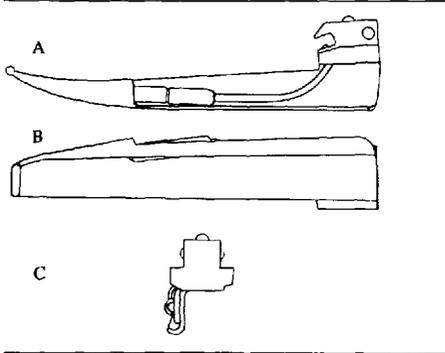


FIGURE 4 The Soper blade: A, side view; B, top view; C, fitting view.

micrognathia or maxillary overgrowth, the tracheal tube itself often must pass between the teeth as well. Such blades may not necessarily provide easier conditions for intubation unless missing molar or premolar teeth provide a space through which it can be passed. The surgery proposed may permit a nasal route for the tube but attempts risk the life-threatening event of profuse nasal bleeding in an anaesthetised, perhaps paralysed, patient who cannot be intubated.

In addition, abolition of the step sacrifices its role in maintaining separation of the upper and lower teeth once the blade has been positioned appropriately. However, if the larynx is to be visualised it does make it almost impossible to use the blade as a lever using the upper teeth as a fulcrum – a cause of dental damage.

Reduced infra oral cavity

The available space for the laryngoscope blade and manipulation of the tracheal tube is reduced if the oral cavity is small and funnel-shaped. A large tongue has a similar effect which will be compounded by a narrow submental angle or scarring in the front of the neck hindering compression of the tongue. Under these circumstances vision and tube direction may be assisted by a blade with a substantial flange and step. The Wisconsin laryngoscope is such an instrument²⁴ (Figure 2) as are the Flagg²⁴ and Guedel²⁴ laryngoscopes. Modification of these straight blades to improve their versatility has also involved some reduction of the step, flange, or beak.^{16,19,25} Another proposal to help cope with the large tongue has been to widen the reversed flange of the Macintosh blade and to add an additional flange on the other side to keep the right-hand cheek of the patient out of the way.²⁶ Another possibility is to use the left-handed versions of

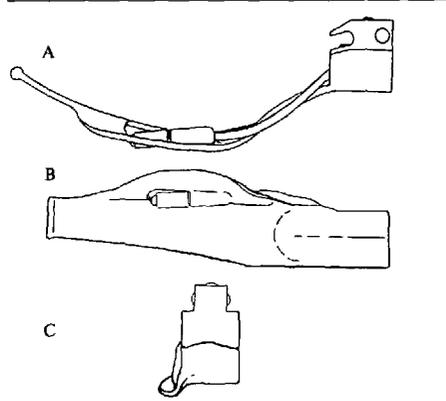


FIGURE 5 The Bizarri-Guffrida blade: A, side view; B, top view; C, fitting view.

Macintosh and Miller instruments that were produced originally to accommodate left-handed anaesthetists.²⁷⁻²⁹

Traumatised tissues, malformations, and tumours on the right side of the mouth can cause serious interference. Straight blades that are wholly or partially tubular possess a lumen that will accommodate the endotracheal tube and through which other manipulations are possible. There is renewed interest in modifying^{30,31} (Figure 6) laryngoscope blades designed many years ago and still popular with ENT surgeons.

The "anterior" larynx

A common triad that makes intubation particularly difficult occurs when the vocal cords are anterior to the anaesthetist's line of vision, the tip of the tube approaches the vocal cords at an angle approaching 90 degrees, and the oropharynx is particularly small.

"Straight" blades designed to elevate the epiglottis directly often have a distal curve or beak directed anteriorly. Theoretically^{19,32} this is helpful and explains the widespread use of such blades. Since 1941 many new blades have been designed with that triad in mind which suggests that neither the Miller blade nor the original design of the Macintosh blade is ideal under these circumstances.³³ In 1944 Macintosh had modified his original straight blade with its epiglottis retractor and introduced a curve blade to elevate the epiglottis indirectly by stretching the hypo epiglottic ligament.³⁴ The instrument provided more room in the oropharynx, but he did not believe that for routine use there was a difference between three curves tested.³⁴ The principles of the

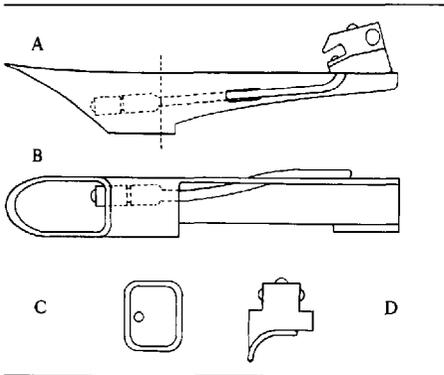


FIGURE 6 The Bainton blade: A, side view; B, top view; C, fitting view; D, cross section of back.

Macintosh blade were recognised as sound for routine patients and modifications were directed to improve performance in patients who presented the triad of difficulties and perhaps others as well.⁴ Fink applied information acquired during an oropharyngeal airway study³⁵ to the design of the Fink blade. The wider blade with an increasingly anteriorly curved tip would enable the hyoid bone to be pushed forward from behind in the vallecula dragging the epiglottis with it. This increased exposure of the vocal cords and the room in which to manoeuvre the tracheal tube. Gabuya and Orkin³⁶ raised the level of the middle third of such a blade and diminished the radius of the curved tip of the blade as well as extending it. They emphasised that to produce optimum results after insertion into the vallecula the blade must be withdrawn slightly while simultaneously elevating the root of the tongue in an anterocephalad direction. This manoeuvre can be valuable when other laryngoscope blades are in use. Mirrors and prisms have had a place in medical optics for a long time and Siker's and Hoffman's mirrors^{37,38} improved visualisation of the vocal cords. However, under these difficult circumstances it has been the incorporation of fiberoptic visual devices in bronchoscopes and laryngoscopes^{39,40} that has simplified intubation of the anteriorly placed larynx.

Discussion and conclusion

In North America three laryngoscope blades, curved (Macintosh), straight (Wisconsin) and straight with curved tip (Miller) fulfil anaesthetists' requirements for most patients. However, as every experienced clinician knows, going through every "trick of the trade" using one's favourite blade, taking the necessary time, and exerting

the necessary force may not be in the patient's best interests even though the tube is eventually passed into the trachea. Under ideal circumstances preanaesthetic examination⁴ will identify the patient for whom intubation employing a bronchoscope^{39,40} or laryngoscope incorporating a fiberoptic visual device is highly desirable. If this is not deemed necessary, a laryngoscope blade suitable for the occasion must be selected. Sykes⁴¹ stated that: "Accessories for endotracheal anaesthesia are without end. There is no living anaesthetist who holds the distinction of not having designed one or more." Accessories must include laryngoscope blades and testifies to the continuing difficulty of intubating some patients. The basis for the design of new laryngoscopes seems to have been x-ray and anatomical studies as well as mental imagery derived from clinical experiences. As there are many individual factors influencing the process of intubation, it is not surprising that detailed evaluations of the performance of any particular laryngoscope blade are extremely rare and critical analysis virtually nonexistent. Each anaesthetist has a preference based on his clinical experience. Any one of a wide variety of blades can be suitable for the routine patient once the anaesthetist has learned how to use it. However, certain blades have been designed to help cope with problems that present only occasionally. These can be classified according to the intubation problems that seem to have been addressed by the design. A representative selection comprises the Macintosh, Bizzari-Guffrida, Wisconsin, and Bainton blades with appropriate handles and fittings. On the basis of clinical examination the anaesthetist can select the laryngoscope most likely to be helpful. That group of instruments should also be readily available for use when a patient is unexpectedly difficult to intubate.

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Résumé

Lors de l'examen physique d'un patient, on peut habituellement prédire si l'intubation trachéale risque d'être difficile et susceptible d'endommager bouche et articulation temporo-mandibulaire. Pourtant, on a tendance à réserver l'usage des laryngoscopes et bronchoscopes à fibres optiques flexibles aux cas les plus complexes. On peut classer les autres types de laryngoscope en fonction des particularités anatomiques qu'ils permettent de contourner: sternum proéminent, espace restéint entre les incisives, petit volume de la cavité orale, larynx dit antérieur. En choisissant parmi les Miller, Jackson-Wisconsin, Macintosh, Soper, Bizarri-Guffrida et Bainton, les lames et manches de laryngoscope appropriés à la morphologie du patient, on pourra plus facilement intuber la trachée en douceur.