What future is there for predicting difficult intubation?

With the publication of another study on the accuracy of clinical bedside tests to predict difficulty with intubation it is perhaps reasonable to question what impact these studies have had on our understanding of difficult intubation and what lies in the future in this field. One of the problems with many of these studies it that there has been a lack of reproducibility and perhaps a tendency to modify the tests accordingly. Because of the diversity of factors involved, the desire to have a simple bedside test to predict almost all cases of difficulty may be considered unduly optimistic. Presumably, Wilson and colleagues started with this hope when they proposed a scheme specifically to assess a combination of factors. Another major problem in this area is the lack of universal agreement on what is implied by “difficult”.

Bellhouse and Doré derived a predictive formula based on a retrospective radiological survey of subjects who presented difficulty in tracheal intubation. More importantly, they claimed that the most important features relevant to difficulty were reduced atlanto-occipital extension, reduced mandibular space and increased anteroposterior thickness of the tongue. Recent studies have focused most attention on the Mallampati test, thyromental distance and sternomental distance. The Mallampati test involves the relative size of the tongue by observation of the degree to which it appears to fill the mouth (i.e. obscure the view of the soft palate). The two other tests fit with the concept of space for the tongue within the constraints of the mandible and the degree to which the airway is opened by adequate extension of the neck. Many studies have supported their individual or combined efficacy, but each test has also been questioned or received only qualified support by others. Reproducibility of the Mallampati test in particular has been questioned and the relevant issues were well reviewed in the study of Pilkingon and colleagues who made photographic assessments for Mallampati gradings during pregnancy.

While clinical studies on prediction of difficulty in intubation have been published on a regular basis, a parallel branch of clinical and theoretical research has continued, following on from another aspect of Bellhouse’s work, that is to further understand and model the mechanisms of difficulty. This culminated in a two-dimensional mathematical model for osseous factors in difficult intubation. At the time it was thought that verification of this model would be daunting. The main principle for appropriate use of the traditional Macintosh laryngoscope is negotiation of the curved blade around and beyond the base of the tongue to make contact with the hyoid bone in order to elevate the epiglottis. The hyoid can be lifted forward if the blade tip is at least in contact with the lesser horns of the hyoid, but shortening of the hyoepiglottic ligament maximizes elevation of the epiglottis and this is achieved when the blade tip is directly behind the body of the hyoid and particularly when it is below this level. Apart from when there is severely limited mouth opening, the usual obstruction to adequate exposure of the larynx is the tongue.

From the point of view of the two-dimensional model, the main considerations are the relative alignment of two intersecting straight lines. The first line extends from the tip of the upper incisors to an anterior airway point immediately above the laryngeal inlet and may be considered to represent the optimal natural eyeline. The second line is the median plane and represents the jaw as an imaginary line from the internal midpoints of the mandible to an imaginary point midway between the condyles. The relationship between these lines can be used to describe anatomical variations and also dynamic changes which occur on mouth opening or change in head and neck position, or both. A “final common pathway” for most causes of difficulty with intubation has been suggested to be the relative lack of space into which the tongue remaining anterior to the laryngoscopy blade (the “minimal residual volume”) can be displaced in order to view the larynx. This space is represented in the model by the triangle demarcated by the jaw line superiorly and the optimal natural eyeline posteriorly. When this space is severely restricted, attempts to perform conventional laryngoscopy with a Macintosh blade have been shown to force the tongue down into the pharynx with the result that the epiglottis can become fixed against the posterior pharyngeal wall. This has been termed the “peardrop effect”, on the basis of the way in which the minimal residual volume becomes distorted under these circumstances. In this context the actual laryngoscopy blade used is important and an appropriate analysis of the blade shape was suggested by Marks, Hancock and Charters.

There is a paradox in many of these considerations in that, to anaesthetists who regularly deal with the most difficult intubations in their routine clinical practice, much of what has already been described is fairly irrelevant. Dealing with tumours of the supraglottic region and base of tongue represents the most challenging intubation problem and yet it is very unlikely that predictions of degree of difficulty for such cases would be fruitful. Even benign soft tissue problems such as vallecula cysts may cause severe laryngoscopic embarrassment because they interfere with the usual mechanism of laryngoscopy (i.e. the blade tip must enter the vallecula) or push the epiglottis posteriorly, making it difficult to reposition the blade tip below the epiglottis to lift it up. These patients tend to be asymptomatic even when the cysts are fairly large. Radiation changes may also have an important effect in decreasing soft tissue mobility but the history and preoperative clinical findings should indicate the likely effect in these cases. Stylohyoid ligament calcification is another
unusual cause of difficulty but it is important in understanding the mechanisms of intubation as it limits forward movement of the hyoid which is required to elevate the epiglottis19. The prediction tests would not be expected to be sensitive to these uncommon but important conditions nor would the mathematical model, but then the model specifically describes osseous factors only.

An important discovery with the intubation model was the prediction of a previously unreported mechanism of difficulty termed the “hi-slung mandible”. With respect to intubation, it is the lower compartment of the temporomandibular joint which needs to be considered because the condyles are naturally in this position when the mouth opens and when the laryngoscope is pulling the hyoid forward. In the condition of “hi-slung mandible”, the temporomandibular joint is abnormally anterior and rostral. When a patient is positioned in the “standard intubating position”17 with the laryngoscope exposing the larynx, the optimal natural eyeline and jaw line intersect at approximately 90°21. This implies that if the jaw is considered to simply rotate around the condyles (given that it is already in the lower compartment of the temporomandibular joint), the jaw line is as far in front of the natural optimal eyeline as possible. On the other hand, if the centre of rotation is higher and more anterior than normal, as with the “hi-slung mandible”, opening the jaw sufficiently to admit a laryngoscope blade will ensure that the jaw line/optimal natural eyeline intersection is significantly less than 90°. Therefore, even if jaw translation appears normal with the mouth closed, the act of mouth opening in this condition makes the jaw fall back markedly so as to make it behave as if it were receded. The incidence of this phenomenon is unknown but examples have been cited and it may not be very uncommon. It would be expected that the currently popular predictive tests would not recognize this problem.

One unfortunate feature of most of the studies which have attempted to predict difficulty in intubation appear to be the inability to explain failures. This is perhaps understandable because of the requirement to examine large numbers of subjects in order to determine low failure rates and false positive predictions. This deficiency has been commented on previously24. The most important lesson from the intubation model is that factors combine to produce a net effect and it may be that adverse effects are counterbalanced to a greater effect by favourable ones. For example, absent upper incisors may make a severely receded jaw less of a problem but if prominent buck teeth occur in the presence of a receded jaw, the effect is likely to be considerably worse. In the model, this net effect on expected laryngeal exposure is measured as an “F” score which is directly related to the area of the triangular space below the mandible, as described above.

Bellhouse also described a new blade25. This was the first blade design to be related specifically to measurements and ideas derived from an analytical clinical study. The study on the function of various blade shapes by Marks, Hancock and Charters22 was essentially descriptive but could be converted relatively easily to a computational form. It remains to be seen if this approach challenges further the position of the Macintosh blade as the optimal rigid design. At present the future for simple predictive bedside tests is speculative. It is clear from all the published work over the past decade that our understanding of the mechanisms of tracheal intubation have advanced substantially. As far as modelling is concerned, the future holds great potential. Three-dimensional computer imaging is already in existence and it may only be a short time before routine preoperative imaging of ENT/facio-maxillary patients can be presented to the anaesthetist in a virtual reality setting in which various alternative intubation techniques can be tried by simulation before taking the patient to the operating theatre.

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References


