Anaesthesia Equipment

An evaluation of a modified Macintosh laryngoscope in a manikin

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Purpose: In this manikin study a modified Macintosh blade was prospectively compared with its original focussing on the forces exerted on the maxillary incisor teeth and intubation success. The modified blade, a standard Macintosh blade with a reduced proximal flange, was intended to reduce the forces exerted on the maxillary incisors.

Methods: A manikin equipped with two sensors, to measure forces applied to the maxillary incisors in the axial and the transverse direction, was used. Fourteen staff anaesthetists and 16 residents each performed two laryngoscopies with both blades.

Results: All laryngoscopies resulted in successful tracheal intubation. The maximal and mean forces exerted on the teeth in the axial direction were 12 N and 5.8 N smaller ($P < 0.0005$ and $P < 0.0005$, respectively) when the modified blade was used.

Conclusion: The use of the modified blade resulted in a reduction of the forces on the maxillary incisors whereas the intubation success rate was the same as with the original. Studies in manikins can be useful in comparative laryngoscope testing.

Objectif : Dans cette étude sur mannequin, une lame de MacIntosh modifiée a été comparée à la lame originale en s'intéressant aux forces exercées sur les incisives supérieures et à la réussite de l'intubation. La lame modifiée était une MacIntosh standard où l'épaule proximale était réduite dans le but de diminuer les forces exercées sur les incisives supérieures.

Méthodes : Un mannequin, équipé de deux senseurs pour mesurer les forces appliquées aux incisives dans les plans axial et transverse, a été utilisé. Quatorze anesthésistes et 16 résidents ont pratiqué chacun 2 laryngoscopies avec chacune des lames.

Résultats : Toutes les laryngoscopies ont permis d'intuber la trachée. Les forces maximales et moyennes exercées sur les dents dans le plan axial étaient de 12 N et 5,8 N ($P < 0,0005$ et $P < 0,0005$, respectivement) lorsque la lame modifiée était utilisée.

Conclusion : L'utilisation de la lame modifiée permet de réduire les forces appliquées aux incisives supérieures tout en maintenant la réussite de l'intubation. Des études sur mannequin peuvent être utiles dans des essais comparatifs de laryngoscopes.

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DETAILED evaluation of the performance of any particular laryngoscope blade is extremely rare and critical analysis virtually non-existent.¹ Instead, the majority of laryngoscope designers resort to subjective anecdotal recommendations ranging from modest claims to bold generalisations.²

Among the factors which have contributed to this situation are our limited ability to quantify important aspects of the laryngoscopic procedure and the great variability in the anatomy of the upper airways of patients. The former problem has been greatly reduced with a recently introduced "measuring" laryngoscope handle.³ The latter can be circumvented by using intubation manikins, which also enable measurements to be made which can not be performed in patients.⁴ Moreover, manikins easily allow discrimination between the effects of the laryngoscope and additional manoeuvres, such as head positioning and fixation.

Recently, a modification to a standard Macintosh blade was described⁵ (Figure 1). The modification, which was based on biomechanical modelling, was intended to reduce the forces exerted by the blade on the maxillary incisors. The intended beneficial effect of the modified blade was demonstrated in a prospective comparative study in patients.⁵ However, some doubt about the success of intubation using the modified blade remained and it was suggested that head fixation during laryngoscopy might have an influence. This can easily be studied using a manikin in which the head can be put in a fixed or non-fixed position.

The aim of the present study was to compare prospectively the modified Macintosh with the standard Macintosh blade using an intubation manikin and focussing on the forces exerted on the teeth. In addition, the effect of head fixation on laryngoscope performance was studied.

Method

The modified Macintosh blade is a standard Macintosh blade #3 (Penlon Ltd) with a reduced proximal flange (Figure 1). This modification, intended to reduce the forces exerted on maxillary incisors, was the result of biomechanical modelling. The biomechanical basis and experience with this blade in patients have been described recently.⁵

In the present study, a recently described modified Laerdal Airway Management Trainer was used, because the forces used to perform laryngoscopy in this manikin have been shown to compare well with those in routine laryngoscopy in patients.⁴ Two shear-force sensors are built into the maxilla of this manikin, enabling measurement of the forces applied to the

maxillary incisors in the axial (parallel to the axis of the incisor teeth) (F_{ma}) and the transverse direction (perpendicular to the axis of the incisor teeth) (F_{mt}) (Figure 2). This manikin can be used with the head in a fixed or non-fixed position, the latter preventing

FIGURE 1 Photograph of the standard Macintosh blade (top) and the modified blade (bottom).

FIGURE 2 Diagram of the forces exerted on the maxillary incisors. F_{ma} , forces exerted in the axial direction; F_{mt} , forces exerted in the transverse direction.

movement of the head during laryngoscopy. When transverse forces were exerted towards the base of the skull they were defined as being exerted in a positive direction (Fmtp). Unfortunately, the readings of the sensor in the axial direction were related to the amount of force exerted on the tongue.⁴ At full exposure of the glottis, the misreading of the sensor was 2.2 N small, allowing negative values when the teeth were not contacted.

Fourteen staff anaesthetists and 16 residents (> two years experience or > 300 tracheal intubations) were randomised into two groups. In group one, the manikin was first used with the head in the fixed position. Each participant was asked to perform two subsequent tracheal intubations using the modified Macintosh and the standard Macintosh in a randomised order. A maximum of 60 sec was allowed to introduce a Portex 8.5 mm endotracheal tube. Some days later, this procedure was repeated. This time, the head of the manikin was in a non-fixed position. In group two, the same procedures were carried out. However, at first the head of the manikin was non-fixed and later fixed.

To avoid any influence on the way laryngoscopy was carried out, the participants were not informed of the purpose of this study, nor were any comments made about the way laryngoscopy was performed. During laryngoscopy, no person other than the investigator and the study participant was present. During measurement the data were stored onto a memory card for later analysis, so that no-one was aware of the results.

During laryngoscopy of the manikin with the head in the non-fixed position, the tendency toward ante-flexion of the head was graded as absent, moderate or severe. In addition, the need to counteract this ante-flexion was recorded.

The best view obtained during laryngoscopy was determined by the investigator by asking the intubator which (and how much of the) structures in the larynx-pharynx area of the manikin were identified.

Subsequently, this view was graded according to Cormack and Lehane;⁶ grade 1, most of the cords visible; grade 2, less than half of the cords visible; grade 3, only the epiglottis visible; and grade 4, not even the epiglottis visible. After each intubation attempt, the investigator determined the position of the tube by looking at the transparent trachea at the back of the manikin which was not visible to the intubator. The tip of the tube in the trachea represented successful intubation.

Statistical analysis

The effect of the type of blade on the laryngoscope performance variables was assessed by first computing, separately for fixed and non-fixed head position, the mean difference between the modified and the standard Macintosh blade. The effect of the type of blade was tested as follows. If the mean difference between the blades was *not* significantly different ($P > 0.05$) between the fixed and non-fixed head position (as tested by Student's paired *t* test for continuous variables or Wilcoxon's matched pairs test for other variables such as the Cormack and Lehane's best view score), the two were averaged, in order to obtain one estimate of the mean difference between the two blades, independent of head position. Subsequently the significance of this was assessed with the paired *t* test or Wilcoxon's matched pairs test. If the mean difference between the blades was significantly different between the fixed and non-fixed head position (as was only the case for Fmtpmax), the effect of blade type was tested separately for fixed and non-fixed head position. The influence of the head position on the laryngoscope performance variables was analysed analogously.

Results

Table I presents data on the laryngoscopic factors measured in both blades. Table II presents the effect of type of blade and head fixation on the laryngoscopic factors. Independent of the head being fixed or not, the modi-

TABLE I Laryngoscopic measurements with the modified and standard Macintosh blade.

	<i>Modified Macintosh</i>		<i>Standard Macintosh</i>	
	<i>fixed</i>	<i>non-fixed</i>	<i>fixed</i>	<i>non-fixed</i>
Duration (s)	12.8 ± 9.5	15.8 ± 6.2	9.6 ± 3.2	11.4 ± 4.3
Fmax (N)	2.0 ± 4.4	2.4 ± 5.8	12.4 ± 15.5	15.0 ± 13.0
Fmean (N)	-0.5 ± 0.6	-0.4 ± 0.7	4.8 ± 8.1	5.9 ± 7.4
Fmtpmax (N)	2.1 ± 2.7	2.7 ± 3.7	4.4 ± 3.7	6.6 ± 5.4

Values are mean ± SD

fixed, head of manikin in fixed position; non-fixed, head in non-fixed position.

Fma: forces exerted on the maxillary incisors in the axial direction;

Fmtp: forces exerted on the maxillary incisors in the transverse direction (towards the base of the skull);

max, maximum value; mean, mean value.

TABLE II Effect of type of blade and head fixation on laryngoscopic measurements

	<i>modified minus standard Macintosh</i>		<i>fixed minus non-fixed head position</i>	
Duration (s)	3.8*	<0.0005	-2.4	<0.0005
Fmamax (N)	-11.5	<0.0005	-1.5	0.32
Fmamean (N)	-5.8	<0.0005	-0.6	0.28
Fmtpmax (N)	-2.3†	0.002	-0.6‡	0.57
	-3.9§	0.0005	-2.2¶	0.001

Values are mean (*P*)

Fma, forces exerted on the maxillary incisors in the axial direction; Fmtp, forces exerted on the maxillary incisors in the transverse direction (towards the base of the skull); max, maximum value; mean, mean value.

*signifies that independent of head fixation, the duration of laryngoscopy was 3.8 s longer with the modified blade ($P < 0.0005$)

†difference between blades in fixed position

‡difference between head positions in the modified Macintosh

§difference between blades in non-fixed position

¶difference between head positions in the standard Macintosh

fied blade, compared with the standard blade, resulted in an increased duration of laryngoscopy of 3.8 sec ($P < 0.0005$) and in a decrease of the maximal and mean forces on the maxillary incisors of 12 N ($P < 0.0005$) and 5.8 N ($P < 0.0005$), respectively.

The effect on the maximal transverse forces was dependent on head fixation; the modified blade resulted in a decrease of 2.3 N ($P = 0.002$) in the fixed position and 3.9 N ($P = 0.005$) in the non-fixed position. As the mean transverse forces were extremely small, these were considered irrelevant and are, therefore, not reported here.

Independent of the type of blade used, when the head of the manikin was put in a fixed position, this resulted in a decrease of the duration of laryngoscopy of 2.4 sec ($P < 0.0005$). An effect of head fixation on the forces exerted on the teeth could only be demonstrated for the transverse forces when the standard blade was used; fixation resulted in a decrease of 2.2 N ($P = 0.001$).

All laryngoscopies performed during this study resulted in successful tracheal intubation of the manikin.

In the fixed head position, the best view of the glottis in the modified Macintosh group was graded in 27 as grade 1, and in three as grade 2. In the standard Macintosh group these values were 28 and 2, respectively. When the head was not fixed, in the modified Macintosh group these values were 24 and 6, and in the standard Macintosh group 28 and 2, respectively. No grade 3 or 4 views were obtained. There were no significant differences between the groups in the best view obtained.

Obviously, antelexion was only studied when the head was in the non-fixed position. In the modified Macintosh group antelexion was absent in one, moderate in 10 and severe in 19. In the standard Macintosh group these values were 23, 6 and one, respectively ($P < 0.00005$, Wilcoxon's signed rank test). Antelexion was counterbalanced in 22 laryngoscopies of the modified Macintosh group and in 3 of the standard Macintosh group ($P = 0.001$, chi-square test).

Discussion

Damage to the teeth is the most common complication of laryngoscopy and the most common reason for complaints against anaesthetists.⁷ Despite this and the results of studies quantifying the forces exerted on the teeth during routine laryngoscopy, many anaesthetists seem convinced that they do not exert forces on the teeth with the laryngoscope. In the present study, the most accurate method presently available to measure forces exerted on the teeth in both the axial and transverse direction was used.

The results indicate that the modification of the Macintosh blade resulted in a small increase in duration of laryngoscopy and a reduction of the forces exerted on the maxillary incisor teeth, both in the axial and transverse direction. The latter results are in accordance with those obtained in patients and support the validity of the underlying biomechanical concept.⁵ In addition, other observations on this modified blade were confirmed such as its similarity with the Macintosh as far as the view of the glottis is concerned and the increased tendency toward antelexion of the head. This suggests that intubation manikins are useful for comparative studies of laryngoscope blades, although the potential effects of head fixation should be recognised. Studies in manikins will prevent unnecessary testing in patients, although studies in patients remain the ultimate proof of effectiveness of new blades. The manikin used in the present study was a commercial manikin, modified to make it more realistic to the clinical situation. In the original version the forces needed for intubation were about twice as high as in patients.⁴ Further discussion between manufacturers and anaesthetists about the desirable characteristics of intubation manikins might be useful.

Important aspects of the present study were the success of intubation with the modified blade and the effect of head fixation. As the success rate with both blades was 100%, blade type and head fixation did not affect intubation success. The high success rate with the modified blade is in contrast with a previous study in patients⁵ in which the success of the modified blade was 83% *vs* 100% with the standard blade. Although this difference

was not statistically significant, it raised concerns about the effectiveness of the modified blade. The improved intubation success rate in the present study can be explained by the anaesthetists being more accustomed to the characteristics of the modified blade, in particular to the increased tendency of the head toward anteflexion, resulting from the lower forces on the maxillary incisors. Anteflexion may have been more effectively counterbalanced and laryngoscope handling could have been improved. Unfamiliarity with the characteristics of a new device is a disadvantage inherent to all new devices and should not lead to premature rejection.

In conclusion, the use of the modified Macintosh blade resulted in a reduction of the forces on the maxillary incisors. Successful intubation was the same as with the original blade. Studies using manikins can be useful in comparative laryngoscope testing.

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