Anesthesiology

AN ANALYSIS OF UNIVARIATE INDICES VERSUS MULTIVARIATE INDICES FOR PREDICTING DIFFICULT AIRWAY AND THE USEFULNESS OF LEVERING LARYNGOSCOPE McCOY BLADE IN DIFFICULT INTUBATION

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AIM

To develop a clinically useful and valid model for predicting difficult laryngoscopic tracheal intubation in patient by adhering to principles of multivariable model development and using commonly employed airway tests both individually and in combination.

To study the efficacy of McCoy blade in improving laryngoscopic view when compared to the standard curved Macintosh blade.

INTRODUCTION

The importance of the prediction of difficulty in intubation is well known to anaesthesiologist. Though the incidence of difficulty is low, the consequences can be serious, and hence there is a need for a simple clinical method which can be done at bed side. The method should be sensitive enough to pick up all the difficult cases and at the same time have high specificity to minimize the false positives.

There are many methods which are recommended for this purpose based on clinical and radiological studies. All these studies assessed the anatomical factors which are involved in the act of laryngoscopy and co-related these with difficulty in intubation which was defined according to the amount of larynx seen during laryngoscopy. However none of these methods was found to be ideal, as some of them which were highly sensitive gave too many false positives, while other methods which were more accurate missed out many difficult cases. We attempted to find a method of assessment which would avoid these drawbacks.
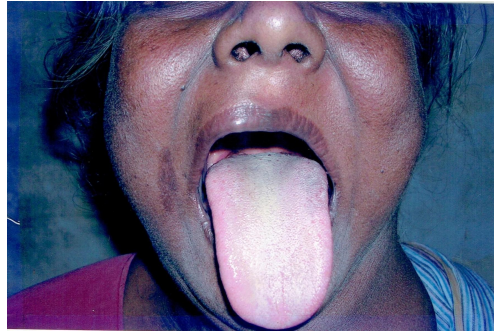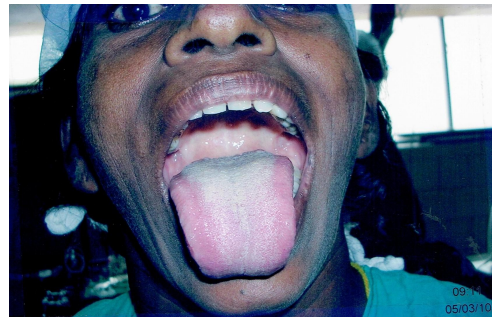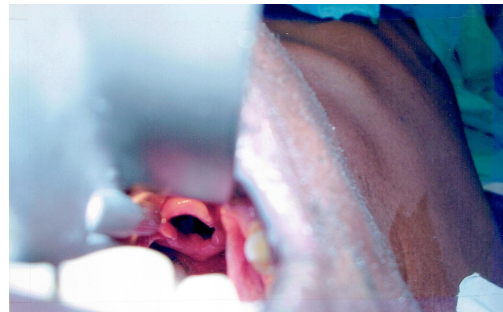
MALLAMPATI CLASS 0 AIRWAY

MALLAMPATI CLASS 1 AIRWAY
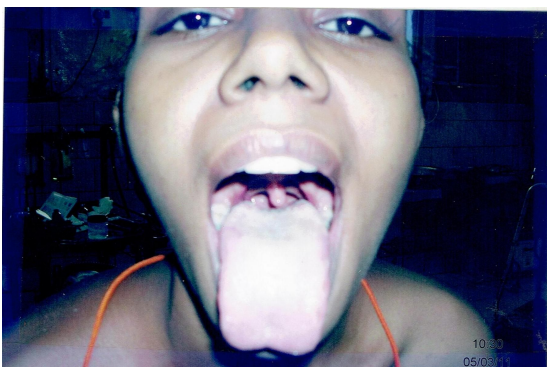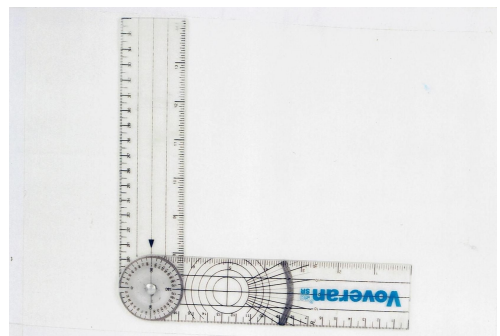

MALLAMPATI CLASS II AIRWAY

MALLAMPATI CLASS III AIRWAY

CORMACK – LEHANE GRADE I VIEW OF GLOTTIS

PROTRACTER COMPASS USED TO MEASURE DEGREE OF NECK MOVEMENT

AIRWAY ASSESSMENT
The purpose of undertaking airway assessment is to diagnose the potential for difficult airway for:

a) Optimal patient preparation
b) Proper selection of equipment and technique and
c) Participation of personnel experienced in the difficult airway management.

This usually leads to a successful airway management. On the other hand, determining that the airway is normal avoids time consuming, invasive, and potentially more traumatic methods of securing the airway from being adopted.

A multitude of indices have been used to predict a difficult airway. However, it should be noted that though each of these indices may be useful in particular patients, and for the particular clinician who employs them, none have the prediction capability reaching close to 100% sensitivity or specificity. Thus the "cannot intubate" or the "cannot ventilate-cannot intubate" conditions may still arise. This does not negate the usefulness of airway assessment as it has been verified by Rose and Cohen (1994) that it helps in identifying more than 98% of difficult airways.

The airway may be assessed for difficult airway using **Individual indices** or **group indices** (with and without scoring).

The process of endotracheal intubation can be divided into a number of elemental acts. Usually, mask ventilation preceedes laryngoscopy, which is in turn, followed by laryngoscopy and endotracheal intubation. Thus, to undertake assessment in a more systematic manner, the various assessment indices/predictors (individual or group) have been categorized separately as those which shall help predict difficult mask ventilation and those which help in predicting difficult laryngoscopy and tracheal intubation. During any exercise of airway management, the ability to ventilate a patient remains one of the most crucial events. Today, we have several pointers of difficult mask ventilation, both as individual and group indices.

Individual indices
a) *Presence of beard:* Presence of a beard creates difficulty in creating an effective seal by mask leading to loss of ventilated volume. Spreading opsite film over the beard or applying Vaseline has also been recommended to improve mask seal.
b) *Obesity:* Patients with large body mass index (>26 kg/m^2) are often at greater risk of difficult mask ventilation. 2-person mask ventilation, using large mask and appropriate size oral/nasal airways, can aid adequate mask ventilation in such patients.
d) *Abnormality of teeth:* Patients with irregular teeth/artificial dentures or those who are edentulous offer poor fit for the conventional mask ventilation. It is recommended that the artificial dentures be left in place if they are well attached,
d) *Elderly patient:* Patients over the age of 55 years may be difficult to mask ventilate.
e) *Snorers:* Patients with a history of snoring may pose problems during facemask ventilation. Application of gentle but continuous positive airway pressure (5-10 cm H$_2$O) while ventilating may help.
f) *Hair bun:* Tying of hair in a bun over the occiput is often practiced in India. Placing such a patient in the sniffing position is difficult as the bun prevents extension of the atlanto-occipital joint. It is advisable to undo the bun prior to positioning the head and neck.
g) *Jewellery and facial piercing:* These may not be a common sight in India. Lip, tongue and cheek piercings may come in the way of mask ventilation. It is recommended to get them removed prior to the procedure.

Group indices: 5 individual predictors have been grouped together under a simple mnemonic **BONES** for better assessment of difficult mask ventilation:

Bearded individual, **O**besity (BMI > 26 kg/m^2), **N**o teeth, **E**lderly (age > 55 years), **S**norer.

Patients having 2 or more of these predictors are likely to have difficult mask ventilation.

Individual Indices: These individual predictors of difficult airway

may be further sub-grouped into:

1. Physical examination indices.
2. Radiological indices.
3. Advanced indices.

I. *Physical examination indices:*
A. *Assessment of cervical and atlanto-occipital joint* **(a-o)** *function:* These functions may be assessed directly and also indirectly especially in patients of stiff joint syndrome.

Direct assessment: Laryngoscopic view becomes easier when the neck is flexed on the chest by 25-35° and the a-o joint is well extended (85°). This is called the "sniffing or the "Magill's position ". First assess the movement by asking the patient to touch his manubrium sternii with his chin. If done, this assures neck flexion of 25-30°. Following this, ask the patient to look at the ceiling with-out raising eyebrows to test a-o joint function.

2/3rd or complete reduction of extension at a-o joint is a clear pointer to difficult rigid laryngoscopy.

*Indirect assessment: L*ong-term juvenile diabetic patients present with laryngoscopic difficulties due to "stiff joint syndrome". Patients have difficulty in approximating their palms and cannot bend their finger backwards ("prayer sign"). If present, it should alert the laryngoscopist to the possibility of cervical spine involvement and limited a-o movement.

B. *Assessment of temporo-mandibular joint (TMJ) function:* The two functions of TMJ are rotation of condyle in the synovial cavity and forward displacement of condyle.

Two individual tests for assessing the TMJ function are:
1. Ask the patient to open his mouth wide and place his three fingers (index, middle and ring) in the opening. If done, this is >5 cm and is adequate for direct laryngoscopy (sensitivity 0.26 and specificity 0.94) and,
2. Place index finger in front of the tragus and the thumb in front of the lower part of the mastoid process behind the ear. Ask the patient to open his mouth wide.

As the condyle of the mandible slides forward, the index finger in front of the tragus can be indented in its space and the thumb can feel the sliding of the condyle. This suggests good sliding function of mandible (subluxation of the lower jaw).

C. *Assessment of the mandibular space:* It can be expressed as thyromental or hyomental distance. This space determines how easily the laryngeal and pharyngeal axis will fall in line when the a-o joint is extended because laryngoscopy pushes the tongue into this space, and if reduced or narrowed the exposure of the glottis may be inadequate.

1. **Thyromental distance:** This is the distance between the thyroid notch and mental symphysis when the neck is fully extended.
I. >6.5 cm: no problem with laryngoscopy and intubation.
II. 6.0-6.5 cm: without other concomitant anatomical problems, laryngoscopy and intubation are difficult but possible.
III. <6 cm: Laryngoscopy may be impossible.

It has a sensitivity of 0.65 and Specificity of 0.81.

2. **Hyomental distance:** This is the distance between the mentum and hyoid bone. It is graded as:

Grade I:> 6.0 cm
Grade II: 4.0-6.0 cm
Grade III: <4.0 cm
Grade III hyomental distance is usually associated with impossible laryngoscopy and intubation.

Tests for assessing the adequacy of the oropharynx for laryngoscopy and intubation.
There are two tests to assess the adequacy of the oropharynx for laryngoscopy and intubation: the Mallampati grading test and assessing the narrowness and arching of the hard palate.

1. Mallampati grading: This is probably the most commonly employed test for predicting airway management difficulty. It indicates the amount of space within the oral cavity to accommodate the laryngoscope and ETT. This is performed by having the patient open the mouth as wide as possible and stick out the tongue without phonation such as "saying "aah" which lowers the grade by one step (grade II becomes grade I). The patient is in the sitting position with the head protruding forward, mimicking the "sniffing" position for laryngoscopy and intubation. The observer's eye should be at level of the patient's open mouth. The degree to which faucial pillars, uvula, soft palate and the hard palate are visible is observed. As per Samsoon & Young's modification of Mallampati grading, following 4 grading may be noted

Grade I: Faucial pillars, uvula, soft and hard palate visible.
Grade II: Uvula, soft and hard palate visible.
Grade III: Base of uvula or none, soft and hard palate visible.
Grade IV: Only hard palate visible

Grade I and II are associated with easy laryngoscopic view of the glottis. Grade III and IV offer difficult and impossible viewing of the glottis by conventional laryngoscopy. Mallampati grading has a sensitivity of 0.4-0.67 and specificity of 0.52-0. 84.

3. Narrowness of the palate: A narrow, high arched palate offers very little space for laryngoscopy and simultaneous endotracheal intubation.

E. Assessment for *quality of glottic viewing during laryngoscopy:* These include: Indirect mirror laryngoscopic view and the "Awake look" direct laryngoscopy.

1. Indirect mirror laryngoscopic view: It is an effective method to predict difficult laryngoscopy and translaryngeal intubation. This offers better predictive value than Mallampati classification. Classification of lndirect mirror laryngoscopic view is as follows-

a) Complete vocal cords visible.
b) Posterior commissure visible.
c) Epiglottis visible.
f) No glottic structures visible.

4. Direct laryngoscopy "awake look": Limited direct laryngoscopy in awake patient is possible with appropriate sedation and local anesthetic to the tongue and back of pharynx.
5. Cormack and Lehane graded the laryngoscopic view into 4 grades. Cook (1999) has further subdivided Cormack and Lehane's as

Grade I: Visualization of entire laryngeal aperture
Grade 2A: Arytenoids and Posterior cord visible
Grade 2B: Arytenoids only visible
Grade 3A: Only epiglottis visible liftable with bougie
Grade 3B: Only epiglottis visible adherent not liftable with bougie
Grade 4: No laryngeal structures visible

F. Thyroid to Floor of the mouth distance: A larynx that is placed higher in the neck, as in obese patients, may be difficult to visualize during laryngoscopy than a larynx, which is lower. The larynx is normally placed if the patient can place two fingers between the top of the thyroid cartilage and the floor of the mouth.
G. Sterno - mental distance: This is measured with head in full extension and mouth closed: < 12.5 cm predicts difficult laryngoscopic intubation. The sensitivity and specificity of this measurement are 0.82 and 0.89 respectively and it as the single best predictor of difficult laryngoscopy.

II Group Indices: To enhance the sensitivity of predicting difficult laryngoscopy and intubation, several workers have used multiple parameter system (with and without scoring). Some of the important group indices system are: Wilson's scoring system, Benumof's 11 parameter analyses, Rocke's assessment of obstetrical patient and Rapid airway assessment (1-2-3).
1. Wilson scoring system: Wilson analyzed 5 parameters simultaneously and gave them 0,1 and 2 scores each. On the basis of their sum total, ease of easy laryngoscopy and intubation can be made.

parameter	0	1	2
Weight (kg)	<90^0	90-110	>110
Head and neck movement	<90^0	=90°	<90°
Jaw movement (inter-incisor gap)	>5 cm	=5 cm	< 5 cm
(SL)	0	=0	< 0
Receding mandible	None	Moderate	Severe
Buck teeth	None	Moderate	Severe

(SL is protruding of mandibular incisors beyond maxillary incisors) Patients scoring 5 or <, have easy laryngoscopy, 6-7 moderate difficulty and those scoring 8-10 have severe difficulty during conventional laryngoscopy.

The incidence of difficult laryngoscopy and intubation in the general surgical population varies greatly depending on its grade. Its range in different grades is as follows:

Cormack and Lehane's Grade I view: Most patients.
Grade II view: 1-18%.
Grade III view: 1-4%
Grade IV view: 0.05-0.035%

"Cannot ventilate and cannot intubate" situation occurs in 0.0001-0.02% of cases.

Multivariate Predictive Tests
Most of the predictive tests for airway assessment are based on identifying abnormal anatomical features which either singly or in combination lead to difficult laryngoscopy and intubation. It is believed that using more than one-test increase the degree of predictability. This has lead to use of many multivariate tests.

cass, James and Lines were the first to draw attention to anatomical features like short muscular neck with full set of teeth, a receding mandible with obtuse mandibular angles, protruding maxillary incisor teeth, poor mobility of the temporo mandibular joint, a long high arched palate and increased alveolo- mental distance, which are associated with difficult intubation. Other tests like 'Wilson's risk sum score. 'Clinical multivariate risk index, Nath score etc. have also been reported to have good predictability.

In our institution we proposed and evaluated an objective airway assessment score, combining five commonly used tests like modified Mallampati test, thyromental distance, sternomental distance, inter-incisor gap and atlanto occipital extension when used alone or in combinations.

How Predictive Are Predictive Tests
A predictive test is validated on a population to see how well it predicts a difficult airway. It is usually described in terms of

- sensitivity : proportion of difficult patients correctly identified
- specificity : proportion of easy patients correctly identified
- positive predictive value (PPV): how specific is a positive result
- negative predictive value (NPV): percentage of predictive easy which were actually easy.

Karkouti et al compared the reliability of ten commonly used tests to identify difficult airway. They found excellent reliability of inter-incisor gap and chin protrusion tests between different observers. Modified Mallampati score had poor reliability while seven other tests had moderate inter-observer reliability.

IMPROVING LARYNGOSCOPIC VIEW - NEW BLADE DESIGNS

McCoy blade : This is based on a standard Macintosh blade with the addition of an adjustable tip that is operated by a lever on the handle. The blade is inserted in the normal way and if the view of the larynx is obscured the tip can be flexed so that it elevates the epiglottis. It allows a decrease in the force required to bring the larynx into view and moves that point on the blade which acts as a fulcrum further into the pharynx so that inadvertent contact with the upper teeth should be eliminated.

The three main factors that can cause difficulty during intubation are forward displacement of the larynx, forward or prominent upper teeth and backward displacement of the tongue.

It is usually possible to expose the epiglottis, but because of anatomical peculiarities such as decreased mouth opening, enlarged tongue, recessive mandible, protruding upper teeth and fixed cervical spine, elevation of the epiglottis is difficult or impossible.

It is in these situations that force applied during laryngoscopy increases as the degree of difficulty increases. However, in difficult situations, instead of the normal elevations of the structures in the same axis by moving the Laryngoscope forwards and upwards, a levering movement of the blade may be necessary. In such situations the upper teeth may inadvertantly be used as a fulcrum and persistent attempts to elevate the epiglottis frequently results in damage to the upper teeth. A blade designed to eliminate contact with the upper incisor teeth and also to have its fulcrum at a lower point within the pharynx might simplify elevation of the epiglottis and exposure of the larynx.
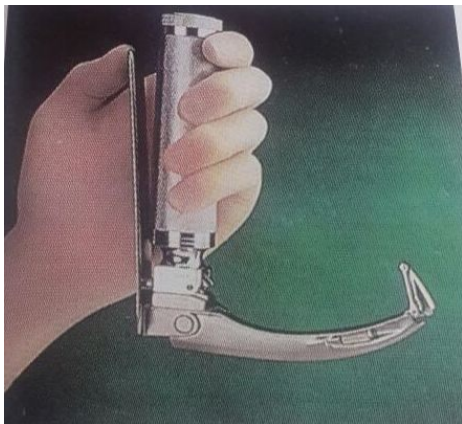
Description the modified Blade
The levering laryngoscope differs from the usual curved blade in four respects.

It has a hinged tip, a lever at the proximal end, a spring loaded drum and a connecting shaft.

The hinged tip : The blade has been cut 25 mm proximal to the tip and a hinge placed between the two parts. The flange has been cut in a curved manner so the adjustable tip locks with the rest of the blade in the resting position. Therefore pressure exerted on the tip will be transmitted down the long axis of the flange and not exerted at the hinge.

The proximal lever
A lever 15.5 cm in length and 1 cm wide, is attached to the proximal end of the blade. It is connected to a spring loaded drum on the proximal end of the blade by a pin through the flange.

The spring loaded drum
An enclosed, spring loaded drum lies on the left side of the flange, the spring acting in a clockwise manner when viewed from the left side.

The connecting shaft
A connecting shaft links the spring loaded drum to the hinged tip. It is 10 cm long, concave up-wards and cut so as not to impinge on the bulb:

At the distal end it is linked to the hinged tip by way of a 1.5 cm wire, soldered to the connecting shaft proximally, bent to 90 distally and inserted through a hole in the flange of the hinge. Proximally the connecting shaft joins the spring loaded drum via a second hinge. The modified blade weighs 170 g as compared to a 100g weight of the ordinary blade. However, it is not significant when considering the total weight of the Laryngoscope.

Use of the modified blade
The blade is attached to a standard laryngoscope handle. The handle is grasped in the normal manner with the lever lying posterior to the thumb and the thumb may be moved posterior to the lever to lie along its long axis. Compression of the lever towards the handle will cause the spring - loaded drum to rotate anticlock wise, the rotational movement of which causes the connecting shaft to move forward along the blade. At the tip the forward motion of the connection shaft will push the 1.5 cm wire forwards resulting in elevation of the hinged tip. Release of the lever at the handle allows the spring loaded drum to return the connecting shaft and therefore the hinged tip to the resting position.

Laryngoscopy : Laryngoscopy is conducted in the usual way with the blade maintaining the normal shape at rest. The blade tip is inserted into the vallecula. The operator then moves his thumb from the Laryngoscope handle to behind the lever and exerts gentle pressure on the lever. Approximately 20 movement of the lever causes the blade tip to elevate 70 upwards, lifting the hyo - epiglottic ligament and exposing the larynx. The tracheal the in placed in the usual way, the lever released, the blade returning to its resting shape and withdrawn normally.

The available Laryngoscope blades, once inserted, are inflexible, allowing no adjustment of their shape during the laryngoscopy and therefore no alteration in the fulcrum. Any degree of movement of Laryngoscope tip at the epiglottis, other than in one axis, depends on a much larger degree of movement of the handle.

The blade described above overcomes these short comings by shifting the fulcrum of movement in difficult visualization nearer to the area which need to be visualized.

MATERIALS AND METHODS
An observational study performed at a tertiary – care teaching hospital. Pre-operatively randomly selected patients requiring tracheal intubation for elective surgery were assessed using multiple variables. These findings were co-related with the ease of exposure of glottis at laryngoscopy. The visibility of glottis was graded according to modified classification of Cormack and Lehane. The Macintosh, and McCoy largngoscopes very compared with respect to the grade of laryngeal visualization and difficulty of intubation. A reliable definition for difficult intubation was used and all attempts were made to eliminate source of bias.

Exclusion Criteria
1. Emergency surgery
2. Nasotracheal Intubation
3. Inter incisor Distance less then 2cm
4. Fixed Neck Flexion
5. Gross obesity.

Inclusion Criteria
Elective surgery
Requiring GA
Age> 18 yrs

Following variables were included in airway assessment
1. Age, Sex, Height in cm, Weight in Kg, were noted from patient chart.
2. Neck following measurements were taken using an inch tape and a divider

a) Neck-length vertical – Distance between sternal notch and thyroid cartilage.
b) Neck Length Oblique – distance between tip of mastoid process and medial end of clavicle on the same side.
c) Neck Circumference – At the level of cricoid cartilage.
d) Neck flexion – Any obivious restriction was noted subjectively.

3. Head extension – Bedside evaluation of extension at the atlanto – occipital joint is performed by having the patient sit upright with head held erect and facing directly to the front and keeping the mouth slightly open. The plane of the occlusal surface of the upper teeth is horizontal and parallel to the ground. The angle between the erect and extended planes of the occlusal surface of the upper teeth will form an angle with the plane parallel to the ground. The angle between the erect and extended planes of the occlusal surface of the upper teeth quantitates the degree of Atlanto – occipital joint extension. A normal person can produce 35^0

Atlanto – occipital joint extension.
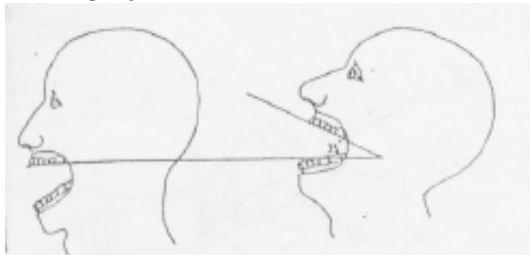
Willson's Rule for predicting difficult Intubation
TABLE Wilson's rule for predicting for difficult intubation

Risk Factor	Riskscore	Level
Weight	0	< 90 Kg
	1	90-110 Kg
	2	> 110 Kg
Head and neck Movement	0	Above 90^0
	1	About 90^0 (i.e., $+10^0$)
	2	Below 90^0
Jaw movement	0	IG > 5 cm or SLux > 0
	1	IG < 5 cm and SLux = 0
	2	IG < 5 cm and SLux < 0
Receding mandible	0	Normal
	1	Moderate
	2	Severe
Buck teeth	0	Normal
	1	Moderate
	2	Severe

**IG = Interincisor gap (Normal = 5 cm) SLux = Subluxation**

Risk Sum value of 2 or more is taken to indicate a risk of difficult intubation.

Patil's score
Patient is asked to extend the head as far as possible, keeping the mouth closed. The straight distance from the inside of the mentum to the thyroid notch is measured if the distance was less than 6 cm it is suggested that direct laryngoscopy would be difficult. If it is less than 6.5 cm visualization would be predictably difficult. If it is 6.5 cm and more problems should not occur.

Mallampati score (Oropharyngeal Structure visibility):
According to the classification modified from Mallampati by Samsoon and Young.
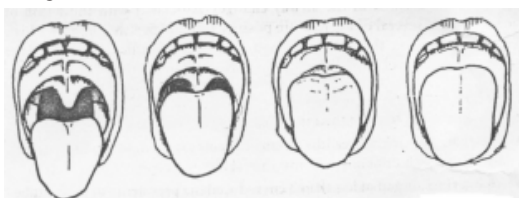
The patient while sitting upright with the head in the neutral position, is asked to open the mouth as widely as possible and maximally protrude the tongue. The observer sits opposite the patient with the patient's mouth at his eye level and inspects the pharyngeal structures with a pen torch. The airway is then classified according to the pharyngeal structures seen.

1. Soft palate, Fauces, Uvula, Anterior and Posterior, Tonsillar Pillars visible.
2. Soft plate, Fauces, Uvula, Visible.
3. Soft plate, Base of Uvula, Visible.
4. Not even the soft palate was visible.

Laryngoscopic Evaluation:
Laryngoscopic grading was carried by the anesthesiologist who intubated the patient according to modified Cormack and Lehane classification.
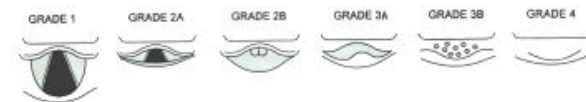
Grade 2A: Arytenoids and posterior chink of cords visible
Grade 2B : Arytenoids only visible
Grade 3 : Epiglottis only Visible.

Subdivided in to 3A and 3 B, with 3A epiglottis can be lifted with Gum elastic Bougie; 3B – epiglottis cannot be lifted with Gum elastic Bougie. Since our study does not include Gum elastic Bougie .The subdivisions of Grade 3 are not used.

Grade 4 : No laryngeal structures seen.

In Operating Theater
Premedication: TAB. Diazepam 5 mg P.O.
Pre Operatively at 6A.M   TAB. Ranitidine 150 mg.P.O
                TAB . Perinorm 10 mg.P.O
In Operating Theater- IV line started with balanced salt solution.
Monitors- NIBP, SPO2, ECG, Temperature were used

After preoxygenation, IV Pentazocine lactate 0.5 mg / kg to a maximum initial dose of 21 mg and Glycopyyrolate 0.2 mg/ kg. IV given.

Patient occiput was placed on a intubating pillow 10cm. in height.

Induction : Thiopental sodium- 5 mg / kg.
Suxamethonium – 2 mg / kg
Xylocard - 1 mg / kg.
Intubation was attempted at 60 seconds after suxamethonium.

Macintosh blade size 3 or size 4 was used. The blade size was selected based on mandibular size and depth of the patient. Laryngoscopic view was assessed using Modified Cormack and Lehane score without any form of external intervention like OELM (Optimum External Laryngeal Manipulation) and BURP. After recording, laryngocopy was repeated with the same sized McCoy blade and Modified Cormack and Lehane scores recorded with the lever half engaged and with the lever fully engaged. After all the scores are recorded patient were intubated with appropriate sized endotracheal tube.

At this point, to aid intubation all maneuvers and devices were permitted. Maneuvers like OELM, BURP and gadgets like Gum Elastic Bougie and stillete were used to ensure fastest, safest intubation of trachea. Anaesthesia was maintained by a balanced technique of 02-N20-Inhalational-Narcotic and non-depolarizing muscle relaxant. At the end of the procedure patient was reversed with anti-cholinesterases along with anti-cholinergics. The findings were tabulated and statistically analysed.

STATISTICS
MALLAMPATI

Mallampati	Macintosh Intubation		
		D	E
	D	35	25
	E	25	15

Sensitivity - 58% (45% to 71%)
Specificity - 38% (23% - 54%)
Correct classification - 50% (40% - 60%)
Misclassification - 50% (40% - 60%)
Positive predictive value - 58% (45% - 71%)
Negative predictive value 38% (23% - 54)

False positive rate - 63% (46 - 77%)
False Negative rate - 42% (29% to 55%)
McNemar's test – 0.34
p = 0.88 Not significant

Wilson Risk Sum score

Wilson	Macintosh Intubation	
	D	E
D	34	21
E	26	19

Sensitivity - 57% (43% to 69%)Specificity - 48% (32% - 64%)
Correct classification - 53% (43 - 63%)
Misclassification - 47% (37 - 60%)
Positive predictive value - 62% (48% - 75%)
Negative predictive value 42% (28% - 58%)
False positive rate - 53% (33 - 69%)
False Negative rate - 43% (31% to 57%)
McNemar's test- 0.34   p = 0.88 Not significant

Patil's

Patil's	Macintosh Intubation	
	D	E
D	8	4
E	52	36

Sensitivity - 13% (6% to 25%)
Specificity - 90% (76% - 97%)
Correct classification - 44% (34 - 54%)
Misclassification - 56% (46 - 78%)
Positive predictive value - 67% (34% - 90%)
Negative predictive value 41% (31% - 52%)
False positive rate - 10% (3 - 24%)
False Negative rate - 87% (76% to 94%)
McNemar's test- 41 p < 0.001 statistically significant difference

Neck Movements	Macintosh Intubation	
	D	E
D	58	40
E	2	0

Sensitivity - 97% (88% to 100%)
Specificity - 0 (0% - 9%)
Correct classification - 580% (42 - 68%)
Misclassification - 42% (32 - 16%)
Positive predictive value - 59% (49% - 69%)
Negative predictive value 0% (0% - 9)
False positive rate - 1% (91% to 100%)
False Negative rate - 3% (0 - 12%)
McNemar's test- 34 P < 0.001 statistically significant difference

SMD

SMD	Macintosh Intubation	
	D	E
D	9	4
E	51	36

Sensitivity - 15% (7% to 27%)
Specificity - 90% (76% - 97%)
Correct classification - 45% (33 - 55%)
Mis - classification - 55% (45 - 77%)
Positive predictive value - 69% (39% - 91%)
Negative predictive value 41% (31% - 32)
False positive rate - 10% (3 - 27%)
False Negative rate - 85% (73% to 93%)
MCNemar's test 44
p < 0.01 Statistically significant difference

Mallampati + Wilson		
	D	E
D	48	31
E	12	9

Sensitivity - 80% (68% to 90%)
Specificity - 23% (11% - 38%)
Correct classification - 57% (47 - 67%)

Misclassification - 43% (33 - 41%)
Positive predictive value - 61% (49% - 72%)
Negative predictive value 43% (22% - 66)
False positive rate - 78% (62 - 89%)
False Negative rate - 20% (11% to 32%)
McNemar's tests - 8.4
p < 0.01 statisitically significant difference

Mallampati + Patil		
	D	E
D	39	26
E	21	14

Sensitivity - 65% (50% to 77%)
Specificity - 35% (20% - 52%)
Correct classification - 53% (43 - 63%)
Misclassification - 47% (37% - 55%)
Positive predictive value - 60% (47% - 72%)
Negative predictive value 40% (24% - 58%)
False positive rate - 65% (48% - 80%)
False Negative rate - 35% (23% to 48%)
McNemar's test - 0.56
p > 0.05 Not significant

Mallampati + Neck Movements		
	D	E
D	60	40
E	0	0

Sensitivity 100%
Specificity 0%

Error! Bookmark not defined.Mallampati + SMD		
	D	E
D	36	26
E	24	14

Sensitivity - 60% (47% to 72%)
Specificity - 35% (21% - 52%)
Correct classification - 50% (40 - 60%)
Misclassification - 50% (40 - 60%)
Positive predictive value - 58% (45% - 71%)
Negative predictive value 37% (22% - 54%)
False positive rate - 65% (48% - 80%)
False Negative rate - 40% (29% to 53%)
McNemar's test - 0.34
p = 0.88 Not significant

Wilson + Patil		
	D	E
D	36	22
E	24	18

Sensitivity - 60% (47% to 72%)
Specificity - 45% (30% - 62%)
Correct classification - 54% (44% - 64%)
Misclassification - 46% (36% - 57%)
Positive predictive value - 62% (48% - 74%)
Negative predictive value 43% (28% - 59%)
False positive rate - 55% (38% - 71%)
False Negative rate - 48% (28% to 54%)
McNemar's test- 0.1p > 0.05 Not significant

Wilson + Neck Movements		
	D	E
D	59	40
E	1	0

Sensitivity - 98% (91% to 100%)
Specificity - 0% (0% - 9%)
Correct classification - 59% (49 - 69%)
Misclassification - 41% (31 - 11%)
Positive predictive value - 60% (49% - 69%)
Negative predictive value - 0% (0% - 97%)
False positive rate - 100% (91% - 100%)
False Negative rate - 2% (0% to 9%)
McNemar's test - 37
p < 0.01 statistically significant difference

Patil + Neck Movements

	D	E
D	59	40
E	1	0

Sensitivity - 98% (91% to 100%)
Specificity - 0% (0% - 9%)
Correct classification - 59% (44 - 69%)
Misclassification - 41% (31 - 51%)
Positive predictive value - 60% (49% - 69%)
Negative predictive value - 0% (0% - 97)
False positive rate - 100% (91% - 100%)
False Negative rate - 2% (0% to 9%)
McNemar's test - 37p < 0.01 statistically significant difference

Patil + SMD

	D	E
D	16	8
E	44	32

Sensitivity - 27% (16% to 46%)
Specificity - 80% (64% - 91%)
Correct classification - 48% (38 - 58%)
Misclassification - 52% (42 - 73%)
Positive predictive value - 67% (45% - 84%)
Negative predictive value - 42% (31% - 54%)
False positive rate - 20% (9% - 36%)
False Negative rate - 73% (60% to 84%)
McNemar's test - 24
p < 0.01 statistically significant difference

Wilson + SMD

	D	E
D	38	23
E	22	17

Sensitivity - 63% (50% to 75%)
Specificity - 43% (27% - 59%)
Correct classification - 55% (45% - 65%)
Misclassification - 45% (35% - 55%)
Positive predictive value - 62% (49% - 74%)
Negative predictive value - 44% (28% - 60%)
False positive rate - 58% (41% - 72%)
False Negative rate - 37% (25% to 50%)
McNemar's test- 0.02
p > 0.05 Not significant

Mallampati + wilson + patil

	D	E
D	25	17
E	35	23

Sensitivity - 42% (29% to 55%)
Specificity - 58% (41% - 73%)
Correct classification - 48% (38% - 58%)
Misclassification - 52% (42% - 68%)
Positive predictive value - 60% (43% - 74%)
Negative predictive value - 40% (27% - 53%)
False positive rate - 43% (27% - 59%)
False Negative rate - 52% (45% to 71%)
McNemar's test- 6.2
p = 0.02 Not significant

Mallampati + Wilson + Neck movements

	D	E
D	47	30
E	13	10

Sensitivity - 78% (66% to 88%)   Specificity - 25% (13% - 41%)
Correct classification - 57% (47 - 67%)
Misclassification - 43% (33% - 42%)
Positive predictive value - 61% (49% - 72%)
Negative predictive value 43% (23% - 60%)
False positive rate - 75% (59% - 87%)
False Negative rate - 22% (12% to 34%)   McNemar's test- 6.72
p < 0.01 statistically significant difference
Mallampati + patil + Neck movements

Mallampati + patil + Neck movements

	D	E
D	36	25
E	24	15

Sensitivity - 60% (47% to 72%)
Specificity - 38% (23% - 54%)
Correct classification - 51% (41% - 61%)
Misclassification - 49% (39% - 59%)
Positive predictive value - 59% (46% - 17%)
Negative predictive value - 39% (23% - 55%)
False positive rate - 63% (46% - 77%)
False Negative rate - 40% (28% to 53%)
McNemar's test-
p > 0.05 Not significant

Mallmpati + wilson + patil + SMD + Neck Movements

	D	E
D	29	20
E	31	20

Sensitivity - 48% (35% to 62%)
Specificity - 50% (34% - 66%)
Correct classification - 49% (39% - 59%)
Misclassification - 51% (42% - 65%)
Positive predictive value - 60% (44% - 73%)
Negative predictive value - 40% (26% - 54%)
False positive rate - 50% (34% - 66%)
False Negative rate - 50% (38% to 65%)
McNemar's test- 2.37
p = 0.16 Not significant

Mallampati + Wilson + Patil + SMD

	D	E
D	29	20
E	31	20

Sensitivity - 48% (35% to 62%)
Specificity - 50% (34% - 66%)
Correct classification - 49% (39% - 59%)
Misclassification - 51% (42% - 65%)
Positive predictive value - 60% (44% - 73%)
Negative predictive value - 40% (26% - 54%)
False positive rate - 50% (34% - 66%)
False Negative rate - 50% (38% to 65%)
McNemar's test - 2.37
p = 0.16 Not significant

Univariate Indicies

Univariate Indicies	Sensitivity	Specificity
Mallampati	58%	38%
Willson	57%	48%
Patils	13%	90%
Neck movements	97%	0%
SMD	15%	90%

Multivariative Indicies

Multivariate Indicies	Sensitivity	Specificity
Mallampati + Wilson	80%	23%
Mallampati + patil	65%	35%
Mallampati + Neck movements	100%	0%
Mallampati + SMD	60%	35%
Wilson + Patil	60%	45%
Wilson + Neck Movements	98%	0%
Patil + Neck movements	98%	0%
Patil + SMD	27%	80%
Wilson + SMD	63%	43%
M + W + P	42%	58%
M + W + N	78%	25%
M + P + N	60%	38%
M + W + P + SMD + N	48%	90%
M + W + P + SMD	48%	50%

Tests used in the study:
Pearson chi - Square test

Student Test
Diagnostic tests like -Sensitivity
- Specificity
- Positive predictive value
- Negative predictive value
- False Positive rate
- False Negative rate
- McNemar's test

	Difficult	Easy	P Value
Oblique - length	17.83 ± 1.63	17.27 ± 1.73	P > 0.05 Not Significant
Vertical Length	8.00 ± 1.63	7.81 ± 1.70	P > 0.05 Not Significant
Circumference	33.8 ± 3.04	33.99 ± 3.01	P > 0.05 Not Significant

Neck Parameters

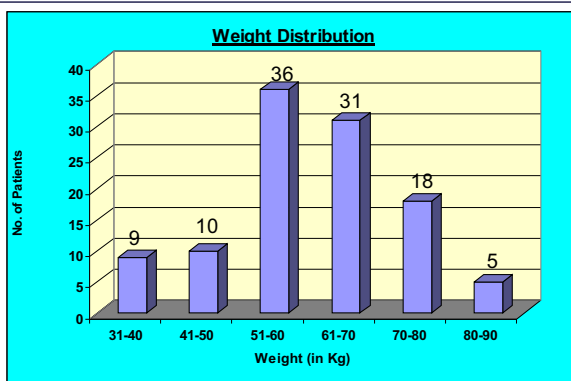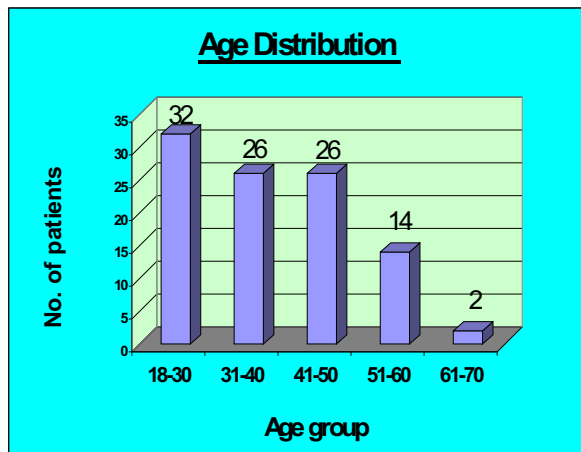| Macintosh Grade	McCoy ½ engaged	McCoy Fully engaged
I (40 Cases)	No Improvement 21 (52.5%) Worsened 19 (47.5%)	No Improvement 8-(20%) Worsened 32 (80%)
IIA (21 Cases)	No improvement 9 (42.9%) Improved 6 (28.6%) Worsened 6 (28.6%)	No Improvement-3 (14.3%) Improved - 1 (4.8%) Worsened - 17 (80%)
IIB (24 Cases)	No Improvement 11 (45.84%) Improved 10 (41.7%) Worsened 3 (12.5%)	No improvement 9 (37.5%) Improved 5 (20.9%) Worsened 10 (41.7%)
III (15 Cases)	No improvement 4 (26.7%) Improved 11 (73.4%)	Not Improved 1 (6.7%) Improved 12 (80%) Worsened 2 (13.3%)

Manuvers		No. of Cases	Percentage
Attempts	1	91	91%
	2	9	9%
OELM	-	80	80%
	+	20	20%
BURP	-	85	85%
	+	15	15%
Stilette	-	99	99%
	+	1	1%
Trauma	-	82	82%
	+	18	18%
Bougie	-	93	93%
	+	7	7%

Experience of the laryngscopist and the No. of cases done by them

Experience in Years	No. of Cases	Percentage
6 month - 12 month	15	15%
1 - 2 Years	68	68%
2-5 years	6	6%
> 5 Years	11	11%

ANALYSIS
Demographic Data

Age Distribution

Weight Distribution

Macintosh and Mccoy fully Engaged Crosstabulation

Count

		Mccoy Fully Engaged					Total
		I	IIA	IIB	III	IV	
Macintosh Grade	I	8	19	8	3	2	40
	IIA	1	3	11	3	3	21
	IIB	1	4	9	4	6	24
	III	2	1	9	1	2	15
Total		12	27	37	11	13	100

Macintosh and Mccoy half Crosstabulation

Count

		Mccoy half Engaged					Total
		I	IIA	IIB	III	IV	
Macintosh Grade	I	21	14	4	1	0	40
	IIA	6	9	4	1	1	21
	IIB	0	10	11	3	0	24
	III	0	1	10	4	0	15
Total		27	34	29	9	1	100

ANALYSIS OF UNIVARIATE INDICES

Test	Sensitivity	Specificity	PPV	NPV	p-value
Mallampati	58%	38%	58%	38%	p = 0.88 Not significant
Wilson	57%	48%	62%	42%	p = 0.88 Not significant
Patils	13%	90%	67%	41%	p<0.001 Significant
Neck movements	97%	0%	59%	0%	p<0.001 Significant
SMD	15%	90%	69%	41%	p<0.01 Significant

An analysis of statistical data above reveals that most of the univariate tests have a comparable power of predicting a difficult airway.

Based on sensitivity the top three tests in desending order of sensitivity were:

Neck movements > Mallampati > Wilsons.

The least sensitive were :
Patils < SMD.

Based on specificity the top two tests in equal order of specificity were:

SMD and Patils
The least specific were
Neck movements < Mallampati < Wilson.

Based on the positive predictive value (PPV) the tests in desending order of PPV were:

SMD > Patils, SMD > Mallampati > Neck movements

Analysis of Multivariate Indices : 2 Variables Compared

Test	Sensitivity	Specificity	PPV	NPV	p-value
Mallampati + Patil	65%	35%	60%	40%	p > 0.05 Not Significant
Mallampati + Wilson	80%	23%	61%	43%	p < 0.01 Significant
Mallampati + Neck movements	100%	0%	-	-	-
Mallampati + SMD	60%	35%	58%	37%	p > 0.05 Not Significant
Wilson + Patil	60%	45%	62%	43%	p > 0.05 Not Significant
Wilson + Neck movements	98%	0%	60%	0%	p < 0.01 Significant
Patil + Neck movements	98%	0%	60%	0%	p < 0.01 Significant
Patil + SMD	27%	80%	67%	42%	p < 0.01 Significant
Wilson + SMD	63%	43%	62%	44%	p > 0.05 Not Significant

The top tests in desending order of frequency based on sensitivity :
Mallampati +Neck movement>Wilson + Neck movements Patil + Neck movement > Mallampati + Wilson>Mallampati + Patil

The least sensitive were:
Patil + SMD<Mallampati + SMD Wilson + Patil<Wilson + SMD

Based on Positive predictive value (PPV) the tests in desending order of frequency :

Patil + SMD>Wilson + SMD

Wilson + Patil>Mallampati + Wilson>Mallampati + Patil Wilson + Neck movements Patil + Neck movements

Based on Negative predictive value (NPV) the tests in desending order of frequency :

Wilson + SMD>Mallampati + Wilson + Patil>Patil + SMD> Mallampati + Patil>Mallampati + SMD

Tests with least Negative predictive value (NPV) (0%).

Wilson + Neck movements, Patil + Neck movements, Mallampati + Neck movements.

MULTI VARIATE 3 VARIABLES COMPARED

Test	Sensitivity	Specificity	PPV	NPV	p-value
Mallampati + Wilson + Patil	42%	58%	60%	40%	p < 0.02 Significant
Mallampati + Wilson + Neck movements	78%	25%	61%	43%	p < 0.01 Significant
Mallampati + Patil + Neck movements	60%	38%	59%	39%	P<0.05 Not Significant

Based on sensitivity the top tests in desending order of frequency :
Mallampati + Wilson + Neck movements>Mallampati + Patil + Neck movements>Mallampati + Wilson + Patil

Based on specificity the tests in desending order were:
Mallampati + Wilson + Patil>Mallampati + Patil + Neck movements> Mallampati + Wilson + Neck movements

Based on Positive predictive value (PPV) the tests in desending order of frequency :

Mallampati + Wilson + Neck movements> Mallampati + Wilson + Patil>Mallampati + Patil + Neck movements

Based on Negative predictive value (NPV) the tests in desending order of frequency :

Mallampati + Wilson + Neck movements>Mallampati + Wilson +

Patil>Mallampati + Patil + Neck movementsNeck Parameters

	Difficult		Easy		p-value
	Mean (cms)	SD	Mean (cms)	SD	
Oblique length	17.33	± 1.63	17.27	± 1.73	> 0.05 Not Significant
Vertical length	8.00	± 1.63	7.81	± 1.70	> 0.05 Not Significant
Neck circumference	33.8	± 3.04	83.9	± 1.01	> 0.05 Not Significant

Neck parameters have no value in predicting difficult intubation. In analysis of all the above results the superiority of multivariable indices is statistically superior to univariate indicies and three variables are superior to two variables.

As per the above, top three multivariate tests were :
Mallampati + Wilson + Patil>Mallampati + Patil + Neck movements>Mallampati + Wilson + Neck movements

Two variable multivariate analysis reveals top four tests as
Mallampati + Patil>Wilson + SMD>Wilson + Patil>Mallampati + SMD

and they are superior to univariate indices.

McCOY Vs MACINTOSH BLADE

TABLE

Macintosh Grade	McCoy ½ engaged	McCoy Fully engaged
I (40 Cases)	No Improvement 21 (52.5%) Worsened 19 (47.5%)	No Improvement 8-(20%) Worsened 32 (80%)
IIA (21 Cases)	No improvement 9 (42.9%) Improved 6 (28.6%) worsened 6 (28.6%)	No Improvement-3 (14.3%) Improved - 1 (4.8%) Worsened - 17 (80%)
IIB (24 Cases)	No Improvement 11 (45.84%) Improved 10 (41.7%) Worsened 3 (12.5%)	No improvement 9 (37.5%) Improved 5 (20.9%) Worsened 10 (41.7%)
III (15 Cases)	No improvement 4 (26.7%) Improved 11 (73.4%)	Not Improved 1 (6.7%) Improved 12 (80%) Worsenal 2 (13.3%)

Use of McCoy blade in class I Cormack-Lehane airway worsened the view in 47.5% - 80% of the cases showing that McCoy blade has no utility in Class I airway.

In Cormack - Lehane grade IIA airway it improved by 28.6% and the improvement is by one grade.

In Cormack – Lehane grade IIB airway it improved by 41.7% and the improvement was by one grade.

In Cormack Lehane III airway it improved by 73.4% - 80% and by one grade.

McCoy blade is an useful aid in difficult intubation.

Worsening of view decreases as experience of the Laryngoscopist increases.

Trauma has no correlation with the experience of the Laryngoscopist.

SENSITIVITIY
Proportion of difficult cases predicted to be difficult.

SPECIFICITY
Proportion of easy cases predicted to be easy.

POSITIVE PREDICTIVE VALUE
Proportion of those predicted to be difficult which were actually difficult.

NEGATIVE PREDICTIVE VALUE

Is defined as the percentage of persons with negative test results who do not have the disease of interes

INFERENCE

1. Multivariate indices using a combination of 2 or more tests has better predictability of a difficult airway when compared to univariate indices.

2. Among the univariate indices Neck Movements had the best sensitivity of 97% and Patil's TM distance and SMD had the best specificity (90% each respectively)

3. The positive and negative predictive values of all the 5 univariate indices compared had minor differences which were statistically insignificant.

4. Multivariate analysis using 2 variables revealed a combination of Mallampati test + Neck movements to have the highest sensitivity, while Patil's TM distance+ Sternomental distance had the highest specificity.

5. Multivariate analysis using 3 variables revealed that the highest sensitivity occurred when Mallampati test was combined with Wilson's score and Neck movements.

6. All parameters related to various neck lengths and circumferences had no predictive value in assessment of difficult airway.

7. McCoy levering laryngoscope blade is a useful intubating tool in modified Cormack-Lehane class, IIa, IIb and III laryngoscopic views.

8. McCoy levering blade improved the laryngoscopic view by one class in all the above mentioned categories which aided intubation.

9. McCoy levering blade worsens the view in class I laryngoscopic views and hence is unsuitable as the primary choice of blade for all the standard uncomplicated intubations.

10. The role of McCoy levering blade in class IV laryngoscopic views could not be conclusively established.

11. Combining the use of McCoy levering blade with other airway devices and maneuvers like OELM, BURP and Bougie have a definite role in aiding intubation.

12. Experienced intubators have more success in the use of airway devices and less incidence of trauma.

CONCLUSION

Multivariate indices are better predictors of difficult intubation than univariate indices.

The levering laryngoscope McCoy blade is an useful aid to difficult intubation, by improving laryngoscopic view.

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