Difficult Laryngeal Exposure in Microlaryngoscopy: Can it be Predicted Preoperatively?

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Received: 2 April 2015 / Accepted: 16 September 2015 / Published online: 21 September 2015
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Abstract The aim of the present study was to identify preoperative clinical predictors for difficult laryngeal exposure (DLE) and to define a simple grading system for laryngeal exposure. This is a prospective descriptive study carried out in a tertiary teaching hospital in South India. Patients above 18 years undergoing microlaryngoscopy had presurgical evaluation of 11 physical parameters. Grading of Modified Cormack–Lehane Score (MCLS) and rigid laryngoscopy were done during procedure. On logistic regression analysis, with a 95 % confidence interval (CI) MCLS was found to be a statistically significant predictor (odds ratio 12). With 90 % CI, neck circumference, atlanto-occipital extension and MCLS were

significant (odds ratio of 4, 4, 12 respectively). Neck circumference of more than 34.25 cm and limited atlanto-occipital extension of less than 19.50, predicts difficult laryngeal exposure. A simple grading system for laryngeal exposure during microlaryngoscopy is being proposed. MCLS grade more than 2a done intra operatively correlates well with difficult intubation.

Keywords Difficult laryngeal exposure (DLE) · Microlaryngoscopy · Pre-op clinical parameters · Neck circumference · Atlanto-occipital extension · Odds Ratio

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Introduction

Microlaryngoscopy is a common procedure done in the field of laryngology. It is essential in the management of both benign and malignant laryngeal lesions. The key to successful microlaryngoscopy is proper exposure of the larynx. In some patients visualization of the larynx may be improved by external counter pressure or using special laryngoscopes like anterior commissure laryngoscope [1]. However, in some patients in spite of the best efforts, visualization of the larynx may not be possible. Any difficulty in exposing the larynx adequately will not only make appropriate management impossible, but can also result in injury to the larynx. Studies done in various population mention that the possible factors that leads to exposure difficulties during rigid laryngoscopy are difficulties in opening of the mouth, retrognathia, short neck, stiff and muscular neck, obesity, macroglossia, and extension limitations of the cervical spine. Most of these studies have evaluated laryngeal exposure for intubation or in sleep apnoea syndrome. Studies evaluating laryngeal

exposure in microlaryngoscopy are limited. The results of these studies also are varied and they have not been reproducible [2–5].

Definition of difficult laryngeal exposure (DLE) is not well explained by the previous studies [2–5]. As there is no consensus in the grading of difficult laryngeal exposure in microlaryngoscopy, it appeared that a simple, yet practical grading system was necessary. External counter pressure has been shown to improve laryngeal exposure [1]. Hence we defined DLE as inability to visualize anterior commissure in spite of external manual compression. Thus, our study was done to evaluate parameters that could individually predict a difficult laryngeal exposure.

Methods

A prospective descriptive study was done in the Department of ENT in Christian Medical College, Vellore, India from August 2007 to July 2009. This study was presented and cleared in the Institutional Review Board and Ethical Committee.

Patients included were those above the age of 18 years undergoing microlaryngoscopy under general anesthesia (e.g. vocal polyps, malignancy of the vocal cords, cyst). Patients with history of neck surgeries including tracheostomies, previous radiation to head and neck region and lesions obscuring vision of anterior commissure were excluded from the study. Informed consent was obtained from all patients who were enrolled in the study.

Patients were recruited into the study and were subjected to a detailed presurgical evaluation which included information about age, sex, weight, height and physical parameters such as thyromental distance (TMD), horizontal thyromental distance (HMD), sternomental distance (SMD), mallampatti score (MMI), neck circumference, thyromandibular angle (TMA) and atlanto-occipital extension (A-O extension). The parameters were assessed with the patient sitting upright with head in natural position without swallowing at the end of expiration. Natural head posture is defined as patient looking into his or her eyes reflected in a mirror located at eye level [3]. The Modified Cormack–Lahane Score (MCLS) grading was done by anesthetist during intubation; the surgeon assessed the grade of laryngoscopy intra-operatively. Both of them were unaware about the pre operative parameters. Intraoperative complications were also noted.

The TMD, HMD, SMD were measured using a standard 15 and 30 cm measuring scales. A-O extension and TMA were measured using a goniometer. Neck circumference was measured using a standard measuring tape. MCLS was assessed after visualization using a Macintosh curved blade laryngoscope. Microlaryngoscopy was done by Storz

laryngoscope. Patients on whom the exposure was inadequate (DLE), anterior commissure scope was used. No procedure was thus abandoned.

The patient was intubated and positioned under general anaesthesia in the classic Boyce Jackson sniffing position. Storz laryngoscope was inserted and suspended with the rod and ring chest support. Using an operating microscope larynx was examined and appropriate procedures were done. Using the operational criteria for grading the laryngoscopy every patient enrolled in the study underwent a grading of the scope by the anaesthetist and the surgeon.

In our present study, we defined a grading system for laryngeal exposure based on the visualization of the anterior commissure of vocal cords with and without external manual compression. Grade 1 was full view of vocal cords, while grade 2 was partial view of vocal cords with the anterior commissure seen only with external pressure. Grade 1 and 2 came under the non difficult category. Grade 3 was non visualization of the anterior commissure even with external compression and grade 4 was visualization of only posterior 1/3rd of vocal cord. Grade 3 and 4 were categorized as DLE.

Results

Sample size for this descriptive study was calculated as 10 per parameter being assessed. There are 11 parameters included in our study and therefore 110 patients were recruited for the study ($n = 110$). The data entered on the perform were analysed using Statistical Package for Social Sciences 16.0 for windows (Sassing, Chicago, IL). Descriptive statistics such as mean $\pm$ standard deviation and frequency with percentage were used to present continuous and categorical variables respectively. Independent samples 't' test was used to compare continuous variables and Chi square test was used to assess the association between categorical variables.

Predictors that were significantly associated with the outcome at 10 % significance level were taken into a multivariable logistic regression model to compute adjusted odds ratios. Continuous predictors were dichotomized based on diagnostic test criteria (sensitivity, specificity and ROC curve).

A total of 117 patients undergoing microlaryngoscopy under general anaesthesia were assessed for the study. There were 96 men and 21 women. Of the 117 patients 31 (26.5 %) had a difficult laryngeal exposure. Among the 11 parameters considered for DLE, 8 were continuous variables and 3 were categorical variables (Table 1). Using ROC curve, the cut off values of the parameters in the continuous variables, found to be significant, were noted. The categorical variables were MMI, BMI and gender. In

Table 1 Univariate analysis

Variable	Outcome		<i>p</i> value
	Easy	Difficult	
Neck circumference [†]	35.51 ± 3.58 cm	37.86 ± 3.26	0.002
A-O extension [†]	27.64 ± 7.27°	22.65 ± 7.078	0.001
BMI [†]	22.36 ± 3.80	23.91 ± 4.34	0.068
Thyromental distance [†]	6.11 ± 1.01 cm	5.87 ± 0.68	0.217
Horizontal thyroid distance [†]	5.11 ± 0.78 cm	4.93 ± 0.72	0.250
Sternomental distance [†]	12.65 ± 1.60 cm	12.62 ± 1.93	0.925
Thyromandibular angle [†]	101.87 ± 10.48°	104.19 ± 13.47	0.331
Ratio of height to TMD [†]	27.35 ± 4.59	28.55 ± 3.30	0.185
Gender [‡] (male)	68 (79.06 %)	28 (90.3 %)	0.16
MMI [‡]	70 (84.3 %)	19 (61.3 %)	0.008
MCLS [‡]	75 (91.5 %)	13 (48.1 %)	0.000

Of the eleven parameters, eight were continuous variables and three were categorical variables. Using Independent sample *t* test for continuous and Chi square ratio for categorical 4 of the 11 were found to have a *p* value of less than 0.05. Along with these four, BMI was also taken up for analysis though *p* value was 0.068 as it was presumed to be a good predictor

A-O extension Atlanto-occipital extension, *BMI* body mass index, *TMD* thyromental distance, *MMI* modified mallampatti index, *MCLS* modified Cormack–Lehane scoring

[†] Continuous variables as mean ± standard deviation

[‡] Categorical variables as frequency (percentage)

gender we assumed that male gender had a predisposition of having a difficult laryngoscopy. Using Independent sample '*t*' test for continuous and Chi square ratio for categorical variables, four of the 11 parameters i.e., A-O extension, Neck circumference, MCLS, and MMI were found to have a *p* value of less than 0.05. Along with these four, BMI was also taken up for analysis though *p* value was 0.068 as it was presumed to be a good predictor (Table 2). For BMI, definition of obesity (25 kg/m²) was taken as a cut off. For MCLS, grade 2b and above were taken as a predictor and for MMI, grade 3 and 4 were taken as a predictor. Using ROC curve the cut off values for neck circumference was 34.25 cm and for A-O extension it was taken as 19.5° (Table 3).

Atlanto-Occipital Extension (A-O Extension)

The A-O extension was measured in degrees and the values ranged from 12 to 45° with a mean of 26.24°. The standard deviation was 7.515. Of the 86 non difficult scopes, seven had an A-O extension of less than 19.5° while in the DLE group of 31 cases, six had A-O extension less than 19.5° (Table 4).

Table 2 Significant parameters after univariate analysis

Variable	Outcome		<i>p</i> value
	Easy	Difficult	
MMI [‡] (3 & 4)	70 (84.3 %)	19 (61.3 %)	0.008
MCLS [‡] (>2b)	75 (91.5 %)	13 (48.1 %)	0.000
Neck circumference	35.51 ± 3.58	37.86 ± 3.26	0.002
A-O extension	27.64 ± 7.27	22.65 ± 7.078	0.001
BMI	22.36 ± 3.80	23.91 ± 4.34	0.068

These 5 parameters were the ones among the 11 which were taken up for bivariate analysis

[‡] Categorical variables as frequency

Table 3 Categorized bivariate analysis

Variable	Cut off value	Sensitivity (%)	Specificity (%)
A-O extension	19.5°	80	8.3
Neck circumference	34.25 cm	90	38
BMI	25		
MCLS	2b and above		
MMI	Grade 3 and 4		

Using ROC curve, the cut off values of the significant parameters in the continuous variables were identified. For BMI we took the definition of obesity (25) as a cut off. For MCLS grade 2b and above were taken as a predictor and for MMI, grade 3 and 4 were taken as a predictor

MMI

Among the 117 cases, MMI was calculated for 114 patients. In the 83 non difficult scopes, 70 patients had a MMI of 1 and 2 while 13 had a grade of 3 and 4. In the DLE group, 19 had a MMI of 1 and 2 while 12 had a MMI grade of 3 and 4 (Table 4).

Neck Circumference

Neck circumference for the patients ranged from 28.5 to 46 cm with a mean of 36.13 cm. In the 86 non difficult scopes, 32 patients had a neck circumference of less than 34.25 cm while 54 had a value of more than 34.25 cm. In the DLE group, three had a value of less than 34.25 and 28 had a value of more than 34.25 (Table 4).

MCLS

Though MCLS has been described as 5 grades, in our study group of patients only the first four grading of MCLS was seen. Grade 1 and 2a were considered the non-difficult scopes and grade 2b and 3 were the difficult scope. In the 82 easy scopes, 75 patients had a MCLS of 1 and 2a while

7 had a grade of more than 2b. In the DLE group, 13 had a MCLS of less than 2b and 14 had a MCLS grade 2b and above (Table 4).

Body Mass Index (BMI)

Eighteen patients (15.79 %) had a BMI of grade 1, 65 (57.02 %) had a normal BMI between 18.5 and 24.9, while four (3.51 %) patients were in the obese category. In the 85 easy scopies, 64 patients had a BMI of less than 25 while 21 had a BMI of more than 25. In the DLE group, 20 had a BMI of less than 25 and 10 had a BMI more than 2 (Table 4).

On logistic regression analysis, it was found that with a 95 % CI only MCLS was found to be a statistically significant predictor with an odds ratio of 12 (Table 5).

However with a 90 % CI neck circumference, A-O extension and MCLS was found to be significant with an odds ratio of 4, 4 and 12 respectively (Table 5).

Table 4 Number of scopies that were in DLE and non DLE group in each parameter

		Non difficult	Difficult	Total
Neck circumference	<34.5 cm	32 (37.2 %)	3 (9.7 %)	35
n-117	>34.5 cm	54 (62.8 %)	28 (90.3 %)	82
MMI [#]	Grade 1 & 2	70 (81.4 %)	19 (61.3 %)	89
n-114	Grade 3 & 4	13 (15.1 %)	12 (38.7 %)	15
A-O extension	<19.5°	7 (8.1 %)	6 (19.4 %)	13
n-117	>19.5°	79 (91.9 %)	25 (80.6 %)	104
BMI [#]	<25 kg/m ²	64 (74.4 %)	20 (64.5 %)	84
n-115	>25 kg/m ²	21 (24.4 %)	10 (32.3 %)	31
MCLS [#]	Grade 1 & 2a	75 (87.2 %)	13 (41.9 %)	88
n-109	Grade 2b & above	7 (8.1 %)	14 (45.2 %)	21

[#] Missing data: But analysis done as per protocol

Seven of the 31 had complications (6-tonsillololingual tear and 1 tooth injury). The difficult microlaryngoscopies needed different manoeuvres, change of scope and needed senior surgeon guidance for completion of procedure. It also increased the anaesthetic duration.

Discussion

In laryngology practice, it is inevitable that clinicians will encounter patients for whom rigid laryngoscopy is either not possible or, at best, suboptimal due to an inability to adequately visualize the laryngeal lesions. This study was done with the aim to assess the difficulty of a laryngeal exposure.

Hsiung et al. [2] had assessed 56 patients of which 19(33.9 %) had DLE while Roh et al. [3] had 13 (17.8 %) out of 73 patients with DLE. Pinar et al. [4] also had a similar value of 22 (23.7 %) cases of DLE in the 93 patients assessed. In our study also we had a similar finding with 31 out of 117 patients (26.5 %) with DLE. Presently available studies shows Thyromandibular angle (TMA) value greater than 120 degrees in men and 130 degrees in women [2], Body mass index of >25.0 kg/m² [3], Neck circumference of >39.5 cm [3], Thyroid-mental distance of <5.5 cm [3], Neck circumference >40 cm [4], Horizontal thyromental distance <6.05 cm [2] Sternomental distance <13.9 cm [4] and MCLS [5] as the significant parameters for a difficult laryngeal exposure.

Hsiung et al. [2] defined DLE as exposure of larynx limited to posterior 1/3rd or less in spite of giving external manual pressure and using anterior commissure scope. According to Koh, the use of modified Cormack Lahane scoring was better in identifying difficult laryngoscopies during intubation in Asian and western population when compared with the original Cormack lahanescoring [6]. The 5 graded modified Cormack–Lehane score is Grade 1 (full view of the vocal cords), Grade 2A (partial view of the vocal cords), Grade 2B (only the arytenoids and epiglottis seen), Grade 3 (only epiglottis visible), Grade 4 (neither the

Table 5 Logistic regression analysis

	<i>p</i> value	Odds ratio	95.0 % C.I. for EXP(B)		90.0 % C.I. for EXP(B)	
			Lower	Upper	Lower	Upper
BMI (<25)	0.242	0.448	0.117	1.721	0.145	1.386
Neck circumference (>34.25)	0.077	3.733	0.869	16.036	1.098	12.686
A-O extension (<19.5°)	0.072	3.639	0.890	14.878	1.116	11.864
MCLS (2b & above)	0.000	11.687	3.209	42.566	3.950	34.579
MMI (3 & 4)	0.590	1.452	0.373	5.649	0.465	4.541

On logistic regression analysis, it was found that with a 95 % CI only MCLS was found to be a statistically significant predictor with an odds ratio of 12. However with a 90 % CI, neck circumference, A-O extension and MCLS was found to be significant with an odds ratio of 4, 4 and 12 respectively

epiglottis nor glottis seen). Roh [3] based grading of laryngeal exposure during microlaryngoscopy on the MCLS grading: Grade 1 as full view of vocal cords, Grade 2A as partial view of cords but anterior commissure not seen, Grade 2B as less than half of vocal cords seen, Grade 3 as only arytenoids visible, Grade 4 as entire glottis and arytenoids hidden. Pinar et al. [4] graded glottic visualization into 2 groups after using a rigid laryngoscope of appropriate size or smaller if required and after giving external compression. Exposure of laryngeal view limited to posterior 1/3rd after the above mentioned efforts were defined as DLE group. The others were in the non DLE group. Hekiart et al. [5] used Visual analogue score (VAS) to assess degree of complexity during microlaryngeal surgery 1 being least difficult and 10 being most difficult [5].

The visualization of the anterior commissure is of importance in most microlaryngoscopic procedures. Treatment of early glottic carcinoma (T1a, T1b, and T2a) extending into the anterior commissure is in itself controversial because of the fact that anterior commissure involvement may be associated with a higher local recurrence rate. The anatomy of the anterior commissure and its impact as a tumor barrier was the subject of several investigations and is still the subject of controversy [7, 8]. The lack of perichondrium or periosteum in the area of insertion, ossification of the thyroid cartilage and the associated vascularisation of the skeleton allow the invasion of tumours in the thyroidal skeleton [9].

Hence it was decided to include anterior commissure in our grading system for difficult laryngeal exposure.

Modified Cormack–Lehane score seems to be broadly defined as only whether the laryngeal view is adequate for endotracheal intubation. In the field of otolaryngology, even a subtle difference of vocal fold exposure can affect the outcomes of microlaryngeal surgery. Therefore, the Cormack–Lehane score may not be appropriately applied in the DLE studies, and a sub classification of laryngeal exposure according to the extent of vocal fold visualization needs to be established which is fulfilled by our proposed grading system. This will be helpful in communication between otolaryngologists, as well as in further study of DLE. The grading system of glottic visualization enabled us to identify the potential parameters for predicting DLE in a clinical setting.

Grading for DLE

We have now proposed a new classification of difficult laryngeal exposure based on the 5 grade MCLS scoring used by anaesthetists.

Grade 1: Full view of vocal cords

Grade 2: Partial view of vocal cords—Anterior Commissure seen only with external compression

Grade 3: Anterior commissure not seen even with external compression

Grade 4: Only posterior 1/3rd vocal cords seen with external compression

Grade 3 and 4 are classified as DLE.

The new classification appears to be a simple and practical grading system for evaluating the extent of laryngeal exposure during micro laryngoscopy. In this study, the laryngeal exposure score significantly correlated with the Cormack–Lehane score used by anesthesiologists. This finding implies that patients who are difficult to intubate are likely to represent difficult cases for rigid laryngoscopy.

The various parameters reported significant in other studies were used in our study and significant risk factors for DLE by univariate analysis were noted. Considering neck circumference, Pinar et al. [4], Roh et al. [3] and Hekiart et al. [5] reported that it was a statistically significant independent predictor in DLE. Hsiung et al. [2], however did not find neck circumference to be significant. In our study of 117 patients, neck circumference was found to be significant with a p value of 0.002. Regarding *atlanto-occipital extension* only Roh et al. [2] assessed A-O extension as a parameter for assessment for DLE. But they did not find it to be a statistically significant predictor. In our study this was found to be a significant independent predictor with a p value of 0.001. This suggests that restriction in neck movements does affect glottic visualization.

Regarding *Modified Mallampatti Index* (MMI) Hsiung et al. [2], Roh et al. [3] and Pinar et al. [4] reported that it was not a good predictor for DLE while in the study by Hekiart et al. [5] it was found to be a good predictor in non obese patients (BMI < 30). In our study MMI grade 3 and 4 were found to be a significant predictor for DLE with p value of 0.008. Our study also noted a very significant correlation with MCLS and the grading used by us for DLE with a p value of 0.000. This was in accordance to the studies done by Roh et al. [3], Pinar et al. [4] and Hekiart et al. [5] who also found a significant correlation between MCLS and DLE.

Body mass index (BMI) on univariate analysis had a p value of 0.068 in our study. Though this was not statistically significant it was taken for further analysis as it was assumed that BMI could be a good predictor. The cut-off values according to Roh et al. [3] for predicting DLE was a body mass index of >25.0 kg/m² [2]. But Hekiart [5] found a good correlation with a BMI of more than 30 kg/m². Pinar et al. [4] and Hsiung et al. [2] did not find a correlation with BMI for DLE. Gender, thyromental distance, horizontal thyromental distance, sternomental distance, ratio of patient's height to TMD (RHTMD) and thyroid-

mandible angle (TMA) were not found to be significant on univariate analysis.

Considering the significant risk factors for DLE by multivariate analysis with logistic regression analysis in our study, it was found that with a 95 % CI only MCLS was found to be a statistically significant predictor with an odds ratio of 12. However with a 90 % CI neck circumference, A-O (atlanto-occipital) extension and *Modified Cormack–Lehane scoring system* (MCLS) was found to be significant with an odds ratio of 4, 4 and 12 respectively. This has not been previously reported.

This is the first time that a study of physical parameters predicting DLE has been done in India. The difference in physical attributes of Indians as compared with people in Turkey, Korea, Taiwan and USA, where the other studies are done may be the reason for difference in results.

Difficult laryngeal exposure (DLE) in microlaryngoscopy is a challenge to the laryngologist. A simple and practical grading of laryngeal exposure in microlaryngoscopy is being proposed in this study. It is possible to predict preoperatively DLE with simple clinical evaluation of neck circumference and atlanto-occipital extension. A patient with a neck circumference more than 34.25 cm or A-O extension less than 19.5° is 4 times likely to have difficult laryngoscopy. In addition, intraoperatively, a patient with MCLS score of 2b and above is 12 times more likely to have a difficult laryngeal exposure. The proposed grading system is a simple tool which can be employed in any set up by otolaryngologists in preparation for microlaryngoscopy. Anterior commissure scope is an important alternative in patients with DLE which helps in adequate

completion of the procedure. In addition to the laryngoscope, this instrument appears to be mandatory in a setup for microlaryngoscopy.

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