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ORIGINAL ARTICLE

Chest anteroposterior diameter affects difficulty of laryngoscopy for non-morbidly obese patients

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Abstract

Purpose This prospective, observational study was performed to examine the hypothesis that if conventional 7-cm head elevation is applied, laryngoscopy is more difficult for patients with anteroposterior chest diameter (chest AP diameter) outside the average range ($\geq$17.7 or $\leq$14.7 cm).

Methods Chest AP diameter at the sternal notch were measured preoperatively. All patients were placed on a surgical bed with an incompressible 7-cm pillow. During laryngoscopy, the laryngeal view was graded by use of the Cormack–Lehane classification. Difficult visualization of the larynx (DVL) was defined as a grade 3 or 4 view.

Results DVL was observed for 49 patients (18.2 %). Differences between measured chest AP diameter for each patient and the calculated median value were used for statistical analysis. In univariate analysis, the difference between chest AP diameter and the median value was significantly related to DVL. Logistic regression analysis confirmed that the difference between chest AP diameter and the median value was an independent predictor of DVL (odds ratio, 3.900; 95 % confidence interval, 2.371–6.415; $p < 0.001$). Receiver operating characteristic curve analysis showed that this test with a test threshold of 1.5 cm had reasonable diagnostic accuracy (area under the curve of 0.748).

Conclusion When using a standard pillow size of 7 cm, chest AP diameter above or below the average range ($\geq$17.7 or $\leq$14.7 cm) was a strong predictor of DVL for apparently normal-sized patients. In such cases, modification of pillow height should be considered.

Keywords Diagnostic tests · Intratracheal intubation · Laryngoscopy

Introduction

Difficult visualization of the larynx (DVL) usually leads to difficult intubation [1, 2]. A primary factor determining a good laryngoscopic view is correct positioning of the patient's head and neck. Elevating the head 7–9 cm by placing a pillow or cushion under the occiput is conventionally performed to achieve the "sniffing position", which has been widely accepted as the standard for direct laryngoscopic intubation [2, 3].

However, Adnet et al. [1] demonstrated that simple head extension was as good as the sniffing position for improving glottic visualization in most situations, and other groups reported that hyperelevation of the head had an appreciable advantage over the sniffing position for cases of DVL [4] and for obese patients [5]. We suspected that these discrepancies may be because of an interaction between head elevation and the subject's anteroposterior chest diameter (chest AP diameter). This assumption is supported by a radiology investigation [6], which showed that even if the head was fully extended during laryngoscopic intubation, the vertical distance of the narrowest

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This study was registered with Clinical Research Information Service (CRIS; http://cris.cdc.go.kr/cris/en/use_guide/cris_introduce.jsp) (ref: KCT0000395).

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part in the airway passage from the mouth to the glottic opening was only approximately 1.7 cm. Because the line of sight should be brought as close as possible to the airway passage for the best laryngoscopic view [1–3], the interaction between head elevation and subject's chest AP diameter may strongly affect the vertical dimension of the oropharyngolaryngeal structures, thereby determining the difficulty of laryngoscopy.

Thus, we hypothesized that with elevation of the head to a standardized height, laryngoscopy would be more difficult for patients whose chest AP diameter was larger or smaller than average, even for the non-morbidly obese population. This prospective, observational study was performed to evaluate the association of patient chest AP diameter with difficulty of laryngoscopy, using a head elevation of 7 cm.

Materials and methods

The study was approved by the Institutional Review Board of Samsung Medical Center, Seoul, Republic of Korea (IRB file no.: 2011-09-010-001) and registered with the Clinical Research Information Service (CRIS; ref: KCT0000395). All patients provided written informed consent before participation. A total of 280 consecutive patients of ASA physical status I or II, aged 18–70 years old, and who were scheduled to undergo elective surgery under general anesthesia were considered for enrollment. Patients with loose upper incisors, airway pathology, gross anatomical abnormalities, body mass index (BMI) >35 kg/m^2, or any history of difficult intubation were excluded.

Preoperative airway assessment

All preanesthetic airway assessments were performed by a single anesthesiologist who was not subsequently involved in airway management for the recruited patients. The modified Mallampati classification was used to assess the visibility of oropharyngeal structures [7]. The interincisor gap, measured in centimeters with the mouth fully opened, was defined as the mouth opening [8]. The hyomental distance ratio was measured to assess the occipitoatlanto-axial complex extension capacity and was defined as the ratio of the hyomental distance at the extreme of head extension to that in the neutral position [9]. Neutral head position was obtained with the patient lying on a flat operating table without head extension or neck flexion.

Chest AP diameter was measured in centimeters along the vertical axis from the operating table to the sternal notch, using an adjustable sliding T-bevel rule (Universal Bevel$^{\text{TM}}$; Long Jer Precise Industry, Taichuang, Taiwan). This measurement device has a movable arm which can be easily locked at any angle by a pivot and wing nut system, making it suitable for vertical distance measurement.

Induction of anesthesia and laryngoscopic intubation

When all airway evaluations were complete, each patient was placed on a surgical bed with an incompressible pillow, 7-cm in height. Standard monitors were applied, and anesthesia was induced with fentanyl (1–2 μg/kg), thiopental (5–7 mg/kg), and vecuronium (0.1 mg/kg) to facilitate tracheal intubation. After loss of all four twitches on the train-of-four obtained by ulnar nerve stimulation, laryngoscopy was performed by use of a size 3 Macintosh blade. To eliminate variations introduced by involvement of more than one larygoscopist, a single experienced anesthesiologist with >10 years of clinical experience, unaware of the results of the airway assessments, performed all of the direct laryngoscopies and classified the laryngoscopic view according to Cormack–Lehane grade [10] without external laryngeal manipulation. Easy visualization of the larynx (EVL) was defined as a grade 1 or 2 view, and DVL as a grade 3 or 4 view, on direct laryngoscopy.

In cases of DVL at the first laryngoscopy attempt, the following sequence of consecutive maneuvers was used. During the first attempt, external laryngeal pressure was promptly applied with the help of an assistant, and the laryngoscopic view was graded once more under these conditions. For patients for whom laryngoscopic intubation was impossible despite external laryngeal manipulation, a second attempt at intubation was performed with the aid of a stylet. After two failed attempts at laryngoscopic intubation, the patient was managed at the discretion of the attending anesthesiologist using the anesthesia department's difficult airway practice guidelines.

Statistical analysis

Statistical analysis was performed with SPSS v. 18.0 (SPSS, Chicago, IL, USA) and MedCal for Windows v. 7.3 (MedCal Software, Mariakerke, Belgium). First, we calculated average chest AP diameter from the measurements for all patients. Normality test using the Kolmogorov–Smirnov test indicated that chest AP diameters were non-normally distributed (median, 16.2 cm; range, 12.0–19.7 cm). Thus, the differences (i.e., the net differences with absolute values) between measured chest AP diameter for each patient and the calculated median value were used for statistical analysis.

Second, univariate analysis was performed to assess the associations of each variable, including chest AP diameter, with DVL, using a χ^2 or Fisher's exact test, unpaired t test, or Mann–Whitney U test. Variables with $p \leq 0.2$ in univariate analysis were entered into a binary multivariate logistic regression model, using Wald statistic backward stepwise selection. Odds ratios, 95 % confidence intervals, and *p* values were obtained for the independent predictors. For this analysis, modified Mallampati class was dichotomized: classes I and II were scored as 0; classes III and VI, as 1.

Third, receiver operating characteristic (ROC) curves were constructed to investigate compromises between sensitivity and specificity for each independent predictor. The ROC area under the curve (AUC), which ranges from 0.5 to 1.0, equals the probability of correctly predicting DVL. Therefore, the optimum cutoff points for each test were determined at the maximum AUC for the corresponding ROC curve. Because the difference between an individual's chest AP diameter and the median value was identified as an independent predictor of DVL, its diagnostic accuracy was compared with those of the other proved single predictors by calculating the AUC for each ROC curve. The AUC values were compared by use of the nonparametric method of Delong et al [11], which is based on the Mann–Whitney *U* statistic.

In all analyses, $p < 0.05$ was taken to indicate statistical significance.

Results

Of the 280 subjects considered for enrollment, 11 did not complete the study: nine were eliminated by our exclusion criteria and the other two were excluded because of their refusal to give informed consent. Finally, 269 subjects were included in the study.

Outcomes of laryngoscopy and intubation

DVL was observed for 49 subjects (18.2 %). For 28 of these 49, application of external laryngeal pressure improved the laryngeal view to EVL (Cormack–Lehane grade 1 or 2). In sub-group analysis, the utility of external laryngeal pressure was significantly greater for patients with chest AP diameter smaller than the median value than for those with AP diameter larger than the median value (92.0 % (23/25) vs. 20.8 % (5/24), respectively; $p < 0.001$).

Among the 21 patients for whom external laryngeal manipulation failed to improve the laryngeal view to EVL, a stylet was used for 16 patients, and intubations under direct laryngoscopy were successful at the second attempt. Two patients were eventually intubated by an alternative method using a lighted stylet at the third attempt. No cases of failed intubation occurred.

Univariate and multivariate logistic regression analysis

In univariate analysis, significantly different hyomental distance at the extreme of head extension, hyomental distance ratio, interincisor gap, and modified Mallampati test were observed between the DVL and EVL groups ($p < 0.05$). With regard to the difference between chest AP diameter and its median value, the value was significantly higher for the DVL group than for the EVL group (1.7 ± 0.8 vs. 1.0 ± 0.8 cm, $p < 0.001$) (Table 1).

Eight variables associated with DVL at $p \leq 0.2$ in the univariate analysis were entered into multivariate logistic regression analysis. Logistic regression showed that five variables (the difference between chest AP diameter and its median value, age, hyomental distance ratio, interincisor gap, and modified Mallampati test class III–IV) were independent predictors of DVL ($p < 0.05$; Table 2).

Table 1 Univariate analysis of the variables that affect difficulty of laryngoscopy

Variable	EVL ($N = 220$)	DVL ($N = 49$)	*p* value
Gender: male/female	115/105	22/27	0.438
Age (years)	55.2 ± 13.6	58.1 ± 11.8	0.172
Weight (kg)	62.5 ± 11.6	60.9 ± 9.1	0.352
Height (cm)	162.8 ± 8.5	161.0 ± 7.1	0.135
BMI (kg/m^2)	23.5 ± 3.7	23.5 ± 3.2	0.977
ASA physical status (I/II)	147/74	26/23	0.112
Modified Mallampati class: easy (class I or II)/difficult (class III or IV)	191/29	24/25	<0.001*
Hyomental distance in the neutral position (cm)	4.1 ± 0.6	4.0 ± 0.6	0.165
Hyomental distance at the extreme of head extension (cm)	6.5 ± 0.7	5.9 ± 0.8	<0.001*
Hyomental distance ratio	1.6 ± 0.2	1.5 ± 0.2	0.004*
Interincisor gap (cm)	4.4 ± 0.6	4.0 ± 0.5	<0.001*
Difference between chest AP diameter and its median value (cm)	1.0 ± 0.8	1.7 ± 0.8	<0.001*

Values are presented as mean ± SD or numbers

EVL easy visualization of the larynx (Cormack–Lehane grade 1 or 2), *DVL* difficult visualization of the larynx (Cormack–Lehane grade 3 or 4)

* Statistically significant ($p < 0.05$)

Table 2 Logistic regression analysis showing the independent predictors of DVL

	Odds ratio	95 % CI	*p* value
Age	1.037	1.005–1.070	0.024*
Modified Mallampati test (class III–IV)	0.145	0.063–0.330	<0.001*
Interincisor gap	0.249	0.112–0.555	0.001*
Hyomental distance ratio	0.050	0.006–0.397	0.005*
Difference between chest AP diameter and its mean value	3.900	2.371–6.415	<0.001*

CI confidence interval

* Statistically significant ($p < 0.05$)

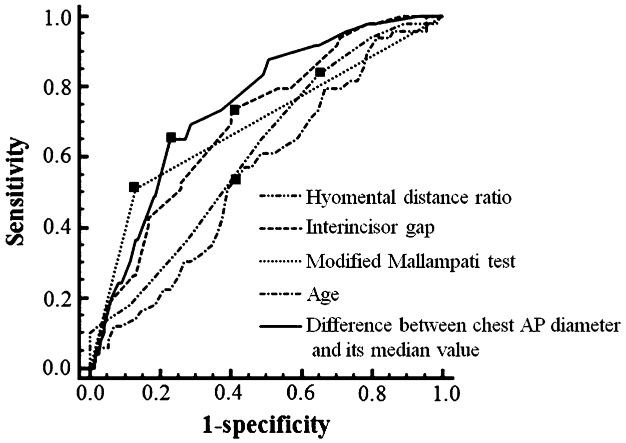

Fig. 1 Receiver operating characteristic curves for hyomental distance ratio, interincisor gap, modified Mallampati test, age, and difference between chest AP diameter and its median value. *Filled squares* indicate the optimum cutoff point for each test

ROC curve analysis

The ROC curves of the five single predictors that were relevant to DVL in the multivariate analysis are shown in Fig. 1. The difference between chest AP diameter and its median value alone with a test threshold of 1.5 cm resulted in reasonable accuracy (AUC, 0.748; 95 % confidence interval, 0.692–0.799). In comparison with the AUC value for the difference between chest AP diameter and its median value $\geq$1.5 cm, those for the modified Mallampati class III–IV and interincisor gap $\leq$4.3 cm were similarly high whereas those for age >57 years and hyomental distance ratio $\leq$1.6 were significantly lower ($p < 0.05$; Table 3).

Table 3 Comparison of receiver operating characteristic curve of the difference between chest AP diameter and its median value and four other independent predictors of difficult visualization of the larynx

Airway assessment test	AUC	SE	95 % CI
Difference between chest AP diameter and its median value $\geq$1.5 cm	0.748	0.036	0.692–0.799
Modified Mallampati class III–IV	0.689	0.038	0.630–0.744
Interincisor gap $\leq$4.3 cm	0.701	0.039	0.643–0.755
Hyomental distance ratio $\leq$1.6	0.618*	0.042	0.557–0.676
Age >57 years	0.559*	0.043	0.498–0.620

AUC area under the curve, *SE* standard error, *CI* confidence interval

* Significantly different from the difference between chest AP diameter and its median value ($p < 0.05$)

Discussion

Our results indicated that if an identical 7 cm head elevation was applied during laryngoscopic intubation, laryngoscopy was more difficult for patients whose chest AP diameter was either relatively large or small than for those with values within the average range (14.8–17.6 cm), irrespective of external laryngeal manipulation. This is the first study to demonstrate that the interaction of the head elevation height and chest AP diameter can strongly affect DVL, even for normal-sized adults.

Currently, there are two prominent airway theories (two-curve theory [12, 13] and obstacle theory [14, 15]), which are clinically useful and relevant to laryngoscopic intubation. We believe that the two-curve theory is more suitable for explaining the findings of radiology or more detailed anthropometric investigations. In this regard, our results can be schematically explained by the obstacle theory proposed by Isono [14, 15], who suggested that two groups of obstacles (posterior or anterior to the oral space) between the laryngoscopist's eyes and the vocal cord can impair the laryngeal view during direct laryngoscopy (a in Fig. 2).

Use of a head elevation of 7 cm for patients with a relatively small chest AP diameter raises posterior obstacles to a greater extent than anterior obstacles, but little change in the vocal cord position occurs (b-1 in Fig. 2). Considering the insufficient downward movement of posterior obstacles, a large amount of upward movement of the anterior obstacles and the vocal cord would occur during occipitoatlantoaxial complex extension. Despite subsequent movement of anterior obstacles during laryngoscopic handling, this structural arrangement eventually impedes the laryngoscopist's view of the glottis (b-2 in Fig. 2).

In the optimum head-elevation position, upward movement of the anterior and posterior obstacles is similar, and both obstacles are horizontally located (c-1 in Fig. 2). Subsequent occipitoatlantoaxial complex extension and laryngoscopic handling enable complete visualization of the vocal cord (c-2 in Fig. 2).

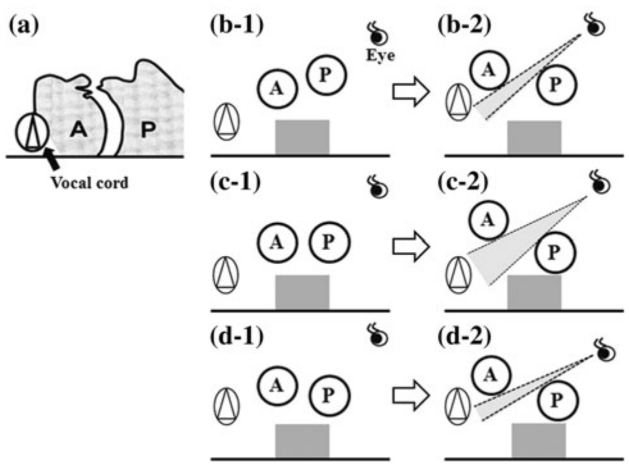

Fig. 2 Schematic explanation of dynamic configuration changes during direct laryngoscopy for patients with a relatively small chest AP diameter (**b**), chest AP diameter within the average range (**c**), and a relatively large chest AP diameter (**d**) using the "obstacle theory" [14, 15]. **a** Original configuration; **b-1**, **c-1**, **d-1**, 7 cm head elevation position; **b-2**, **c-2**, **d-2**, occipito–atlanto–axial complex extension and laryngoscopic handing. *P* obstacles located posterior to the oral airway space (upper teeth, maxilla, head, and others); *A* obstacles located anterior to the airway (tongue, epiglottis, mandible, and others). The *shaded quadrangle* represents the 7-cm-height pillow. The *shaded area* represents the visual field. The optimum position of the laryngoscopist's eyes may differ between individual situations

In contrast, use of 7-cm head elevation for patients with a relatively large chest AP diameter results in greater upward movement of the vocal cord and anterior obstacles than of posterior obstacles (d-1 in Fig. 2). As a result, this structural arrangement limits upward movement of the anterior obstacles and vocal cord and downward movement of the posterior obstacles during occipitoatlantoaxial complex extension. Even considering additional upward movement of the anterior obstacles during laryngoscopic handling, the initial structural arrangement in this head elevation leads to DVL (d-2 in Fig. 2). This is supported by previous reports that hyperelevation of the head beyond the sniffing position improved visualization of the glottic structure of morbidly obese patients [4, 5]. For this patient population, chest AP diameter is certainly larger than the upper limit of the average range.

In this study, the utility of external laryngeal pressure was significantly greater for patients with chest AP diameter smaller than the median value than for those with chest AP diameter larger than the median value (92.0 vs. 20.8 %, respectively). This can be explained by the different structural arrangement in the two subgroups of patients during occipitoatlantoaxial complex extension. Compared with patients with a relatively large chest AP diameter, greater upward movement of the anterior obstacles and the vocal cord occurs for patients with a relatively small chest AP diameter, and thus external laryngeal pressure is of greater benefit in these cases.

In this study, the incidence of DVL was 18.2 %, which was within the range of a DVL incidence of 6–27 % reported by a meta-analysis [16]. In addition to different patient characteristics (e.g., age, gender, BMI) and clinical settings (e.g., sizes or types of laryngoscope blade used), a problem inherent in the definition of difficulty of laryngoscopy may cause wide variations in the incidence of DVL [16, 17]. Most studies evaluating laryngoscopy difficulty have relied on categorical measures, for example "DVL" versus "EVL". However, as Benumof remarked, there is no real border between "DVL" and "EVL", but rather a range of difficulty, from easy to impossible [17]. There is, in addition, much uncertainty and inaccuracy in this grading system, especially between Cormack–Lehane classification grade 2 (defined as EVL in our study) and 3 (defined as DVL in our study) [16, 18].

The large incidence of DVL in our study may be related in part to the study design, in which a 7-cm high incompressible pillow was applied without consideration of ethnic differences. Although elevating the occiput by use of a 7-cm-high incompressible pillow can cause flexion of approximately 35° in the lower cervical spine on the chest (one of the end points for the sniffing position) [2, 19] in Western populations, it may lead to over-flexion of the lower cervical spine in Asian populations because of their relatively small chest AP diameter. The conventional recommendation of 7–9 cm head elevation may increase the risk of DVL in Asian populations because the same problem can occur as observed for 7-cm head elevation for patients with a relatively small chest AP diameter. Although some of our findings (i.e., the test threshold and diagnostic validity profile of the difference between chest AP diameter and its median value) may be somewhat different for different amounts of head elevation, our results cannot be affected by ethnic differences. Even if different amounts of head elevation are used, chest AP diameter of individual subjects is more important than ethnicity for the best laryngoscopic view.

The sample size in this study may be criticized. Unlike a comparative study, the specific sample size formula using 4 components (type I error, power, the variance of the outcome measure, and the difference the investigator wishes to detect) cannot be used for a cohort observational study. Nonetheless, a reasonably acceptable level of sample size should be required to draw inferences about the effect on subjects of "exposure" or "intervention", even in an observational study [20]. Although we, a priori, decided to enroll 280 subjects on the basis of previous similar research (most observational research on DVL studied 200–400 subjects [16]), one possible solution for determination of sample size is to use the sample size formula for prevalence survey for dichotomous outcome (given below) [21].

$$N = Z^2P(1-P)/d^2$$

where $N =$ sample size, $Z = Z$ statistic for the level of confidence required (for the level of confidence of 95 %, which is conventional, the Z value is 1.96), $P =$ expected prevalence (if prevalence is 20 %, $P = 0.2$), and $d =$ precision or allowable error (if the conventional value of 5 % is used, $d = 0.05$).

Retrospective sample size calculation for this study, using this sample size formula and 18.2 % prevalence, reveals that our sample size ($N \geq 229$) is large enough to reflect the general surgical population accurately.

This study had the limitation that we did not evaluate the amount of head elevation required to achieve the best laryngoscopic view for individual patients relative to chest AP diameter. With regard to this issue, horizontal alignment of the external auditory meatus with the sternum may be a useful option as an endpoint of optimum head elevation. This endpoint was originally developed for use with obese patients and was shown to produce excellent results in such cases [5]. In an experimental study using magnetic resonance imaging [13], this endpoint also seemed to be applicable to non-obese patients.

Another limitation is that our results obtained by a single operator may be biased. Cormack–Lehane classification can be fundamentally affected by the skill levels (clinical experiences) of the anesthesiologists performing the laryngoscopy. In addition, previous studies [16, 18] indicated that classification error between grades 2 and 3 happened not infrequently. Thus, all laryngoscopy and classifications of laryngoscopic view were performed by a single experienced anesthesiologist to eliminate variations introduced by these two sources (inter-operator variability and inter-rater variability).

Last, it was impossible to completely blind the laryngoscopist to subjects' chest AP diameter during direct laryngoscopies. Even if the laryngoscopist did not know the results of the preanesthetic assessments, large or small chest AP diameter may be obvious for some of the subjects.

In conclusion, chest AP diameter of individual patients was found to be related to difficulty of laryngoscopy in the 7-cm head-elevation position. Chest AP diameters above and below the average range (i.e., ≥1.5 cm from the median value) were strong predictors of DVL, even for non-morbidly obese patients. In this regard, our results indicated that a pillow of 7 cm may be too high for patients with a relatively small chest AP diameter or too low for patients with a relatively large chest AP diameter to obtain a clear view of the glottis in laryngoscopy. Therefore, adjustment of the height of a pillow may be required on the basis of chest AP diameter.

Conflict of interest None.

References

1. Adnet F, Baillard C, Borron SW, Denantes C, Lefebvre L, Galinski M, Martinez C, Cupa M, Lapostolle F. Randomized study comparing the "sniffing position" with simple head extension for laryngoscopic view in elective surgery patients. Anesthesiology. 2001;95:836–41.
2. El-Orbany M, Woehlck H, Salem MR. Head and neck position for direct laryngoscopy. Anesth Analg. 2011;113:03–9.
3. Benumof JL. Comparison of intubating positions: the end point of for position should be measured. Anesthesiology. 2002;97:750.
4. Schmitt HJ, Mang H. Head and neck elevation beyond the sniffing position improves laryngeal view in cases of difficult direct laryngoscopy. J Clin Anesth. 2002;14:335–8.
5. Collins JS, Lemmens HJ, Brodsky JB, Brock-Utne JG, Levitan RM. Laryngoscopy and morbid obesity: a comparison of the "sniff" and "ramped" positions. Obes Surg. 2004;14:1171–5.
6. Sivarajan M, Joy JV. Effect of general anesthesia and paralysis on upper airway changes due to head position. Anesthesiology. 1996;85:787–93.
7. Samsoon GL, Young JR. Difficult tracheal intubation: a retrospective study. Anaesthesia. 1987;42:487–90.
8. Savva D. Prediction of difficult tracheal intubation. Br J Anaesth. 1994;73:149–53.
9. Huh J, Shin HY, Kim SH, Yoon TK, Kim DK. Diagnostic predictor of difficult laryngoscopy: the hyomental distance ratio. Anesth Analg. 2009;108:544–8.
10. Cormack RS, Lehane J. Difficult tracheal intubation in obstetrics. Anaesthesia. 1984;39:1105–11.
11. DeLong ER, DeLong DM, Clarke-Pearson DL. Comparing the area under two or more correlated receiver operating characteristic curves: a nonparametric approach. Biometrics. 1988;44: 837–45.
12. Greenland KB, Edward MJ, Hutton NJ, Challis VJ, Irwin MG, Sleigh JW. Changes in airway configuration with different head and neck positions using magnetic resonance imaging of normal airway: a new concept with possible clinical applications. Br J Anaesth. 2010;105:683–90.
13. Greenland KB, Edward MJ, Hutton NJ. External auditory meatus-sternal notch relationship in adults in the sniffing position: a magnetic resonance imaging study. Br J Anaesth. 2010;104:268–9.
14. Isono S. Common practice and concepts in anesthesia: time for reassessment: is the sniffing position a "gold standard" for laryngoscopy? Anesthesiology. 2001;95:825–7.
15. Kitamura Y, Isono S, Suzuki N, Sato Y, Nishino T. Dynamic interaction of craniofacial structures during head positioning and direct laryngoscopy in anesthetized patients with and without difficult laryngoscopy. Anesthesiology. 2007;107:875–83.
16. Lee A, Fan LT, Gin T, Karmakar MK, NganKee WD. A systemic review (meta-analysis) of the accuracy of the Mallampati tests to predict the difficult airway. Anesth Analg. 2006;102:1867–78.
17. Benumof JL. Management of the difficult adult airway. With special emphasis on awake tracheal intubation. Anesthesiology. 1991;75:1087–110.
18. Cook TM. A new practical classification of laryngeal view. Anaesthesia. 2000;55:274–9.
19. Horton WA, Fahy L, Charters P. Defining a standard intubating position using "angle finder". Br J Anaesth. 1989;62:6–12.
20. Carlson MD, Morrison RS. Study design, precision, and validity in observational studies. J Palliat Med. 2009;12:77–82.
21. Naing L, Winn T, Rusli BN. Practical issues in calculating the sample size for prevalence studies. Arch Orofac Sci. 2006;1: 9–14.