표제지

의학석사 학위논문

경추 수술 환자에서 선상 도수 고정법 하 McGrath® MAC 비디오 후두경 기관 삽관 시 어려움의 영상학적 예측 인자

Radiographic predictors of difficult McGrath□ MAC videolaryngoscopy in patient undergoing cervical spine surgery with manual in-line cervical stabilization during intubation

2020년 2월

서울대학교 대학원
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지도교수 박 희 평

이 논문을 의학 석사 학위논문으로 제출함

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의학과 마취통증의학전공

윤 세 희

윤세희의 석사 학위논문을 인준함

2020년 1월

위 원 장 ________________ (인)

부 위 원 장 ________________ (인)

위 원 ________________ (인)

ABSTRACT

Radiographic predictors of difficult McGrath® MAC videolaryngoscopy in patient undergoing cervical spine surgery with manual in-line cervical stabilization during intubation

Sehee Yoon
Department of Anesthesiology and Pain Medicine
College of Medicine
The Graduate School
Seoul National University

Background : McGrath® MAC videolaryngoscope is a useful device for successful intubation in cervical spine injured patients with manual in-line stabilization of the neck during intubation. We identified radiographic predictors of difficult McGrath® MAC videolaryngoscopy, which was defined as failed intubation at the first attempt or intubation time more than 60 s at the first intubation attempt, in patient undergoing cervical spine surgery.

Methods : Data on airway-related variables and various radiographic indices obtained from preoperative cervical spine lateral X ray and magnetic resonance imaging (MRI) were retrospectively collected from 183 cervical spine surgical patients who were intubated with McGrath® MAC videolayngoscope under manual in-line stabilization of the neck.
Results : 33 (18%) patients showed difficult videolaryngoscopic intubation. In multivariate logistic regression analysis, atlanto-occipital distance (odds ratio [95% confidence interval], 0.75 [0.63-0.89], P = 0.001) on cervical spine lateral X ray, C1-incisor-C6 angle (1.10 [1.01-1.19], P = 0.036) on extended cervical spine lateral X ray, tongue area (1.11 [1.03-1.20], P = 0.007) in the sagittal plane of cervical MRI, and interincisor gap (0.92 [0.86-0.98], P = 0.009) were independent risk factors of difficult videolaryngoscopic intubation.
Conclusions : Radiographic predictors indicating enlarged tongue (large tongue area) and limited neck extension (short atlanto-occipital distance and wide C1-incisor-C6 angle) and limited mouth opening were associated with difficult McGrath® MAC videolaryngoscopy in patients undergoing cervical spine surgery with manual in-line cervical stabilization during intubation. In clinical practice, preoperative radiographic evaluation for the tongue size and the extent of neck extension can be helpful for safe airway management in these patients.

Keywords: cervical spine surgery; difficult McGrath® MAC videolaryngoscopy; tongue size; neck extension
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INTRODUCTION

Patients who are planned to undergo cervical spine surgery have a high risk of difficult laryngoscopic intubation because of restricted movement of the neck during intubation. Cervical spine protective strategies such as manual in-line stabilization of the neck and application of cervical collar during intubation are required to avoid secondary neurologic injuries resulting from excessive neck extension. Such strategies during intubation can disrupt extension of the neck, opening of the mouth, and handling of direct laryngoscope, resulting in difficult laryngoscopy.[1-3] Therefore, various videolaryngoscopy that do not need alignment of laryngeal, pharyngeal and oral axes for intubation are preferred to direct laryngoscopy in those patients, in order to increase the success rate of intubation and to minimize cervical spine movement during intubation.[3-6]

Several previous studies suggested radiographic and sonographic indices as predictors of difficult laryngoscopy, including the tongue area (TA), the distance between hyoid bone and mandible, atlanto-occipital gap, the length of epiglottis, and pre-epiglottic space thickness.[7-10] However, the relationship between these indices and difficult videolaryngoscopy is not fully established. Some radiographic indices representing the tongue size may be associated with difficult videolaryngoscopy because the bulky blade of a videolaryngoscopy makes its manipulation difficult in the oral cavity. On the other hand, some radiographic indices representing the neck extension may not predict difficult videolaryngoscopy, because videolaryngoscopy, unlike direct laryngoscopy, enables successful intubation without achieving alignment of three airway axes through extension of the neck. Moreover, there is no study to investigate predictive factors of difficult videolaryngoscopy in patients undergoing cervical spine surgery with cervical immobilization during intubation.

Therefore, the purpose of this retrospective study was to identify radiographic predictors of difficult McGrath® MAC videolaryngoscopy (McGrath® MAC; Aircraft Medical Ltd., Edinburgh, UK) in patient undergoing cervical spine surgery with manual in-line cervical stabilization during intubation by analyzing preoperative cervical spine magnetic resonance imaging (MRI) and X-ray images.

METHODS

Subjects

This retrospective study was approved by the institutional review board of Seoul National University Hospital (No: 1909-022-1060) and written informed consent was waived due to the nature of retrospective design. Patients who underwent cervical spine surgery and were intubated with McGrath® MAC videolayngoscope at Seoul National University Hospital between June 2016 and August 2018 were included. Also, they were participants for our other previous prospective study comparing the clinical performance of McGrath® MAC videolaryngoscope versus Optiscope video stylet in patients undergoing cervical spine surgery (NCT02769221).[11] Patients who were intubated with other intubation devices, not McGrath® MAC videolayngoscope, were excluded because we sought to identify predictive factors of difficult McGrath® MAC videolayngoscopic intubation. Patients were divided into one of two groups; difficult McGrath® MAC videolaryngoscopic intubation group and easy group based on intubation time and the number of intubation attempt. Difficult intubation was defined as failed intubation at the first attempt or intubation time more than 60 s at the first intubation attempt.[12]

Anesthetic Management

All patients entered the operating room without any premedication. After routine monitoring including electrocardiography, noninvasive blood pressure, and pulse oximetry was applied, anesthesia was induced by target-controlled infusion of propofol (effect site concentration of 4 μg/mL) and remifentanil (effect site concentration of 4 ng/mL). Rocuronium 0.6 mg/kg was administered to obtain appropriate muscle relaxation for tracheal intubation. Intubation was performed by two board-certified attending anesthesiologists with a reinforced tube with internal diameter 7.0 (female) or 7.5 mm (male) using McGrath® MAC videolayngoscope and a 60° angled malleable aluminum stylet. All patients received manual-in-line cervical stabilization during intubation. If patients wore cervical collar, it was removed just before intubation.

Data Collection

Data were divided into three parts; 1) demographic data and general characteristics such as co-morbidity, American society of anesthesiologists physical status, and the operated cervical level were recorded. 2) airway-related variables including Mallampati classification, retrognathia, interincisor gap (IIG), thyromental distance (TMD), thyromental height (TMH) and sternomental distance (SMD) was noted. Patients were asked to extend their neck as much as possible when measuring TMD and SMD, without pain or neurologic signs. 3) 21 radiographic indices such as atlanto-occipital distance (C1OD), tongue length (TL), tongue height (TH), TA, and incisor-C6-C1 angle in the neck extension position (I-C6-C1′) were three times measured and averaged from preoperative cervical spine lateral X−ray and cervical spine MRI images by an investigator who was blinded to group assignment. A detailed description of each radiographic index is shown in Table 1 and Fig. 1. When cervical spine lateral X−ray in extension position was taken, patients were ask to extend their neck as much as possible but without any pain or neurologic symptoms, just like when TMD and SMD were measured.

Statistical Analysis

Continuous variables between the difficult and easy group were compared using the student t test or Mann-Whitney test based on the results of the Shapiro-Wilk test. For discrete variables, the chi−square test or Fisher' s exact test was used. Univariate and multivariate logistic regression analyses were performed to identify predictors of difficult McGrath® MAC videolaryngoscopic intubation. Only variables with $p < 0.2$ in univariate analysis entered into multivariate logistic regression analysis. If collinearity existed among variables, only one variable with the most significant p value in univariate analysis was selected for multivariate analysis. Receiver operating characteristic (ROC) curve analysis was performed to evaluate the diagnostic value of the identified risk factors. The optimal cut−off point was defined as the value maximizing the sum of sensitivity and specificity.

Data are expressed as mean (standard deviation) for normally distributed continuous variables, median (interquartile range) for skewed distributed variables, and number (percent) for categorical variables. Statistical analysis was performed with

SPSS 25 (IBM Corp., Armonk, NY, USA) and Med Calculator (MedCalc Software, Ostend, Belgium). In all analyses, a $P < 0.05$ was taken to indicate statistical significance.

A previous large scaled study showed that the incidence of difficult videolaryngoscopic intubation was 27.4%.[12] To reproduce this incidence with a confidence interval of 95% with its total width of 0.13, a minimum of 181 patients were needed in this study.

RESULTS

183 patients who underwent cervical spine surgery were included in this study. 33 (18%) patients were allocated to difficult intubation group, primarily due to poor glottic visualization and difficulty in passing the tracheal tube, and 150 (82%) patients to easy intubation group.

There was no difference in general characteristics, diagnostic category, the operation site, mallampati classification between the two groups. (Table 2). IIG were significantly smaller in difficult intubation group compared with easy group (40.0 vs 45.0 mm, $P < 0.001$)

Table 3 summarizes the results of radiographic indices examined in this study. C1OD (median [IQR], 5.4 [3.3–7.4] vs 6.7 [5.4–8.7] mm, $P = 0.003$) was shorter, TL (70.6 [6.3] vs 67.8 [7.0] mm, $P = 0.035$) was longer, and TA (26.9 [23.1–31.1] vs 24.7 [21.1–27.1] cm^2, $P = 0.015$) was larger in difficult intubation group.

In multivariate logistic regression analysis (Table 4), C1OD (odds ratio [95% confidence interval], 0.75 [0.63–0.89], $P = 0.001$), C1-I-C6′ (1.10 [1.01–1.19], $P = 0.036$), TA (1.11 [1.03–1.20], $P = 0.007$), and IIG (0.92 [0.86–0.98], $P = 0.009$) were independent risk factors of difficult intubation. In ROC analysis (Figure 2), IIG as a single factor showed the highest area under the ROC curve (AUC) of 0.68 (95% CI: 0.59–0.76, $P = 0.002$), followed by C1OD (AUC = 0.67 [0.56–0.77], $p = 0.003$), TA (AUC = 0.64 [0.52–0.75], $p = 0.015$), and C1-I-C6′ (AUC = 0.60 [0.49–0.72], $p = 0.065$). The optimal cut-off value for IIG was 45.5 mm, and difficult intubation developed more frequently in cases with IIG ≤ 46 mm (9.50 [2.19-41.21]; P = 0.003). The optimal cut-off values for C1OD and TA were 5.6 mm and 27.7 cm^2 respectively, and difficult intubation developed more frequently in cases with C1OD ≤ 5.6 mm (3.83 [1.75-8.38]; P = 0.001) and TA ≥ 27.8 cm^2 (3.47 [1.58-7.62]; P = 0.002).

Tables

Table 1. Table 1.Definitions of radiographic indices investigated in this study

	Detailed description	Meaning
Cervical spine lateral X-ray		
MHD (mm)	Linear distance from the inferior border of the mandibular body to the highest point of the hyoid bone	Tongue size
C1C5D (mm)	Linear distance from the antero-superior border of atlas to the antero-inferior border of the fifth cervical vertebra	Neck length
C1OD (mm)	Linear distance from upper margin of posterior tubercle of atlas to occiput	Neck extension
HCD (mm)	Linear distance from the highest point of the hyoid bone to the anterior border of the nearest cervical vertebra	Tongue size
C1C2D (mm)	Linear distance from lower margin of the spinous processes of atlas to upper margin of the spinous processes of axis in the neutral position	Neck extension
C1-I-C6 (^{0})	The angle between the line from the anterior border of atlas to the tip of upper incisors and the line from the antero-inferior border of C6 vertebral body to the tip of upper incisors in the neutral position	Cervical range of motion
I-C6-C1 (^{0})	The Angle between the line from the tip of upper incisors to the antero-inferior border of C6 vertebral body and the line from the anterior border of atlas to the antero-inferior border of C6 vertebral body in the neutral position	
I-C1-C6 (^{0})	The Angle between the line from the tip of upper incisors to the anterior border of atlas and the line from the antero-inferior border of C6 vertebral body to the anterior border of atlas.	
C1-I-C6′ (^{0})	Same as C1-I-C6 in the extension position of the cervical spine	Cervical range of motion
I-C6-C1′ (^{0})	Same as I-C6-C1 in the extension position of the cervical spine	
I-C1-C6′ (^{0})	Same as I-C1-C6 in the extension position of the cervical spine	

Cervical spine MRI		
TL (mm)	Linear distance from the vallecula to the tip of the tongue	Tongue size
TH (mm)	Perpendicular height from the line of tongue length to the top of the tongue	
TA (mm^2)	Tongue area above the line of tongue length from the tip of the upper incisors to the vallecula in the mid-sagittal plane	Tongue size
EL (mm)	Linear distance from the vallecular to the tip of the epiglottis	Epiglottis size
EPD (mm)	Distance between the epiglottis and the posterior wall of the pharynx	Pharyngeal space
EA (^{0})	Angle of epiglottis from perpendicular line	Epiglottis angle
CVLVC	Anatomical position of the vocal cords in relation to the cervical vertebrae	Anatomical position of vocal cord
SVD (mm)	Linear distance from skin to the vallecula	Pre-epiglottic area
SED (mm)	Linear distance from skin to the tip of the epiglottis	Pre-epiglottic area
SGD (mm)	Linear distance from skin to the anterior tip of vocal cords	Pre-cord area

MHD, mandibulohyoid distance; C1C5D, atlanto-the 5th cervical vertebral distance; C1OD, atlanto-occipital distance; HCD, hyoidocervical distance; C1C2D, atlanto-axial distance; C1-I-C6, C1-incisor-C6 angle in the neutral position; I-C6-C1, incisor-C6-C1 angle in the neutral position; I-C1-C6, incisor-C1-C6 angle in the neutral position; C1-I-C6′, C1-incisor-C6 angle in the neck extension position; I-C6-C1′, incisor-C6-C1 angle in the neck extension position; I-C1-C6′, incisor-C1-C6 angle in the neck extension position; MRI, magnetic resonance imaging; TL, tongue length; TH, tongue height; TA: tongue area; EL, epiglottis length; EPD, epiglottic-pharyngeal distance, EA, epiglottis angle; CVLVC, cervical vertebral level of vocal cords; SVD, skin-vallecular distance; SED, skin-epiglottic distance; SGD, skin-glottic distance.

Table 2. Comparisons of general characteristics and airway-related variables in patients with difficult versus easy McGrath® MAC videolaryngoscopic intubation

	Difficult (n=33)	Easy (n=150)	P value
Male gender	19 (57.6%)	92 (61.3%)	0.839
Age (yr)	59.0 (49.5-64.5)	55.0 (41.0-66.3)	0.348
Weight (kg)	68.5 (13.7)	65.9 (12.5)	0.262
Height (cm)	164.0 (8.3)	163.9 (9.2)	0.941
BMI (kg/m^2)	25.3 (22.2-27.5)	23.9 (22.4-26.4)	0.108
ASA physical status			
1	17 (51.5%)	67 (44.7%)	0.602
2	14 (42.4%)	75 (50.0%)	0.551
3	2 (6.1%)	7 (4.7%)	0.666
4	0 (0.0%)	1 (0.7%)	1.000
Diagnosis			
Degenerative	25 (75.8%)	103 (68.7%)	0.552
Tumor	8 (24.2%)	39 (26.0%)	1.000
Trauma	0 (0.0%)	2 (1.3%)	1.000
Vascular	0 (0.0%)	2 (1.3%)	1.000
Congenital	0 (0.0%)	4 (2.7%)	1.000
Operation site			1.000
Above C2	9 (27.3%)	41 (27.3%)	
Below C3	24 (72.7%)	109 (72.7%)	
Mallampati classification			
1	6 (18.2%)	35 (23.3%)	0.680
2	17 (51.5%)	71 (47.3%)	0.808
3	9 (27.3%)	40 (26.7%)	1.000
4	1 (3.0%)	4 (2.7%)	1.000
Retrognathia of mandible	0 (0.0%)	2 (1.3%)	1.000
IIG (mm)	40.0 (36.5-42.0)	45.0 (40.0-50.0)	0.001
TMD (mm)	78.0 (70.0-86.5)	80.0 (70.0-90.0)	0.523
TMH (mm)	53.0 (47.5-61.0)	51.5 (50.0-60.0)	0.716
SMD (mm)	130.0 (107.5-150.0)	140.0 (118.8-160.0)	0.068

Data are presented as mean (SD), median (IQR), or number of patients (%). BMI, body mass index; ASA, American society of anesthesiologists; IIG, interincisor gap; TMD, thyromental distance; TMH, thyromental height; SMD, sternomental distance

Table 3. Comparisons of radiographic indices in patients with difficult versus easy McGrath® MAC videolaryngoscopic intubation

	Difficult (n = 33)	Easy (n = 150)	P value
MHD (mm)	12.1 (5.4−19.8)	11.4 (5.9−16.7)	0.715
C1C5D (mm)	90.0 (85.8−94.0)	88.4 (83.6−95.3)	0.594
C1OD (mm)	5.4 (3.3−7.4)	6.7 (5.4−8.7)	0.003
HCD (mm)	41.5 (8.8)	42.0 (6.2)	0.760
C1C2D (mm)	4.6 (3.3−6.8)	5.2 (3.8−7.2)	0.375
C1−I−C6 (^{0})	45.2 (5.9)	44.6 (5.1)	0.570
I−C6−C1 (^{0})	92.4 (7.8)	93.3 (7.9)	0.513
I−C1−C6 (^{0})	42.1 (4.6)	41.7 (5.2)	0.656
C1−I−C6′ (^{0})	36.5 (32.3−39.9)	34.4 (32.1−37.8)	0.065
I−C6−C1′ (^{0})	110.4 (104.3−120.6)	113.7 (108.4−118.3)	0.153
I−C1−C6′ (^{0})	32.5 (5.2)	31.4 (4.5)	0.251
TL (mm)	70.6 (6.3)	67.8 (7.0)	0.035
TH (mm)	38.2 (6.7)	36.2 (5.0)	0.053
TA (cm^2)	26.9 (23.1−31.1)	24.7 (21.1−27.1)	0.015
EL (mm)	17.0 (3.3)	17.5 (2.9)	0.429
EPD (mm)	5.8 (4.9−8.0)	5.4 (3.8−6.8)	0.061
EA (^{0})	28.2 (8.9)	28.7 (9.9)	0.847
CVLVC			
C4 vertebral body	1 (3.0%)	8 (5.3%)	1.000
C4−5 intervertebral space	11 (33.3%)	39 (26.0%)	0.522
C5 vertebral body	13 (39.4%)	65 (43.3%)	0.826
C5−6 intervertebral space	4 (12.1%)	26 (17.3%)	0.607
C6 vertebral body	4 (12.1%)	11 (7.3%)	0.480
C6−7 intervertebral space	0 (0.0%)	1 (0.7%)	1.000
SVD (mm)	29.7 (26.6−33.6)	30.3 (28.0−33.3)	0.356
SED (mm)	49.0 (7.2)	49.2 (6.0)	0.915
SGD (mm)	11.2 (9.6−13.3)	11.5 (10.3−12.9)	0.840

Data are presented as mean (SD), median (IQR), or number of patients (%). MHD, mandibulohyoid distance; C1C5D, atlanto−the 5th cervical vertebral distance; C1OD, atlanto−occipital distance; HCD, hyoidocervical distance; C1C2D, atlanto−axial distance; C1−I−C6, C1−incisor−C6 angle in the neck neutral position; I−C6−C1, incisor−C6−C1 angle in the neck neutral position; I−C1−C6, incisor−C1−C6 angle in the neck neutral position; C1−I−C6′, C1−incisor−C6 angle in the neck extension position; I−C6−C1′, incisor−C6−C1 angle in the neck extension position; I−C1−C6′, incisor−C1−C6 angle in the neck extension position; TL, tongue length; TH, tongue height; TA: tongue area; EL, epiglottis length; EPD, epiglottic−pharyngeal distance; EA, epiglottis angle; CVLVC, cervical vertebral level of vocal cords; SVD, skin−vallecular distance; SED, skin−epiglottic distance; SGD, skin−glottic distance.

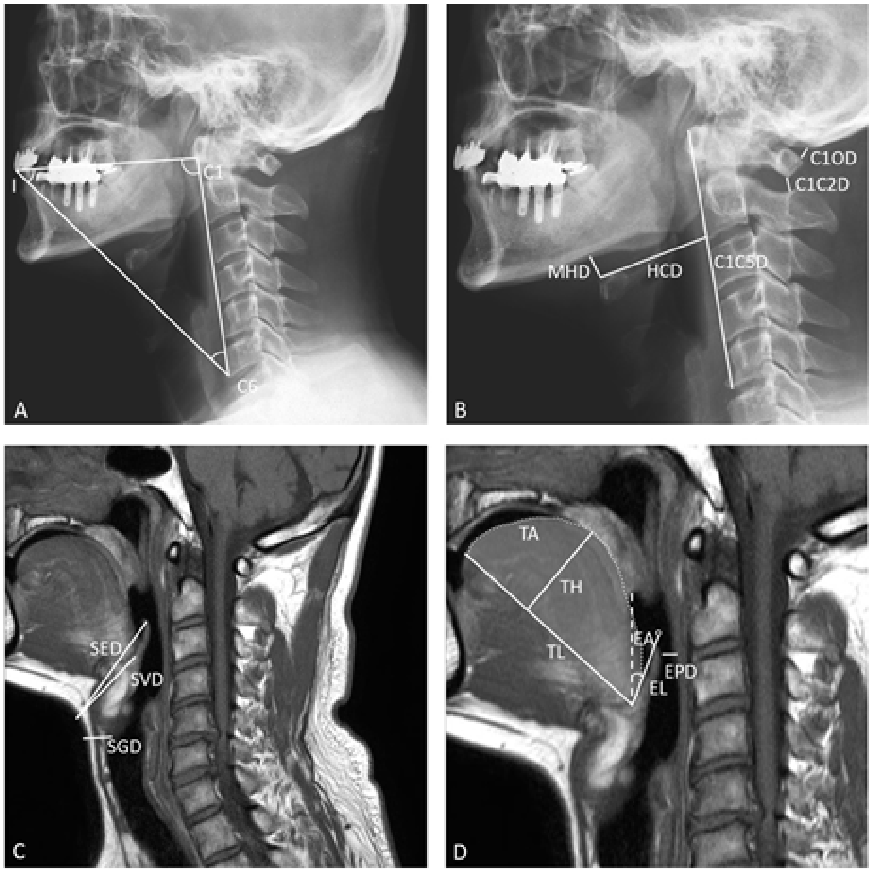
Table 4. Factors for difficult McGrath® MAC videolaryngoscopic intubation on univariate and multivariate logistic regression analyses

	Univariate			Multivariate		
	OR	95% CI	P value	OR	95% CI	P value
C1OD (mm)	0.78	0.66−0.92	0.002	0.75	0.63−0.89	0.001
C1−I−C6′ (°)	1.08	1.00−1.16	0.050	1.10	1.01−1.19	0.036
TL (mm)	1.06	1.00−1.12	0.037			
TH (mm)	1.07	1.00−1.15	0.055			
TA* (cm^2)	1.09	1.01−1.16	0.021	1.11	1.03−1.20	0.007
BMI (kg/m^2)	1.07	0.97−1.19	0.184	1.06	0.93−1.19	0.369
IIG (mm)	0.92	0.87−0.98	0.004	0.92	0.86−0.98	0.009

*Because there was a significant degree of collinearity between TA and TL and between TA and TH, only TA was entered into multivariate analysis. Nagelkerke R2 statistic was 0.272 and Hosmer and Lemeshow goodness of fit test was not significant at 5% (P = 0.320) in multivariate analysis. OR, odds ratio; CI, confidence interval; C1OD, atlanto−occipital distance; C1−I−C6′ , C1−incisor−C6 angle in the neck extension position; TL, tongue length; TH, tongue height; TA: tongue area; BMI, body mass index; IIG, interincisor gap.

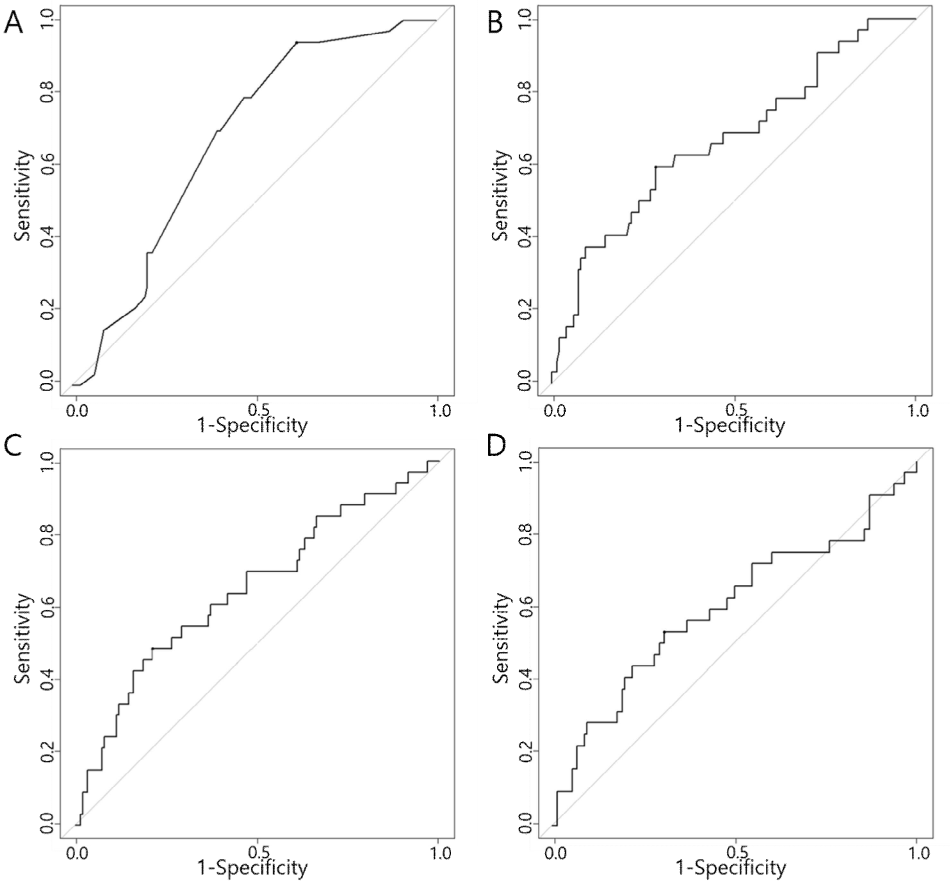
Figures

Figure 1. Illustration of radiographic indices measured in this study.



A and B. parameters in cervical lateral x-ray. C and D. parameters in the sagittal image of cervical spine magnetic resonance imaging. I, the tip of upper incisiors; C1, anterior-inferior border of atlas; C6, anterior-inferior border of the 6th cervical vertebra; MHD, mandible to hyoid distance; HCD, hyoid bone to nearest cervical vertebra distance; C1C5D, atlas to the 5th vertebra distance; C1OD, atlanto-occipital distance; C1C2D, atlanto-axial distance; SED, skin to epiglottis distance; SVD, skin to vallecular distance; SVCD, skin to vocal cord distance; TL, tongue length; TH, tongue height; TA, tongue area; EA, epiglottis angle; EL, epiglottis length; EPD, epiglottis to pharyngeal distance.

Figure 2. Receiver operating characteristic (ROC) curve analyses of the interincisor gap, atlanto-occipital distance, tongue area and C1-I-C6 angle.



The area under ROC curve of interincisor gap(A), atlanto-occipital distance(B), tongue area(C) and C1-I-C6 angle in extension position(D) for predicting difficult McGrath(R) MAC videolaryngoscopy is 0.68, 0.67, 0.64 and 0.60 respectively.

DISCUSSION

This study was designed to find out which radiographic parameters obtained from preoperative routine MRI and X-ray images were predictive of difficult McGrath® MAC videolaryngoscopy. We demonstrated that C1OD and I-C6-C1′ in cervical spine X-ray as well as tongue area in sagittal plane of cervical MRI were significant predictors of difficult McGrath® MAC videolaryngoscopy in patients undergoing cervical spine surgery with manual-in-line cervical stabilization during intubation.

Limited neck extension can cause difficult direct laryngoscopy by affecting alignment of the oral, pharyngeal, and laryngeal axes, which is a critical factor for successful intubation when direct laryngoscopy is used for tracheal intubation. In contrast to direct laryngoscopy, McGrath® MAC videolaryngoscopy do not need alignment of the three airway axes for tracheal intubation because it provides indirect view on the airway structure. In this study, two radiographic parameters (C1OD and I-C6-C1′), among various radiographic parameters representing motion of cervical spine, were predictive of difficult McGrath® MAC videolaryngoscopy. Because short C1OD and large I-C6-C1′ are in association with limited neck extension, both radiographic parameters are also known to be predictors of difficult direct laryngoscopy.[7, 13]

However, as all intubations was performed under manual-in-line cervical stabilization in this study, the relationship between both radiographic parameters and difficult McGrath® MAC videolaryngoscopy was not clearly explainable. A possible explanation is that a little cervical extension occurs during McGrath® MAC videolaryngoscopic intubation and such a cervical extension may be helpful for tracheal intubation. Because McGrath® MAC videolaryngoscopy has a Macintosh-type blade with slightly acute angle, it needs forceful upward and forward elevation of its blade tip to obtain the glottis view. Therefore, some ranges of cervical extension are necessary even in patients with manual-in-line cervical stabilization. As a result, similar with difficult direct laryngoscopic intubation, limited neck extension during elevation of the blade tip of McGrath® MAC videolaryngoscope may result in difficult intubation. Indeed, a previous study investigating cervical spine motion during intubation with McGrath® MAC videolaryngoscopy in patients with cervical immobilization showed that cervical spine extension of 10.4° and 6.0° was observed at the occiput-C1 and C1-C2 segments respectively[14]. Another previous study showed cervical extension of 8.0° at the C1-C2 segment during McGrath® MAC videolaryngoscopic intubation in patients undergoing surgery for unstable cervical spine.[15]

Although range of cervical motion was found to be an important predictor for difficult videolaryngoscopy, clinical airway-related parameters such as TMD and SMD, which are well known to representing neck extension, were found out to be not effective in predicting difficult videolaryngoscope. Considering the fact that the patients have cervical disease, physical examination has a limitation because some of them may have difficult in neck extension due to pain or neurologic signs, or some others of them are even impossible to measure TMD and

SMD because of cervical instability. Therefore, measurement of radiographic parameters associated with neck extension, such as atlanto-occipital distance, was able to substitute physical examination on difficult airway in those patients.

In this study, tongue size was evaluated with measurements of TA, TH and TL in sagittal plane in MRI. Because there was a significant degree of collinearity between TA and TL and between TA and TH, only TA was entered into multivariate analysis. Our results showed that TA was an independent risk factor of difficult McGrath® MAC videolaryngoscopy and patients with TA ≥ 27.8 cm^2 had a 3.5-fold higher risk. This finding is associated with a relatively bulky blade of McGrath® MAC videolaryngoscopy. To visualize the glottic opening, manipulation of McGrath® MAC videolaryngoscopy is difficult in patients with large tongue due to limited space in the oral cavity and pharynx. Two previous studies used ultrasonographic methods to measure thickness of the tongue and found a positive significant association between thickness of the tongue and difficult laryngoscopic intubation.[16, 17] Another previous study demonstrated that TA on ostiomeatal unit computed tomography image was a significant predictor of difficult laryngoscopy in acromegaly patients.[10] Taken together, these previous studies and our study suggest that preoperative evaluation on tongue size via radiographic measurements can be helpful in predicting difficult laryngoscopy and videolaryngoscopy when both intubation devices are used for tracheal intubation.

In general, IIG less than 3 cm is accepted as a substantial sign for difficult intubation since IIG representing mouth opening ability is directly related to the extent of difficult insertion of airway devices into the oral cavity.[18] A previous study reported that small mouth opening was associated with difficult acute-angle videolaryngoscopy with an odds ratio of 1.18.[12] Another previous study conducted in cervical spine patient showed that IIG was a significant predictor of difficult laryngoscopy with AUC of 0.646[7]. Similarly, this study showed a significant negative relationship between difficult McGrath® MAC videolaryngoscopy and IIG with an odds ratio of 0.92 and AUC of 0.68, suggesting that although the extent of mouth opening as a single factor has weak discrimination power in predicting difficult McGrath® MAC videolaryngoscopy, small mouth opening is an important predictor of difficult McGrath® MAC videolaryngoscopy. This finding can be explained by the fact that a relatively bulky blade of McGrath® MAC videolaryngoscope makes its oral insertion difficult in patients with limited mouth opening.

This study also has some limitations. First, the subjects enrolled in this study were participants for a previous prospective study. We selected a cohort of patients from the study in a retrospective fashion. Therefore, selection bias existed. Second, only McGrath® MAC videolaryngoscope was used for tracheal intubation in this study. However, various videolaryngoscopes differing in their geometry (body curvature and thickness of the blade and shape of the blade tip) have been used in clinical practice. Therefore, there is a limitation in generalizing our findings to other videolaryngoscopes. Third, only patients with cervical spine disease were subjected and all intubation practices were performed under manual-in-line cervical stabilization. Although this special condition does not allow our results to be extrapolated to general population, our results can provide clinically useful information on airway management for patients with cervical spine instability, which is one of important reasons to use videolaryngoscopy.[3] Last, radiographic images, which were taken while patients were awake, have their own limitations in evaluating the airway in anesthetized patients because of a difference in muscle tone of the tongue at the time of radiographic examination and intubation. The tongue tends to fall back onto the posterior pharyngeal wall in anesthetized patients.[19] Also, in some patient with cervical instability, taking cervical X ray in the neck extension position may be impossible or is not recommended. Therefore, C1-I-C6 angle in the neck extenstion postion must be interpreted with great caution.

CONCLUSION

For cervical spine surgery patients with manual−in−line cervical stabilization during intubation, radiographic predictors indicating enlarged tongue (large tongue area) and limited neck extension (short atlanto−occipital distance in the neutral neck position and wide C1−incisor−C6 angle in the extended neck position) were associated with difficult McGrath® MAC videolaryngoscopy. Inter−incisor gap was also a significant predictor for difficult videolaryngoscopy. In clinical practice, preoperative radiographic evaluation for the tongue size and the extent of neck extension can be helpful for safe airway management in these patients.

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// 국문초록

서론 : McGrath® MAC 비디오 후두경은 경추 손상이 의심되는 환자에서 선상 도수 고정법(manual in-line stabilization)을 이용한 기관내 삽관에 유용하게 사용되고 있다. 이에 따라, 경추 수술을 시행받는 환자에서 비디오 후두경을 이용한 기관 삽관의 실패 혹은 어려움을 예측하는 영상학적 지표를 제시하고자 한다.

방법 : 경추 수술을 시행 받는 183명의 환자에서 기도 유지와 관련된 지표 및 수술 전 촬영한 경추 X ray와 경추 자기공명영상(MRI)에서 영상학적 지표를 측정하였다. 환자들은 선상 도수 고정법을 이용하여 McGrath® MAC 비디오 후두경으로 기관 삽관을 시행하였으며, 기관 삽관에 걸린 시간 및 기관 삽관의 시도 횟수가 기록되었다.

결과 : 183명의 환자 중 33명의 환자에서 McGrath® MAC 비디오 후두경을 이용한 기관 삽관에 어려움이 있었다. 다변량 로지스틱 회귀분석에 의해, 경추 X ray에서 측정한 환추-후두 거리와 (odds ratio [95% confidence interval], 0.75 [0.63-0.89], P = 0.001), 경추 신전 시 측정한 C1-incisor-C6 각도 (1.10 [1.01-1.19], P = 0.036), 경추 MRI에서 측정한 혀의 면적 (1.11 [1.03-1.20], P = 0.007), 앞니 사이 거리가 어려운 McGrath® MAC 비디오 후두경 기관삽관의 위험 인자임을 확인할 수 있다.

결론 : 경추 수술 시행 받는 환자들에서 혀의 크기, 경추 신전 및 개구 제한을 평가할 수 있는 영상학적 지표들이 McGrath® MAC 비디오 후두경을 이용한 기관 삽관의 어려움을 예측하는 유의한 지표가 될 수 있다. 따라서, 수술 전 시행한 영상 자료들을 평가한다면 보다 안전하고 용이하게 기도 확보를 할 수 있을 것으로 판단된다.

주요어: 경추 수술 환자의 기관 삽관, McGrath® MAC 비디오 후두경, 경추 신전, 혀의 크기

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