Randomized Cinefluoroscopic Comparison of Cervical Spine Motion using McGrath Series 5 and Macintosh Laryngoscope for Intubation with Manual in-Line Stabilization

Prok Laosuwan MD*,
Athitarn Earsakul MD**, Numphung Numkarunarunrote MD***,
Jongkonnee Khamjaisai MD****, Somrat Charuluxananan MD**

** Department of Anesthesiology, King Chulalongkorn Memorial Hospital, The Thai Red Cross Society, Bangkok, Thailand*
*** Department of Anesthesiology, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand*
**** Department of Radiology, King Chulalongkorn Memorial Hospital, Bangkok, Thailand*
***** Department of Anesthesiology, Mae Chan Hospital, Chiang Rai, Thailand*

Background: *Intubation in patients with suspected cervical spine injury must be cautiously performed to avoid any further neurologic trauma. Several intubation techniques have been introduced to minimize cervical spine motion such as the use of the videolaryngoscope.*
Objective: *The present study aims to compare the movement of the cervical spine during intubation by using McGrath series5 videolaryngoscope (MGL) and that of the conventional Macintosh laryngoscope from cinefluoroscopic imaging.*
Material and Method: *Twenty-two patients undergoing elective orthopedic surgery that did not involve cervical spine procedure and required general anesthesia were recruited into the study. All patients were randomized either to have intubation with MGL (n = 11) or Macintosh laryngoscope (n = 11) in a neutral position with manual in-line stabilization (MILS). The primary outcome was the cervical vertebral angle changes pre- and post-intubation, measured by cinefluoroscopy. The number of intubation attempts, the laryngoscopic view, the time to intubation, and the incidence of any complications were recorded as well.*
Results: *Eleven patients were included in each group without any exclusion from the study. The cervical vertebral angle changes pre- and post-intubation with the MGL was less than with the Macintosh laryngoscope at C3/4 (2.00 vs. 4.27 degrees, respectively; p-value = 0.034) and the cumulative changes of all cervical spine levels (9.18 vs. 17.18 degrees, respectively; p-value = 0.017). However, the time to intubation with the MGL was longer (35.07 vs. 23.21 seconds, p-value = 0.004), the laryngoscope view was better. There were no statistically significant differences in the intubation success rate, the number of attempts, and the incidence of complications.*
Conclusion: *Orotracheal intubation with MGL provided less cervical spine motion and improved visualization of the vocal cords, without causing adverse consequences as compared with Macintosh laryngoscope and MILS.*

Keywords: *Tracheal intubation, Laryngoscopes, Airway equipment, Anesthetic technique, Videolaryngoscopes, Cervical spine injury, Fluoroscopy*

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Airway management is the important skill to the anesthesiologists. Emergency tracheal intubation can be challenging in trauma, limitation of neck mobility or difficult anatomy. The incidence of cervical spine injury associated with blunt trauma is 1.8-2.4%[1,2]. Immobilization of the spine during intubation is essential to prevent secondary neurological damage in these patients[3].

Various techniques for tracheal intubation have been suggested for patients with potential cervical spine injury. Manual-in-line stabilization (MILS) should be performed throughout the procedure to stabilize the cervical spines. However, this maneuver can interfere with vocal cord visualization and increase the failure

Correspondence to:
Laosuwan P, Department of Anesthesiology, King Chulalongkorn Memorial Hospital, Thai Red Cross Society, Bangkok 10330, Thailand.
Phone: 08-1795-1414
E-mail: prok.l@chulahospital.org

rate of intubation[4]. Awake fiber optic-assisted intubation may be necessary in some situations, but needs the operator experiences[5]. In addition, this is not advisable in uncooperative patients. Blind nasotracheal intubation can possibly be used when there is no evidence of nasal or basilar skull fractures. However, the success rate depends on the skills of the practitioner. Orotracheal intubation with direct laryngoscopy is a more typical approach in emergency settings. It should be applied with a minimum force to decrease the risk of cervical spine movement[6].

Recently, videolaryngoscopes have become more popular for alternative devices for difficult airway management because they enhance the view at laryngoscopy, when compared with standard direct laryngoscope. Each is distinguish in design with its individual pros and cons. A number of videolaryngoscopes have been investigated regarding their outcomes in cervical spine motion in patients with restricted neck movement. The result demonstrated less cervical movement when compared with conventional laryngoscope.

The McGrath series5 videolaryngoscope (MGL) is a novel portable device, which contains a small camera located at the distal end of the acute angle blade. It is designed to attenuate the lifting force in successful intubation. Previous studies have shown that MGL improved laryngoscopic view in both manikins and patients[7,8]. Nevertheless, there are no data on the cervical spine movement during intubation. Therefore, the aim of the present study is to compare the MGL with the standard Macintosh laryngoscope in cervical spine motion during tracheal intubation in patients with MILS.

Material and Method

The present study has been approved by the institutional ethics committee (IRB No. 524/53). Written informed consent was obtained from patients undergoing orthopedics surgery that did not involve cervical spine procedures,which required orotracheal intubation. The authors included the patients between 20-65 years old, ASA I-II, and had a modified Mallampati score of 1 or 2. Exclusion criteria were: patients with body mass index >30 kg/m^2, presence of difficult intubation predictors, abnormal upper airway or cervical vertebrae, and pregnancy.

Each patient was randomized into 2 groups using a random number table by the principal investigator (PL) either to the MGL or Macintosh laryngoscope group. In the evening before the operation, patients' demographic data and baseline characteristic information were recorded by one of the investigators (JK). No premedication was given. In the operating room, each patient was preoxygenated with 100% oxygen and general anesthesia was induced with propofol 2 mg/kg and fentanyl 1 mcg/kg. All patients were bag-mask ventilated with 100% oxygen and desflurane up to 6%. Then cisatracurium 0.2 mg/kg was used to facilitate tracheal intubation after intravenous injection for 5 minutes to ensure muscle relaxation.

Before laryngoscopy, the forehead of each patient was fixed with medical tapes in the neutral position, resembling MILS. Afterwards, a lead apron was placed to protect the patient's body from the x-ray beam. Oral endotracheal tubes 7.0 mm ID and 8.0 mm ID were selected for female and male patient, respectively. All tubes were inserted with a malleable stylet. Orotracheal intubation was performed only by PL who was well experienced in both instruments. If the first attempt failed within 60 seconds or the patient developed SpO_2 <90%, laryngoscopy would be stopped and the patient would be ventilated with 100% oxygen via anesthetic bag-mask. Failure of intubation was considered when more than 2 attempts were required. Placement of endotracheal tube was confirmed by end-tidal CO_2. All medical personnel were requested to wear a lead apron and a thyroid collar shield during the study.

Cinefluoroscopy (Vision Vario 3D, Ziehm imaging, Germany) was used to capture the lateral view of the upper cervical vertebrae from device insertion until intubation was done and the laryngoscope was removed. The McGregor's line[9], an imaginary line from the caudal and dorsal parts of the occiput to the hard palate, was considered to reference C0. Another imaginary line between the lower cortical margin of anterior and posterior arch of the atlas was the reference line for C1. At C2-C4 level, imaginary lines from inferior to anterior cortical margin to the posterior of each vertebral body were considered reference lines (Fig. 1). Radiographic snapshots, taken at the time of maximum movement of upper cervical spines during laryngoscopy, were printed out. After then, the only radiologist (NN) who was blinded to both study groups measured the angle formed by adjacent vertebral levels. The difference of angle change at each cervical level was also calculated to compare between the pre- and post-intubation periods.

Time to intubation, number of intubation attempts, laryngoscopic views were recorded. Complications of intubation such as dental injury and hoarseness of voice were also recorded at 24 hours postoperatively.

Statistics

Results are presented as mean (SD) values. The mean of post-intubation angle and the difference of the angle change of each cervical spine level between the pre- and post-intubation were compared between both groups. Continuous and categorical data were analyzed by t-test and Chi-square or Chi-square for trend respectively using SPSS program version 18.0.

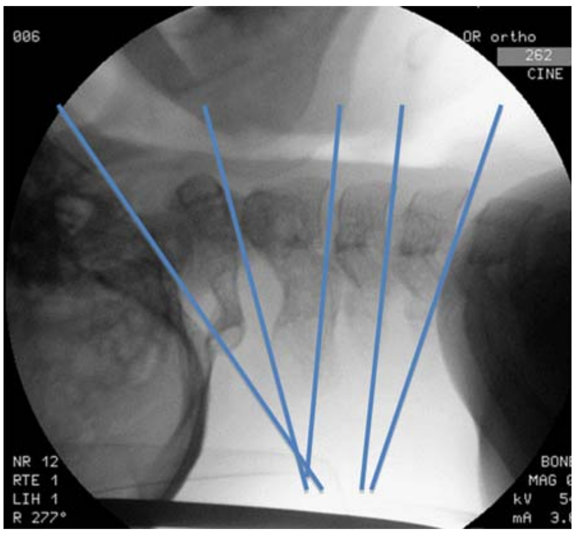

Fig. 1 Angle measurement of cervical spine.

A *p*-value of <0.05 was considered statistically significant.

From apreliminary study, 18 patients would provide 80% power to detect the difference of 5 degrees change of cumulative upper cervical spine angle during laryngoscopy with a probability of 0.05 for type I error. Therefore, to anticipate the missing data, the sample size of the present study was 20% increased to 22 patients.

Results

Twenty-two patients were enrolled in this study. Each group included 11 patients. No patients were excluded from the study. Demographic data and preoperative airway parameters were comparable in both groups (Table 1). Although, all upper cervical vertebrae were displaced in extension in both groups compared to pre-intubation, the M group had significantly less cumulative angle change than the C group ($17.18° \pm 9.65°$ vs. $9.18° \pm 3.37°$, respectively, $p = 0.017$). Moreover, C3/4 level was also less displaced in the M group and was significantly less displaced than the C group ($4.27° \pm 2.79°$ vs. $2.00° \pm 1.78°$, $p = 0.034$) (Table 2).

Regarding the maximum angle in each cervical spine level during laryngoscopy, C1/2 level in the M group was significantly different from the C group ($19.81° \pm 5.81°$ vs. $4.36° \pm 2.80°$, $p = 0.013$). The other cervical spine levels between both groups showed no significant difference (Table 3).

The mean of time to intubation (seconds) in

Table 1. Demographic and baseline parameters, Mean (SD)

	Group		*p*-value
	Conventional macintosh	McGrath	
Number of patients	11	11	
Male: female	9:2	5:6	0.076
Age (years)	35.18 (10.08)	43.18 (11.37)	0.096
Weight (kg)	67.02 (6.91)	63.68 (9.46)	0.356
Height (cm)	165.72 (9.41)	164.00 (5.84)	0.611
ASA PS status			
1	8	6	0.375
2	3	5	
Mallampati’s class			
1	6	9	0.17
2	5	2	
Thyromental distance (cm)	9.10 (1.49)	9.24 (1.13)	0.80
Interincisor gap (cm)	4.36 (0.58)	4.19 (0.57)	0.49
Total pre-intubation angle	35.00 (11.57)	29.91 (5.52)	0.203

the M group was significantly longer than the C group (23.21±7.42 vs. 35.07±9.49, $p = 0.004$) (Table 4), whereas the laryngoscopic view grade in the M group was better than the C group ($p = 0.031$). The number of intubation attempts in both groups showed no significant differences. One case in the M group, however, reported self-limited sore throat; no other intubation-related complications were observed in the C group.

Discussion

In the present study, the authors found that MGL reduced overall upper cervical spine motion during laryngoscopy in the neutral position compared with Macintosh laryngoscopy. These results suggest the potential benefit of MGL in patients with suspected cervical spine injury or known cervical spine pathology. Visualization of the glottis by Macintosh laryngoscope requires the alignment of oral, pharyngeal, and tracheal axes for tracheal intubation. These result in anterior movement of the vertebral bodies against MILS. On the other hand, MGL shows a clear view of vocal cords through a small camera attached to the handle of the ideolaryngoscope[10]. Therefore, without 3-axis requirement, intubation with the MGL causes less cervical spine movement compared with conventional laryngoscopy.

Table 2. Difference of pre- and post-intubation angles

Cervical spine level	Difference of changed degrees, mean (SD)		*p*-value
	Conventional macintosh	McGrath	
C0/1	5.36 (4.56)	3.27 (2.01)	0.180
C1/2	4.27 (3.74)	2.18 (1.08)	0.090
C2/3	3.27 (3.16)	1.82 (0.98)	0.161
C3/4	4.27 (2.79)	2.00 (1.79)	0.034*
Cumualtive angle	17.18 (9.65)	9.18 (3.37)	0.017*

*significant, *p*-value <0.05

Table 3. New angles after intubation of each level

Cervical spine level	Mean maximal new angles, mean (SD)		*p*-value
	Conventional macintosh	McGrath	
C0/1	10.00 (9.62)	11.45 (8.19)	0.707
C1/2	19.81 (5.81)	12.90 (6.14)	0.013*
C2/3	7.36 (4.15)	4.36 (2.80)	0.061
C3/4	4.00 (3.16)	5.54 (2.77)	0.237

* significant, $p<0.05$

Table 4. Secondary outcomes, mean (SD)

Outcomes	Conventional macintosh	McGrath	*p*-value
Time to intubate (sec)	23.21 (7.42)	35.07 (9.49)	0.004
Cormack-Lehane classification [n, (%)]			
1	4	6	
2	4	5	
3	3	0	0.031
Number of attempts			
1	1	9	0.147
2	1	2	

Our findings are in accordance with previous studies of cervical spine movement, using either indirect view or videolaryngoscope such as Pentax Airway Scope, Glidescope, Airtraq, and Bullard laryngoscope[11-13]. However, the findings in those studies differ from the present study in some aspects including the level of cervical spine movement. Maruyama et al demonstrated that the angles of movement between adjacent vertebrae were significantly less at the occiput/C1, C1/C2 and C3/C4 with Pentax Airway Scope compared with the Macintosh laryngoscope[12].Hirabayashi et al compared the degree of the anterior airway distortion and cervical spine movement during laryngoscopy using Glidescope (videolaryngoscope) and Macintosh laryngoscope. They revealed that overall cervical extension (C0-C4) during Glidescope procedure was statistically less than that measured during the Macintosh laryngoscopy[14].

In a previous study, Walker et al found no advantage to using MGL for uncomplicated tracheal intubation due to longer time to intubate[15], which is a similar result to in the present study. The difficulty in passing the tracheal tube into glottis with MGL may be from the non-aligned airway axes, which requires the distal tip of the tracheal tube to be angled by 60-70 degrees. Therefore, some of the unsuccessful attempts with MGL may be due to improper shaping of the stylet inserted into the tracheal tube. Another problem of using MGL is a *torus palatinus* found in one patient, which resulted in difficultmid-line insertion of MGL.

There are several limitations in the present study, however. Firstly, the authors did not attempt to perform external laryngeal manipulation to facilitate laryngeal visualization, which could interfere with cinefluoroscopic images. This might affect the laryngoscopic view grade, intubation time and the angle measurements in the present study. Secondly, to resemble MILI with the neutral position during laryngoscopy, we restricted the cervical spine motion by taping the patient's forehead since other procedures or equipment could interfere with the cinefluoroscopic study. This approach may contribute to unintentional cervical spine movement during intubation with both devices. Thirdly, the use of a single-operator protocol might be a concern. Extension movement of the cervical spine during laryngoscopy might be unfamiliar to other operator. Nevertheless, intubation techniques may differ in a multiple-operator protocol and result in bias.

Conclusion

McGrath Series 5 Videolaryngoscope caused less upper cervical spine movement in patients with manual in-line stabilization during intubation when compared with Macintosh laryngoscope. MGL may be analternative device to facilitate tracheal intubation when cervical motion restriction is required.

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Potential conflicts of interest

None.

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การศึกษาเปรียบเทียบการเขลื่อนของกระดูกสันหลังระดับคอจาก Cinefluoroscopy ขณะใส่ท่อหายใจในท่า Manual in-line stabilization ระหว่างการใช้ McGrath series 5 Video laryngoscope และ Macintosh laryngoscope

ปรก เหล่าสุวรรณ์, อธิฏฐาน เอียสกุล, น้ำผึ้ง นำการุณโรจน์, จงกลนี คำใจใส่, สมรัตน์ จารุลักษณานันท์

ภูมิหลัง: *การใส่ท่อหายใจในผู้ป่วยที่สงสัยว่าอาจจะมีการบาดเจ็บของกระดูกสันหลังระดับคอ ควรปฏิบัติด้วยความระมัดระวังมิให้เกิดการบาดเจ็บของระบบประสาทเพิ่มเติม ดังนั้นวิสัญญีแพทย์ควรใช้วิธีการใส่ท่อหายใจที่มีผลต่อการเคลื่อนของกระดูกสันหลังระดับคอให้น้อยที่สุด เช่น การใส่ท่อหายใจด้วย Video laryngoscope*

วัตถุประสงค์: *ผู้นิพนธ์จึงสนใจทำการศึกษาผลการเคลื่อนของกระดูกสันหลังระดับคอระหว่างการใส่ท่อหายใจในท่า Neutral position ด้วย McGrath series 5 Video laryngoscope (MGL) เปรียบเทียบกับ Macintosh laryngoscope ซึ่งเป็นวิธีมาตรฐานจากการถ่ายภาพรังสีเอ็กซ์แบบต่อเนื่อง*

วัสดุและวิธีการ: *ผู้ป่วย 22 รายที่เข้ารับการผ่าตัดทางศัลยกรรมกระดูกและข้อที่ไม่เกี่ยวกับกระดูกสันหลังระดับคอและต้องได้รับการระงับความรู้สึกแบบทั่วไปและใส่ท่อช่วยใจจะถูกแบ่งออกเป็น 2 กลุ่ม โดยการสุ่มได้แก่ กลุ่มที่ใส่ท่อหายใจด้วย MGL หรือ Macintosh laryngoscope ในท่าสมดุลและถูกจำกัดศีรษะไม่ให้เคลื่อนที่ (Manual in-line stabilization; MILS) จากนั้นการเคลื่อนไหวของกระดูกสันหลังระดับคอระหว่างการใส่ท่อหายใจจะได้รับการประเมินจากภาพรังสีด้วยเครื่อง Cinefluoroscopy โดยวัตถุประสงค์หลักคือ มุมของกระดูกสันหลังส่วนคอช่วงบนระดับต่าง ๆ ที่เปลี่ยนแปลงไปหลังการใส่ท่อหายใจเทียบกับก่อนใส่ท่อหายใจบันทึก laryngoscopic view ที่เห็นเวลาที่ใช้ใส่ท่อหายใจและภาวะแทรกซ้อนที่เกิดขึ้น*

ผลการศึกษา: *ผู้ป่วยกลุ่มละ 11 ราย ไม่มีผู้ใดออกจากการศึกษา กลุ่มผู้ป่วยที่ได้รับการใส่ท่อหายใจด้วย MGL มีผลต่างของมุมกระดูกสันหลังระดับคอที่เปลี่ยนไปหลังใส่ท่อหายใจน้อยกว่ากลุ่มที่ใส่ท่อด้วย Macintosh laryngoscope ทั้งค่ารวมของทุกระดับ (9.18° เทียบกับ 17.18° ตามลำดับ; ค่า $p = 0.017$) และระดับที่ C3/4 (2.00° เทียบกับ 4.27° ตามลำดับ; ค่า $p = 0.034$) แม้ระยะเวลาการใส่ท่อหายใจของกลุ่ม MGL นานกว่ากลุ่ม Macintosh (35.07 วินาที เทียบกับ 23.21 วินาที ค่า $p = 0.004$) แต่สามารถมองเห็นเส้นเสียงได้ดีกว่า ทั้งนี้ไม่พบความแตกต่างในอัตราการใส่ท่อหายใจสำเร็จ จำนวนครั้งที่ต้องใส่ท่อหายใจและภาวะแทรกซ้อนที่เกิดขึ้นระหว่างสองกลุ่ม*

สรุป: *การใส่ท่อหายใจด้วย MGL สามารถลดการเคลื่อนของกระดูกสันหลังระดับคอ รวมทั้งช่วยให้มองเห็นเส้นเสียงได้ดีขึ้นในผู้ป่วยที่อยู่ในท่าสมดุลและตรึงศีรษะกับที่โดยปราศจากภาวะแทรกซ้อนเพิ่มเติมแม้จะทำให้ใช้เวลาในการใส่ท่อหายใจเพิ่มขึ้น*