Radiographic comparison of cervical spine motion using LMA Fastrach, LMA CTrach and Macintosh laryngoscope

Abstract

**Background/Aim:** Optimal technique for airway management in patients with cervical pathology remains unclear. Intubating laryngeal mask airway devices; LMA CTrach-LMA Fastrach have not been compared for cervical spine (C-spine) movements in the context of cervical pathology. Present study aimed to determine upper C-spine movements by radiography during intubation with different devices as well as comparing the duration and success of intubation in cervical surgery.

**Material and Methods:** Sixty patients scheduled for elective cervical surgery were registered in this prospective, randomized study. Patients with cervical trauma/injury, previous neck surgery, and BMI>35kg/m² were excluded. Participants were randomized to one of three groups: LMA CTrach, LMA Fastrach or Macintosh laryngoscope. C-spine motion was evaluated by measuring angles created by bordering vertebrae at cervical 1/2 and 2/3 (C1/2, C2/3) segments on two lateral cervical radiographs for each patient. Also intubation time, ease of intubation, number of attempts and success rate were documented.

**Results:** Demographic data were similar in all groups. The cervical movement with LMA CTrach and LMA Fastrach compared to Macintosh laryngoscope were similar at C1/2. However LMA CTrach significantly reduced extension compared to LMA Fastrach and Macintosh laryngoscopes at C2/3. Duration of intubation was significantly shorter with Macintosh laryngoscope. Rate of successful intubation was 80% with LMA Fastrach, and 100% for both LMA CTrach and Macintosh laryngoscopes.
Conclusion: LMA CTrach laryngoscopy involves less upper C-spine movement than LMA Fastrach and doesn’t increase the duration of the intubation period.

Key Words: Neuroanesthesia, spinal surgery, intubation, spine imaging

1. Introduction

Intubation with various airway devices causes cervical spine (C-spine) extension to some degree. The process gains importance especially in emergency situations with cervical injury and in C-spine surgeries [1,2]. The main concerns of anesthesiologists for airway management both in cervical injury and C-spine surgeries include avoiding prolonged intubation time and preventing neurologic damage due to excess cervical movements [2,3].

Conventional laryngoscopy with Machintosh blade remains most familiar way to enable tracheal intubation; however, maneuvering for intubation and adjustment of the oropharyngeal and laryngeal axes produces C-spine movement [4]. In a recent systemic review, alternative intubation techniques performed in patients with cervical immobilization were compared with Machintosh laryngoscopy [5]. The authors concluded that evidence of the efficacy of alternative devices is missing. Fiberoptic intubation is still the most ideal technique to secure an airway in patients with predicted difficult intubation [2]. Fiberoptic laryngoscopy is considered to facilitate the least cervical movement during laryngoscopy but has several limitations like it requires a cooperative patient, lasts long so unsuitable for emergencies [2,6]. However, intubating laryngeal mask airways (ILMAs), LMA CTrach and LMA Fastrach are alternative techniques that may be useful when fiberoptic bronchoscope is not available. ILMAs have been validated for ventilation and as a conduit to tracheal intubation in patients with difficult airway. LMA CTrach was developed from LMA Fastrach with additional
advantageous features like visualizing glottis and intubation process [7,8]. Yet both
devices require experience to administer and administration may prolong intubation time.
Previous radiographic and fluoroscopic studies were carried out, purporting to evaluate
C-spine movement during intubation with various intubating techniques [4,6,9-12].
Intubating laryngeal mask airways have been compared for the success of tracheal
intubation [13,14]. However there have been no studies investigating C-spine movements
using both of the ILMAs. Moreover, effects of different intubation techniques on cervical
movements were followed up on healthy subjects in non-emergency situations those not
including neck, throat or cervical surgeries, in patients with cervical immobility due to
manual in-line stabilization or cervical collars and in cadaveric models in most studies
[3,12]. Comparative studies performed on patients with cervical pathologies who undergo
cervical surgery are lacking in the literature. So, this prospective, randomized,
radiographic study was conducted to compare the movements of the upper C-spine (C1,
C2 and C3) during laryngoscopy via LMA Fastrach, LMA CTrach and Macintosh
laryngoscopes in patients with lower cervical pathology undergoing C-spine surgery. The
secondary outcomes were comparisons of intubation success and duration.

2. Materials and Methods

The ethics committee of Erciyes University School of Medicine approved this
prospective, randomized, controlled study (reference number: 2011/177). All the patients
were informed about the study and written consents were obtained. Inclusion criteria
were patients with American Society of Anesthesiologists (ASA) physical status I–III,
whose ages were between 18-70 years old, and who were to undergo elective C-spine
surgery. Patients with documented cervical trauma or injury, previous neck surgery,
body mass index>35kg/m², or the possibility of pregnancy and failed tracheal intubation
(more than two intubation attempts with a device) were excluded. All patients’ preoperative height, weight, ASA physical status, body mass index, and Mallampati scores were documented.

Electrocardiography, non-invasive blood pressure measurement, and pulse-oximeter were monitorized in all patients in a standard fashion. Before anesthesia induction, the patients were positioned in the neutral position. Following preoxygenation, anesthesia was induced with intravenous (IV) 2 mg/kg propofol, 1 mg/kg lidocaine, 0.5 µg/kg remifentanil and 0.6 mg/kg rocuronium and maintenance was achieved with sevoflurane in air-oxygen mixture and IV infusion of remifentanil.

In the operating room, sixty-three patients were randomly assigned by a computer random number generator to one of three groups, corresponding to the three airway devices: Macintosh laryngoscope (Group M), LMA Fastrach (Group F) or LMA CTrach (Group C). We didn’t stabilize the head and neck and apply cricoid pressure. In Group M patients, conventional direct laryngoscopy was performed. Diameter of the endotracheal tube (ETT) was 7 or 7.5 mm in females and 8 mm in males. In Group F size 3, 4 or 5 LMA Fastrach (LMA North America, Inc. San Diego, USA) depending on the weight of the patient was applied in accordance with the manufacturer's instructions. A silicone-reinforced ETT was lubricated and inserted. If right position of the tube was achieved without resistance, ETT was advanced into the trachea, and cuff was inflated. Position of ETT was approved by auscultation and capnography. Subsequently, a special stabilizing rod was used to remove the LMA Fastrach. In Group C size 3, 4 or 5 LMA CTrach (LMA North America, Inc. San Diego, USA) was preferred depending on the weight of the patient. Initially, LMA CTrach was inserted without the viewer on, just as LMA
Fastrach was applied. The cuff was inflated and the patient was ventilated. The viewer was then attached to the connector while holding the handle. When a clear image of glottis and vocal cords was achieved an ETT was inserted and intubation was visualized, and the ETT cuff was inflated. The viewer was then detached, and LMA CTrach was removed following the same procedure as LMA Fastrach. Same experienced anesthesiologist, who had performed at least 100 intubations with each of LMA CTrach and LMA Fastrach and 500 intubations with Macintosh laryngoscope, performed all laryngoscopies, in order to minimize interoperator variability.

The intubation techniques were recorded with a portable X-ray machine. Two recordings were performed in a steady distance of the patient and the tube in lateral position. The first was taken in the neutral position before the intubation process and the second was taken when the best view of the glottis was achieved with the LMA CTrach and Machintosh laryngoscopes. For the LMA Fastrach, if no resistance was felt as the ETT was advanced through the mask aperture into the trachea, it was thought to be at correct tube positioning and indicated time for the fluoroscopy. Movement of the Cervical 1-2 and 2-3 segments were evaluated in radiographs. First we drove a reference line, which follows the Cervical 2 dorsal alignment. Then we draw two more lines, which transect the driven reference line; first one between anterior and posterior arches of Cervical 1, and other one through Cervical 3 basal plate of C3. So there were two angles observable; one between the reference line and arches of Cervical 1, named alpha (α). The second angle named beta (β) was located between the reference line and the line passing through Cervical 3 basal plate. The lines were drawn and an investigator, who was unaware of the
study group assignments, randomly measured angles using a goniometer in degree (°) unit.

The intubation duration, number of attempts and intubation success rate were recorded. The duration of intubation was recorded between passage of the intubation device through the lips and inflation of the tracheal cuff. Intubation was considered successful if the patient was intubated in less than two attempts and failed in case of more than two attempts.

Estimated from the data of Watts et al. [15] (12.9±2.1° extension) and based on the assumption of α= 0.05, β= 0.8 to detect 15% reduction in the movement of upper C-spine, each group would need to include at least 18 patients. Therefore 20 patients per group were planned to enroll due to probability of a 10% drop out. SPSS 15.0 for Windows (IBM, USA) was used for statistical analysis. Data are expressed as mean ± standard deviation (mean ± SD), median [min-max], or with numbers (n) and percentage (%). Discrete variables (gender, ASA classification, Mallampati scores, success rate) were compared using the x² test. For numeric parameters of between-group comparisons, one-way analysis of variance (in case of parametric test conditions) or the Kruskal-Wallis (if parametric test conditions could not be obtained) tests were used. Multiple comparisons of the Kruskal-Wallis test were done by the Mann Whitney U test with Bonferroni correction. Analysis of variance was used for repeated measures of arterial pressure, heart rate, and oxygen saturation and angle measurements for both between and intergroup comparisons. And p value<0.05 were considered statistically significant.

3. Results

Sixty-three patients were allocated to intervention groups. In one patient, intubation with LMA Fastrach was not possible, even after the third attempt despite adequate
manipulation. Following three esophageal intubations correct intubation was achieved by
direct laryngoscopy and this patient was excluded from the study. In Group C, the vocal
cords of one patient could not be visualized despite all maneuvers and the patient was
also excluded. One of the patients’ radiographic images could not be printed out and so
angle measurement could not be analyzed in Group M. Subsequently, twenty patients per
groups were analyzed.

Demographic data, Mallampati scores, and ASA physical status classification ($p>0.05$)
were similar in all groups (Table 1). Hemodynamic and ventilation parameters, such as
arterial blood pressure, heart rate, Oxygen saturation, and end-tidal CO$_2$ remained stable
in all groups, anesthesia was uneventful in all patients. None of the patients had
hypertension or tachycardia as a response to laryngoscopy.

Cervical alpha ($\alpha$) angles in degrees at C1/2 segment of the study patients are shown in
Table 2. Baseline measurements were significantly different in Group M compared with
other groups ($p=0.004$). According to neutral baseline position, angulation of C1/2
segment ($\alpha$ angle) decreased during intubation in Group F ($p=0.042$) and Group M
($p=0.001$) whereas there was no significant difference in Group C ($p=0.159$). The mean
degree of the change in angulation compared with the preinduction baseline values at
C1/2 1.2°, 1.1° and 2.9° for Groups F, C and M; was not statistically significant.

Cervical beta ($\beta$) angles of the study patients are displayed in Table 3 in degrees. At the
C2/3 segment ($\beta$ angle) Group F and M similarly represented a significant increase
($p=0.001$, $p<0.001$, respectively) in cervical motion, as there was no difference in Group
C during intubation compared with the neutral position. The mean change in $\beta$ angle
during intubation was prominent in Group F and M, but in Group C extension was statistically less (3.7°, 0.7° and 7.1° for Groups F, C and M).

The mean intubation time was 32 seconds, ranging from 10 to 120 seconds in Group M. It took the longest time to intubate patients in Group F and the shortest in Group M (p<0.001) (Table 4). The mean duration of intubation lasted 98.8 and 61.0 seconds for the LMA Fastrach and LMA CTrach, respectively (p<0.001).

The number of patients intubated in first attempts were 18 with Macintosh laryngoscope, 15 with LMA CTrach, and 11 with LMA Fastrach. While two attempts were required in 2, 5, 5 patients respectively (Table 4). The number of attempts significantly differed in Group F compared to Group M (p=0.016). It required more than two attempts and was successful after repositioning the LMA Fastrach in four patients. Rate of successful tracheal intubation was 80% with LMA Fastrach, and 100% with LMA CTrach and Macintosh laryngoscopes. Group F had the statistically lowest success rate (p=0.009).

4. Discussion

The main result of this study is that LMA CTrach significantly reduced extension compared to LMA Fastrach and Macintosh laryngoscope at C2/3 segment (β angle) without prolonging intubation time in patients undergoing elective C-spine surgery. According to our hypothesis, both LMA Fastrach and LMA CTrach would be associated with less cervical movement than Macintosh laryngoscope, which was at least partially confirmed with LMA CTrach for β angle.

A study by Sawin et al. investigated the behavior of the intact C-spine during direct laryngoscopy with a Macintosh blade and proved the general acknowledgement that a majority of cervical motions associated with laryngoscopy occurs in the upper cervical region [4]. Subaxial segments (under C2) displace minimally. Thus the present study was
undertaken to quantify motion of cervical segments 1/2 and 2/3. The times for
radiography was chosen as one before induction and one during laryngoscopy
immediately prior to insertion of the endotracheal tube or when best glottis view achieved
as Hindman et al. reported maximal intubation biomechanics occurring at that stage [16].
A cadaver model of cervical instability found that supraglottic airways (LMA, ILMA)
cause less or equal C-spine movement compared to conventional laryngoscopes
(Machintosh, McCoy) [9]. The authors therefore suggested that, due to ease of training,
supraglottic airways could be preferred in cervical trauma patients. Komatsu et al. tested
ILMA for controlling the airway in patients undergoing C-spine surgery who were
wearing rigid cervical collars to simulate C-spine injury and found ILMA as a reasonable
alternative for facilitating intubation [17].
Panjabi et al. defined the upper limits of the physiological motion as a rotation of over 20°
in the sagittal plane [18]. The maximum cervical motion at C2/3 in our study was 15° for
Macintosh laryngoscope, 12.4° for LMA Fastrach and 7.6° for LMA CTrach. Sahin et al.
in a video-fluoroscopic study observed a maximum movement of 18.5°, 16.7° and 8.1°
during direct laryngoscopy, intubation with ILMA and fiberoptic laringoscopy at C1/2 [6].
The maximum cervical motion produced with LMA Fastrach likelihood in both studies
was close to the angle of the Macintosh laryngoscope; however, still lower than
instability limits argued by Panjabi et al. [18]. Eventhough, the extension of motion
produced by LMA CTrach in the present study seems to be less than that of produced by
fiberoptic laryngoscopy in Sahin’s study, actually, it is difficult to compare data of
similar studies. Thus in the present study there was a significant difference in baseline
angle measurements at C1/2. We don’t suppose this as a study limitation because initial
position for the patient’s head can’t be standardized however degree of cervical extension
during laryngoscopy gains importance. Previous literature has reported extension at C1/2
produced with ILMA ranging from 1° to 5° even as high as 7.4 [6,10-12]. Our result is in
line with this range. Nevertheless, variability of the results depend on the heterogeneity
introduced by methodological, population differences of the studies and experience of
investigators.

The ability to intubate trachea under glottis visualization with LMA CTrach was reported
with higher first attempt success rates compared with the LMA Fastrach [14]. Liu et al.
found a 98.9% first attempt success rate for LMA CTrach in 100 patients, while Baskett
et al. showed a 79.8% success for the LMA Fastrach with the experience of 500 cases
[7,19]. Bilgin et al. demonstrated first attempt success rate of intubation 54% for ILMA
and 90% for C-Trach [13]. Our success rate is lower than published literature, 75% with
LMA CTrach, 55% with LMA Fastrach. The diversity of the results is probably due to
methodological differences, skills of the investigators and sample sizes of the mentioned
studies. Nevertheless, in the current study ‘successful’ tracheal intubation was defined
only if the patient was intubated at most two attempts with a device and the rate of
successful tracheal intubation was 80% with LMA Fastrach, which had statistically the
lowest rate.

Secondary spinal injury during airway management is not only a result of mechanical
disruption of the unstable segments, but hypoxia is also likely to cause harm [1,20].
Although both LMA CTrach and LMA Fastrach administrations may prolong intubation,
they have established roles in difficult airway management since they don’t interrupt
ventilation [8,21]. Obviously, duration of intubation lasts longer with devices that require
different maneuvers compared to laryngoscopes. In the present study, as the most familiar device for anesthetists, the Macintosh laryngoscope intubation lasted the shortest and duration of intubation was significantly longer with LMA Fastrach. These findings are in line with Bilgin et al. who reported significantly longer mean intubation time with ILMA compared to C-Trach and McCoy [13]. Nevertheless, none of the patients in our study presented hypoxia through the intubation process.

Randomizing the patients without considering their Mallampati scores and evaluating airway difficulties might be a limitation of our study. If the selection of the airway device depended on the possibility of difficulty of airway, a selection bias would occur for LMA CTrach over blind intubation using LMA Fastrach. Nevertheless, Mallampati scores were identical between the groups. Another possible shortcoming of the study is that it was impossible to blind the investigator to the airway device; only an independent radiologist who measured the angles was unaware of the study group assignments. Several investigators may have had different skill levels and experience, so only one investigator performed all laryngoscopies in order to minimize any confounding. The third limitation is that tracheal intubations were facilitated with muscle relaxants. Sawin et al. [4] suggested that muscle relaxation using neuromuscular blockade might reduce the need for cervical extension during laryngoscopy. However, even in injury settings muscle relaxants are used to ease the insertion of the endotracheal tube. Finally, the study conclusions may be limited since this project examined only two X-ray graphics instead of dynamic fluoroscopy.

5. Conclusion

In conclusion, airway management with minimal neck movement improves success of anesthetic management in C-spine surgery. Moreover, there are few data that may help to
understand C-spine kinetics of patients with cervical pathologies especially degenerative disorders requiring surgery. So, it gains importance to be familiar with different intubation techniques, however one should also be aware of their effects on cervical extension. We conclude that the reduced C-spine extension during intubation with LMA CTrach makes it a reasonable alternative to LMA Fastrach and Macintosh laryngoscope in cervical surgery where cervical stability is a concern.

References


5. Suppan L, Tramèr MR, Niquille M, Grosgurin O, Marti C. Alternative intubation techniques vs Macintosh laryngoscopy in patients with cervical spine immobilization:


Table Legends

Table 1. Demographic data of the patients.

Table 2. Alfa (α) angle measurements.

Table 3. Beta (β) angle measurements.

Table 4. Number of attempts, duration and success rate of intubation.
Table 1. Demographic data of the patients.

<table>
<thead>
<tr>
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<th>Group F</th>
<th>Group C</th>
<th>Group M</th>
<th>p values</th>
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<tr>
<td>Gender (F/M)</td>
<td>10/10</td>
<td>12/8</td>
<td>10/10</td>
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<td>ASA (I/II/III)</td>
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<td>Mallampati (1/2/3)</td>
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<td>8/11/1</td>
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<td>Age (years)</td>
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<td>49.2±11.5</td>
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<td>Height (cm)</td>
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<td>Weight (kg)</td>
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<td>74.8±10.8</td>
<td>80.5±8.8</td>
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</table>

The data are presented as n or mean ± standard deviation.

Group M: Macintosh laryngoscope; Group F: LMA Fastrach; Group C: LMA CTrach.
Table 2. Alfa (α) angle measurements.

<table>
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<td>74.0±5.4</td>
<td>69.6±5.7</td>
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<tr>
<td>Laryngoscopy</td>
<td>73.3±4.7*</td>
<td>72.9±6.4</td>
<td>66.7±6.2†</td>
<td>0.001‡</td>
</tr>
</tbody>
</table>

The data are presented as mean ± standard deviation.

Group M: Macintosh laryngoscope; Group F: LMA Fastrach; Group C: LMA CTrach.

*: p<0.05, laryngoscopy versus control.

†: p<0.05, laryngoscopy versus control.

‡: p<0.05, Group M versus Group F and Group C.
Table 3. Beta (β) angle measurements.

<table>
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<th>Group M</th>
<th>p values</th>
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<tr>
<td>Laryngoscopy</td>
<td>105.6±9.7*</td>
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The data are presented as mean ± standard deviation.

Group M: Macintosh laryngoscope; Group F: LMA Fastrach; Group C: LMA CTrach.

*: p<0.05, laryngoscopy versus control.
†: p<0.05, laryngoscopy versus control.
Table 4. Number of attempts, duration and success rate of intubation.

<table>
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<th></th>
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<th>Group C</th>
<th>Group M</th>
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<tbody>
<tr>
<td>Number of attempts (1/2/3)</td>
<td>11/5/4§</td>
<td>15/5/0</td>
<td>18/2/0</td>
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<tr>
<td>Duration of intubation (sec)</td>
<td>62.5 (30-300)*</td>
<td>40 (30-230)</td>
<td>20 (10-120)¶</td>
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<td>Success rate</td>
<td>16 (%80)*</td>
<td>20 (%100)</td>
<td>20 (%100)</td>
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The data are presented as n, median ± minimum-maximum or n (%).

Group M: Macintosh laryngoscope; Group F: LMA Fastrach; Group C: LMA CTrach.

§: p<0.05, Group F versus Group M.

*: p<0.05, Group F versus Group C and Group M.

¶: p<0.05, Group M versus Group F and Group C.