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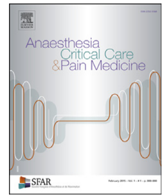

Original Article

Comparison of the effects of the McGRATH MAC, C-MAC, and Macintosh laryngoscopes on the intraocular pressures of non-ophthalmic patients: A prospective, randomised, clinical trial

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A B S T R A C T

Introduction: In this prospective, randomised study, we compared the effects of the Macintosh, McGRATH MAC, and C-MAC laryngoscopes on intraocular pressure (IOP) and haemodynamics of non-ophthalmic patients during endotracheal intubation.
Methods: One hundred and twenty adult patients undergoing non-ophthalmic surgeries performed in the supine position under general anaesthesia requiring orotracheal intubation were included in this study. The patients were separated randomly and prospectively into 3 groups: Macintosh group (n = 40), McGRATH MAC group (n = 40), and C-MAC group (n = 40). Mean arterial pressure (MAP), heart rate (HR) and IOP of left and right eye were measured at specified times.
Results: There were no significant differences with regard to patients characteristics. After intubation, the HR increased significantly in the Macintosh group when compared to the other groups ($p = 0.001$) and the MAP increased significantly in the Macintosh group when compared to the McGRATH MAC group ($p = 0.001$) and the C-MAC group ($p < 0.001$). The IOP values increased in the Macintosh group when compared to the McGRATH MAC group ($p < 0.001$) and the C-MAC group ($p < 0.001$) after intubation. Additionally, there was a significant difference between the McGRATH MAC group and C-MAC group in the IOP values of the eyes after intubation ($p < 0.001$). According to the evaluation within the groups, there were significant differences in all of the groups at all times when compared with the baseline values ($p < 0.001$).
Conclusions: In this study, we concluded that the C-MAC VL may be preferable when compared to the Macintosh and McGRATH MAC laryngoscopes for use in ophthalmic patients in whom a rise in the IOP is undesirable.
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1. Introduction

General anaesthesia and endotracheal intubation (ETI) are usually required during ocular surgery, and the Macintosh laryngoscope has been used widely to perform ETIs for many years. Although classical laryngoscopes have been frequently preferred for intubation for many years, various videolaryngoscopes have been developed to facilitate intubation in many situations, especially in difficult intubation patients. There are many clinical studies with videolaryngoscopes designed with or without channels. But, in recent years, several different videolaryngoscopes (VLs), such as the McGRATH MAC (Medtronic, Minneapolis, MN, USA) and C-MAC (C-MAC, Karl Storz, Tuttlingen, Germany), have gained popularity. They are being used by anaesthesiologists in routine practice not only in patients with

Abbreviations: ASA, American Society of Anesthesiology; BIS, bispectral index; BMI, body mass index; ETI, endotracheal intubation; HR, heart rate; IOP, intraocular pressure; MAP, mean arterial pressure; TOF, a train-of-four; VLs, videolaryngoscopes.

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difficult airways, but also in those with normal airways. Many different VL designs have been produced, but the McGRATH MAC and C-MAC VLs can be categorised by their standard Macintosh-shaped blades [1–4].

An oropharyngeal and laryngeal axis line of sight must be provided by a Macintosh laryngoscope in order to perform an ETI. However, airway manipulation during an ETI and laryngoscopy stimulates the pharyngeal and tracheolaryngeal nociceptors, changing the haemodynamic values [5]. VLs, such as the McGRATH MAC and C-MAC, function independently of the line of sight, and they have been produced to increase the visualisation of the pharynx and larynx [6]. The better laryngeal view, increased glottis opening visibility percentage [7], lesser upward lifting force, and lack of movement [8] are important VL features when performing a laryngoscopy. In addition, VLs ensure an advanced view because they require minimal power during the glottis visualisation [9]. In particular, we think that the C-MAC VL provides a better glottis image than the others, according to our clinical experience, due to its similarity to the conventionally used Macintosh laryngoscope, as well as its wider and higher resolution monitor.

It is shown that a direct laryngoscopy and ETI increase the heart rate (HR), mean arterial pressure (MAP), and intraocular pressure (IOP) [10]. Increases in HR, MAP, and IOP can be damaging in patients with hypertension and glaucoma, and several approaches to reduce these changes have been tried, but none of them have shown effective improvement [11]. Many articles have reported the haemodynamic responses and IOP changes during an ETI using a VL and a Macintosh laryngoscope [12–14]. However, there have been no studies comparing the different VL types according to the effects on intraocular pressure. In our previous study, we found that the McGRATH MAC VL increased IOP less than the Macintosh laryngoscope during a laryngoscopy [15]. However, in this randomised clinical trial, we compared the effects of the Macintosh, McGRATH MAC, and C-MAC laryngoscopes on non-ophthalmic patients in terms of the IOP changes during an ETI. We chose the McGRATH MAC and C-MAC laryngoscopes because their designs are similar to that of a Macintosh laryngoscope with a standard Macintosh-shaped blade.

The primary outcome of this study was the IOP during the ETI, while the secondary outcomes included comparisons of the time taken to intubate and the haemodynamic changes. It was hypothesised that the effects of the C-MAC VL on the IOP during the laryngoscopy and ETI would be less severe than those associated with the McGRATH MAC and Macintosh laryngoscopes.

2. Materials and methods

Ethical approval for this study (approval no: 2018/57 on 18.04.2018) was ensured by the research committee of our university hospital in Malatya, Turkey, and it was registered with ClinicalTrials.gov (NCT03589638). This was a prospective, randomised study of non-ophthalmic surgeries performed in the supine position under general anaesthesia requiring orotracheal intubation.

2.1. Study participants

After obtaining written informed consent, 120 adult patients (Macintosh group (n = 40), McGRATH MAC group (n = 40), and C-MAC group (n = 40)) aged 18–65, with an American Society of Anesthesiologists (ASA) physical status grade of I–II and a Mallampati score of I–II, were included in this study between June 2018 and June 2019. All were operated in the eye operating theatre of our university hospital. This study was prepared in accordance with the Consolidated Standards of Reporting Trials (CONSORT) (Fig. 1) [16].

2.2. Exclusion criteria

The exclusionary criteria were as follows: under 18 or over 65 years old; a body mass index (BMI) > 35 kg/m^2; glaucoma or a preanaesthetic IOP greater than 20 mmHg; cardiovascular such as hypertension, pulmonary, or endocrine disease; contraindications to the use of propofol, fentanyl, or rocuronium; predicted airway difficulties (restricted mouth opening, limited neck extension, a sternomental distance less than 12 cm, and Mallampati scores of III or IV), and obstetric patients. Those patients who were intubated longer than 60 s and whose SpO_2 fell below 92% were also excluded from this study. If there were two or more intubation attempts, it was considered as a failed intubation.

2.3. Study design

Patients were randomly assigned to either Macintosh group, McGRATH MAC group, or C-MAC group; randomisation (1:1) was based on a computer generated random numbers table, using a web research randomiser (http://www.randomizer.org/form.htm). The patients who agreed to participate voluntarily were told about the features of airway devices to be used in airway management, but were not told which device was to be used. Patients were blinded by this method. Haemodynamic data were recorded by the anaesthesia technician who did not know which airway device was used, and the anaesthesia technician was blinded by this method. The ophthalmologist measuring the IOP did not know which airway device was used and the ophthalmologist was blinded by this method.

2.4. Methods

2.4.1. Preoperative procedures

During the preoperative visits, the patients were assessed by different anaesthesiologists for laryngoscopy or glottis visualisation difficulties using Mallampati grading and by measuring the thyromental distance and extension at the atlanto-occipital joint. Each patient was taken to the operating theatre after they had fasted for at least 8 h before the surgery. No premedication was administered, and the patients were all normothermic. An intravenous cannula was inserted, and lactated Ringer's solution was the preferred infusion at a dose of 15 mL/kg/h. In addition to the routine anaesthesia monitoring (HR, electrocardiography, MAP, peripheral pulse oximetry, and capnography), a train-of-four (TOF) neuromuscular monitor (Datex-Ohmeda Instrumentarium Corp., Helsinki, Finland) was used. Additionally, a bispectral index (BIS) monitor (Model 2000; Aspect Medical Systems, Inc., Newton, MA, USA) was used to assess the depth of anaesthesia, and this was kept at a value between 40 and 60. The IOPs were measured in the left and right eyes by the same ophthalmologist using a Tono-Pen AVIA Applanation Tonometer (Reichert Technologies, Depew, NY, USA). Before measuring the IOP, a 0.5% ophthalmic solution of proparacaine hydrochloride was applied. The ophthalmologist, who was blinded to the airway device, measured the baseline IOP in the operating theatre preoperatively, without administering drugs to either eye.

2.4.2. General anaesthesia

The baseline MAP, HR, and IOP values were measured 5 min after the patient arrived in the operating theatre. Polyvinyl chloride cuffed endotracheal tubes (Chilecom Medical Devices Co., Ltd., Boluo, GD, China) were used for all patients; internal diameters of 7.5 mm and 7.0 mm were preferred for the male and female patients, respectively. An intubating stylet lubricated with water-soluble K–Y Jelly (Johnson & Johnson, New Brunswick, NJ,

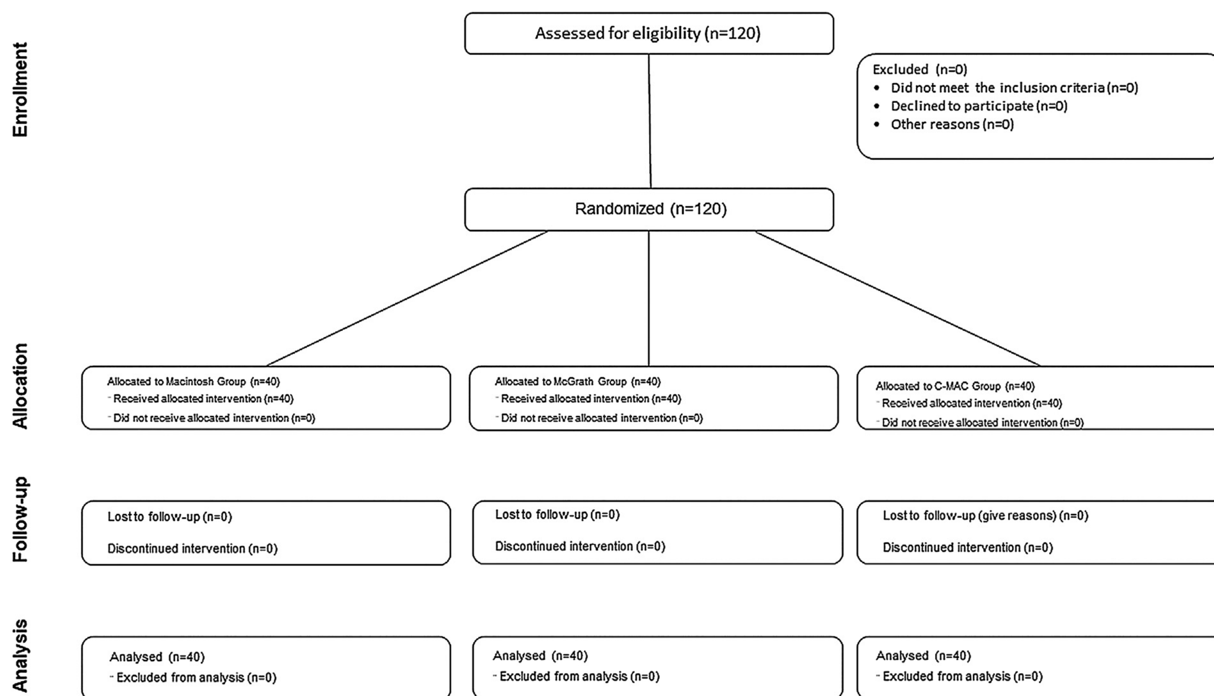

Fig. 1. Flow diagram; CONSORT flow chart for patients' recruitment.

USA) was inserted into the tracheal tube. The distal ends of the tracheal tube and intubating stylet were angled 60° anteriorly, which complied with the designs of the McGRATH MAC and C-MAC VL blades, which had 60° curvatures.

Preoxygenation was applied for 5 min and the anaesthesia induction was performed using 2 mg/kg of propofol and 1 μg/kg of fentanyl intravenously over 15–20 s. In addition, 0.6 mg/kg of rocuronium was used for muscle relaxation. After the eyelash reflex disappeared, each patient was ventilated using a facemask with 100% oxygen, and orotracheal intubation began after complete suppression (zero) of the TOF, as guided by the neuromuscular monitor. The same experienced anaesthetists (with > 100 successful intubations using each device) intubated all patients using the Macintosh, McGRATH MAC, or C-MAC laryngoscopes. After achieving successful intubation, the cuff of the endotracheal tube was inflated with air to a pressure of 15 cmH_2O, which was controlled using a handheld aneroid manometer. The suitable location for each endotracheal tube was verified by capnographic tracing.

After the ETI was accomplished successfully, the tracheal tube was connected to the anaesthesia breathing system, and the anaesthesia was maintained with 1% sevoflurane and a 50% oxygen/air mixture at a fresh gas flow of 2 L/min. The ventilatory parameters included a set tidal volume of 8–10 mL/kg, a respiratory rate of 8–12 breaths/min, and an end tidal CO_2 keep between 30 and 35 mmHg.

2.4.3. Outcome measures

The MAP, HR, and IOP were recorded at the following time points: before intubation, after intubation, 5 min after intubation, and 10 min after intubation. The intubation time was defined as the period from the termination of manual ventilation with a facemask, while the instrument entered the patient's oral cavity, until the observation of end-tidal CO_2 tracing. None of the anaesthesiologists responsible for recording data nor the ophthalmologist responsible for measuring IOP were aware of any of the devices used for the intubation.

2.5. Statistical analysis

To calculate the sample size, a pilot study was performed in 10 patients from the C-MAC VL group. In the pilot group, the IOP value of the left eye and the right eye after intubation in the sample group were 13.50 ± 1.38 and 13.80 ± 1.55, respectively. Assuming an equal SD and to show a difference of 20% (equivalent to a change of about 2 mmHg) in the IOP between the groups, a 2-sided type I error of 0.05 and a power of 0.90 were applied. A minimum of 40 patients in each group was necessary to find a significant difference in the IOP values.

Data were analysed using IBM SPSS Statistics for Windows version 22.0 (IBM Corp., Armonk, NY, USA). The quantitative data were presented as the mean and standard deviation, while the qualitative data were presented as the number and percentage. The Shapiro-Wilk normality test was used to test whether the quantitative variables showed a normal distribution. A repeated measures analysis of variance and a Bonferroni multiple comparison test were applied for the IOP and haemodynamic value. The Kruskal–Wallis test, paired *t*-test, and unpaired *t*-test were used for the statistical evaluation of the other quantitative variables. The statistical evaluation of the qualitative variables was performed using the Pearson's chi-squared analysis and Monte Carlo chi-squared analysis. A p value of less than 0.05 was considered to be significant.

3. Results

A total of 120 patients were included in this study. A flow diagram is presented in Fig. 1 [16]. There were no significant differences with regard to the gender distribution, age, height, weight, ASA score, Mallampati score, and BMI. The intubation time was longer in the McGRATH MAC group when compared to the other groups ($p < 0.001$). Additionally, the intubation time was longer in the C-MAC group when compared to the Macintosh group ($p < 0.001$). None of the patients were excluded from the study, and all of the ETIs were achieved by the same anaesthesiologist during

Table 1
Patients' characteristics.

Groups	Macintosh (n = 40)	McGRATH (n = 40)	C-MAC (n = 40)	*p*
Gender (male/female)	23/17	27/13	19/21	0,915
Age (y)	36,13 ± 8,2	38,63 ± 6,6	37,78 ± 10,3	0,349
Height (cm)	165,95 ± 10,3	172,70 ± 7,6	168,35 ± 8,7	0,400
Weight (kg)	68,00 ± 10,5	69,43 ± 9,3	70,23 ± 9,3	0,786
ASA (I/II)	18/22	23/17	20/20	0,531
Mallampati Score (I/II)	19/21	18/22	17/23	0,935
BMI (kg/m^2)	21,25 ± 2,3	21,48 ± 4,3	21,60 ± 2,8	0,892
Intubation time(sec)*	23,88 ± 1,6 (range 19-27)**	35,50 ± 7,8 (range 23-45)**	30,80 ± 5,5 (range 22-56)**	< 0,001**

Values are means ± SD except for gender and ASA data. ASA: American Society of Anesthesiologist, BMI: body mass index.
* The period from termination of manual ventilation with facemask and the instrument entered the patient's oral cavity until observation of end-tidal CO_2 tracing.
** significant difference at intubation time between groups. ($p < 0,001$).

the first attempt within 60 s. The demographic characteristics and procedural data are presented in Table 1.

In terms of the primary outcome of this study, the induction of anaesthesia decreased the IOP values of the right and left eyes before intubation in all three groups (Fig. 3). The IOP values increased in the Macintosh group when compared to the McGRATH MAC group ($p < 0.001$) and the C-MAC group ($p < 0.001$) after similar intubation in the left and right eyes. Additionally, there was a significant difference between the McGRATH MAC group and C-MAC group in the IOP values of the right and left eyes after intubation ($p < 0.001$). There was no significant difference in the IOP values between the Macintosh group and the McGRATH MAC group 5 min after intubation (left eye $p = 0.392$, right eye $p = 0.288$). However, the IOP values in the C-MAC group were significantly less than those in the Macintosh group ($p < 0.001$) and the McGRATH MAC group (left eye $p = 0.021$, right eye $p = 0.039$). Moreover, there was no significant difference between the Macintosh group and the McGRATH MAC group 10 min after intubation (left eye $p = 0.209$, right eye $p = 0.188$). In contrast, the IOP in the C-MAC group was significantly less than those of the Macintosh group ($p < 0.001$) and the McGrath group 10 min after intubation (left eye $p = 0.013$, right eye $p = 0.018$). According to the evaluation within the groups, there were significant differences in all of the groups at all times when compared with the baseline values ($p < 0.001$) (Fig. 4).

In terms of the secondary outcome of this study, there were no significant differences among the groups in the baseline HR, MAP, and IOP values. The HRs in both groups had decreased before intubation, according to the baseline values (Fig. 2), this decrease was statistically significant ($p < 0.05$). However, there was no significant difference in the HRs between groups before intubation ($p > 0.05$). After intubation, the HR increased significantly in the Macintosh group when compared to the other groups ($p = 0.001$). In contrast, there was no significant difference in the HRs between the McGRATH MAC group and the C-MAC group after intubation ($p = 0.201$). Moreover, there were no significant differences in the HRs 5 and 10 min after intubation in any of the groups ($p > 0.05$). Before intubation, the MAP decreased significantly in all of the groups when compared with the baseline values ($p < 0.001$) (Fig. 2). After intubation, the MAP increased significantly in the Macintosh group when compared to the McGRATH MAC group ($p = 0.001$) and the C-MAC group ($p < 0.001$). However, there was no significant difference between the McGRATH MAC group and the C-MAC group after intubation ($p = 0.592$).

4. Discussion

In the current study, we compared the effects of the McGRATH MAC, C-MAC, and Macintosh laryngoscopes on the IOP and haemodynamic response under general anaesthesia in a total of 120 individuals who were undergoing non-ophthalmic elective surgery. There have been no previous studies examining the C-MAC VL effects on the IOP. The HR increased significantly after intubation in the Macintosh group when compared to the McGRATH MAC and C-MAC groups. Similarly, the MAP increased significantly after intubation in the Macintosh group when compared to the McGRATH MAC and C-MAC groups. Our study demonstrated that the IOP increases after intubation using a C-MAC laryngoscope were less than those when using the Macintosh and McGRATH MAC laryngoscopes. According to the evaluation within the groups, there were significant differences in all of the groups at all times when compared with the baseline values.

In our previous study, we evaluated the effects of the McGRATH MAC and Macintosh laryngoscopes on the IOP and haemodynamics in non-ophthalmic patients. We found that ETIs via the McGRATH MAC VL provided lower IOP values in the patients when compared to the Macintosh laryngoscope when the procedures were performed by an experienced anaesthesiologist [15]. In this study, we preferred the VLs without channel, the McGRATH MAC and C-MAC VLs, in order to evaluate their effects on the IOP and haemodynamic response. In this study, we wanted to determine the best airway device to use during a laryngoscopy in terms of an increased IOP.

In recent years, VLs have played increasingly important roles in airway management in unanticipated difficult or failed ETIs. VLs improve the visualisation of the trachea entry by producing a view of the laryngeal inlet independent of the line of sight. Hassan et al. [17] showed that an ETI stimulated the haemodynamic and epinephrine responses by stimulating the receptors in the larynx and trachea. Although haemodynamic and IOP changes may be acceptable in patients who are not undergoing ophthalmic surgery, they are extremely important for the surgical outcomes, especially in patients undergoing ophthalmic surgery in the presence of an increased IOP and increased haemodynamics. VLs are used because of their benefits with regard to the IOP and haemodynamic changes in patients without difficult airways. In addition, VLs are preferred especially for patients requiring less manipulation and a better laryngeal view quality. Ng et al. [18] reported that the McGRATH MAC VL provided significantly more grade 1 laryngoscopic views than the C-MAC VL in patients with poor Mallampati scores. In addition, Hazarika et al. [19] reported that the haemodynamic changes were comparable between the Macintosh and C-MAC D blade groups during nasotracheal intubation. In their retrospective study, Yokose et al. [20] demonstrated that the incidence of hypertension after an ETI when using the McGRATH MAC VL was less than that when using a Macintosh laryngoscope. Ahmet et al. [21] claimed that the C-MAC VL was better with respect to the intubation time and haemodynamic stability, while Hoshijima et al. [22] claimed that the C-MAC VL provided better glottis visualisation, with improved success rates. However, in one rare

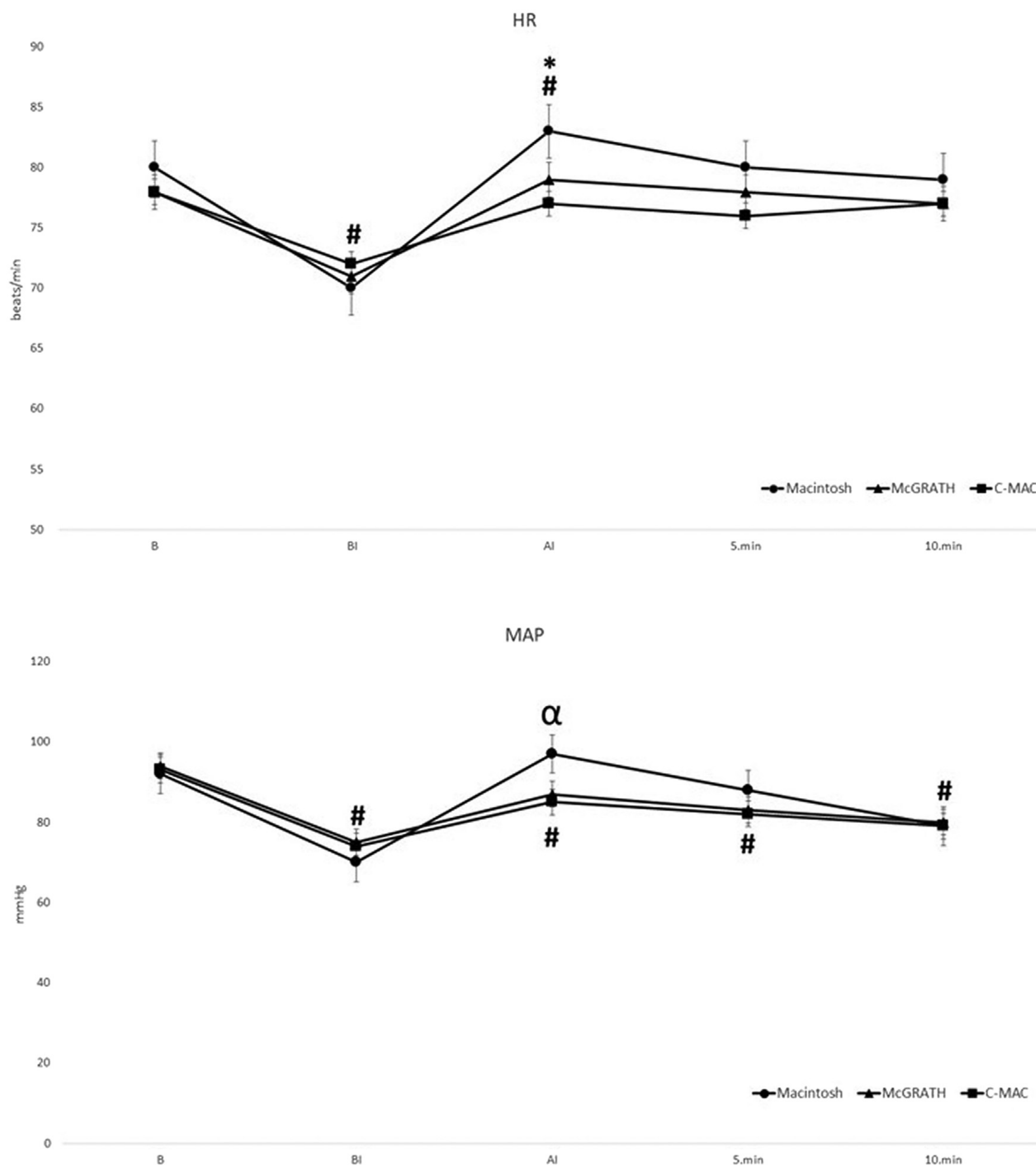

Fig. 2. HR and MAP values. Changes in HR and MAP measurements in Macintosh, McGRATH MAC and C-MAC groups. Measurements were recorded at baseline (B), after intubation (AI), at the 5th minute (5 min), and 10th minute (10 min) after intubation.
* Significant difference in Macintosh group when compared to other groups, ($p = 0.001$). No significance was found between McGrath MAC and C-MAC groups ($p > 0.05$).
# Significant differences in comparison with the baseline values, ($p < 0.05$).
α Significant difference in Macintosh group when compared to other groups, ($p \leq 0.001$).

study, it was reported that there were no statistical differences between the McGRATH MAC VL and Macintosh laryngoscopes with regard to the haemodynamics. Wallace et al. [23] noticed that there was no statistical difference between the performances of the McGRATH MAC VL and the Macintosh laryngoscope. Interestingly, Buhari and et al. [24] found that the C-MAC VL had a greater haemodynamic response to tracheal intubation when compared to a conventional Macintosh laryngoscopy and intubation in ASA I patients. In our study, we showed that the HR and MAP values of the McGRATH MAC and C-MAC groups were similar during the laryngoscopies. However, the HR and MAP increased significantly during intubation via the Macintosh laryngoscope when compared with the McGRATH MAC and C-MAC VLs. The increases in the HR and MAP values in the Macintosh group could have been caused by the force of the tip of the blade on the supraglottic tissues. Overall, our HR and MAP results were similar to those of other studies.

Our study showed that increases in the HR and MAP are simultaneous with an increase in the IOP in both eyes. However, the IOPs in both eyes were more significantly increased when using the Macintosh laryngoscope than when using the C-MAC and McGRATH MAC VLs. These results showed that the IOP, similar to the HR and MAP, increased significantly when using a Macintosh laryngoscope. Because the force of the blade tip on the supraglottic tissues can give rise to a catecholamine release, these laryngoscopes may be particularly useful in patients with high IOP values, such as in glaucoma cases. In addition, they may be the first choice as an intubation device during a laryngoscopy; however, further studies are needed.

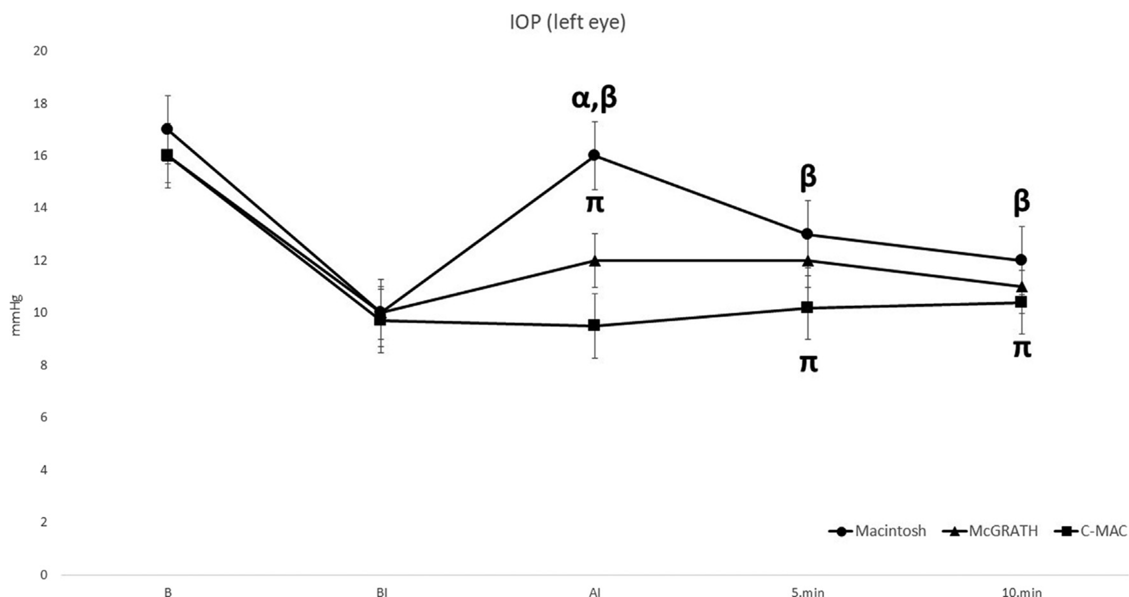

Fig. 3. IOP values of the left eye. Changes in IOP measurements in Macintosh, McGRATH MAC and C-MAC groups. Measurements were recorded at baseline (B), after intubation (AI), at the 5th minute (5 min), and 10th minute (10 min) after intubation.
α Significant difference in Macintosh group compared with McGrath MAC group.
β Significant difference in Macintosh group compared with C-MAC group.
π Significant difference in McGrath group compared with C-MAC group.

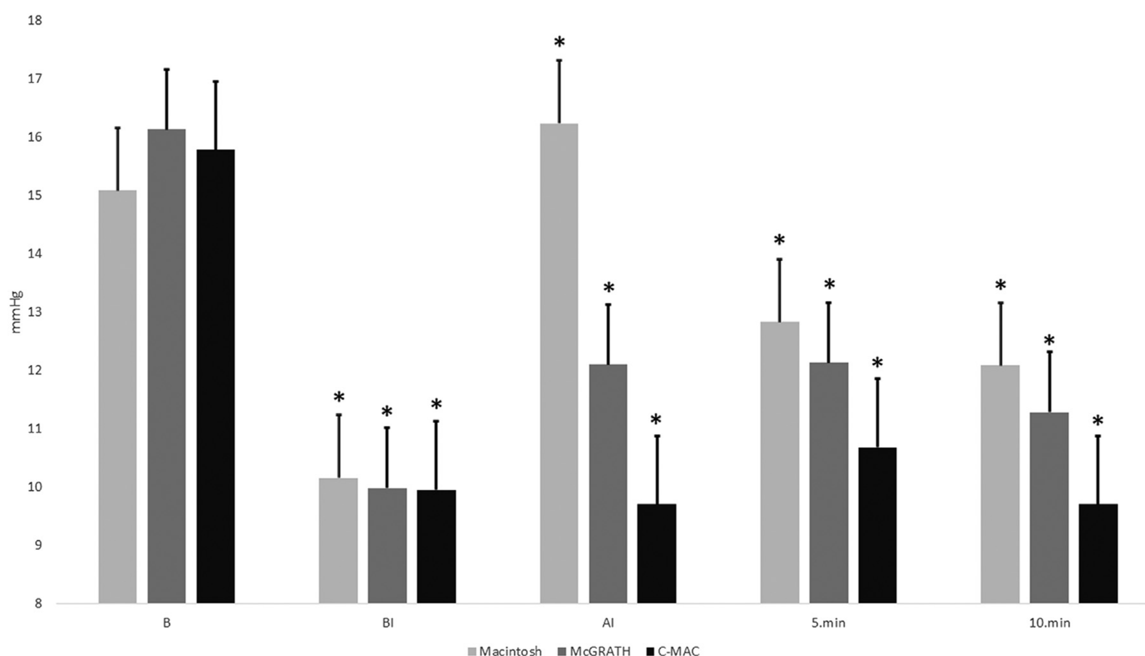

Fig. 4. Intragroup comparisons of the left eye. Changes in IOP measurements in Macintosh, McGRATH MAC and C-MAC groups. Measurements were recorded at baseline (B), after intubation (AI), at the 5th minute (5 min), and 10th minute (10 min) after intubation.
* Significant differences in comparison with the baseline values, ($p < 0.001$).

Several studies have reported that different significant haemodynamic responses can appear when using conventional laryngoscopy and videolaryngoscopy [25–27]. However, there have been no studies comparing the effects of the Macintosh, McGRATH MAC and C-MAC laryngoscopes on the IOP. Overall, the reaction to an ETI is nearly correlated with an increase in the IOP [28]. Moreover, an ETI can also cause increased sympathetic activity, which results in a rising IOP [29]. In their study, Ahmad et al. [13] reported that the GlideScope VL increased the IOP to a lesser extent than the Macintosh laryngoscope during an ETI 1 min after intubation. Das et al. [30] reported that Airtraq laryngoscope in comparison to Macintosh laryngoscope results in significantly fewer rises in IOP and clinically less marked increase in haemodynamic response to laryngoscopy and intubation. Karaman et al. [14] indicated that the IOP increased 5 and 10 min after intubation when compared to the McGRATH MAC VL and the Macintosh laryngoscope. Similarly, the IOP increased just after intubation and 5 and 10 min after intubation in the Macintosh

group when compared to the McGRATH MAC and C-MAC groups in our study. However, there was a significant difference between the McGRATH MAC and C-MAC groups in terms of the IOP values just after intubation and 5 and 10 min after intubation. These results indicated that the stimulation applied to the base of the tongue to obtain a glottis view was the least in the C-MAC group. As intubation with C-MAC would cause less catecholamine release, it may have caused lower intraocular pressure in the C-MAC group, which provided intubation in a shorter time. However, the serum catecholamine levels should also be measured to support this result. Serum catecholamine level measurements may be planned for future studies.

Some studies have reported that the use of a VL during an ETI significantly prolongs the duration of intubation when compared to direct laryngoscopy [31,32]. Conversely, some studies have reported that the use of a VL shortens the duration of intubation when compared to direct laryngoscopy [33]. Ng et al. [18] reported that the intubation time using a C-MAC VL was significantly less than that using a McGRATH MAC VL, which was similar to our study. In terms of our C-MAC VL usage experience, most anaesthetists in our clinic have accepted the C-MAC as a device that is easier to use than the McGRATH MAC VL. Jeon et al. [27] showed that the GlideScope VL reduced the intubation time when compared to the McGRATH MAC VL in patients with normal airways (40.5 s and 53.3 s, respectively). In their study, they defined the intubation time as the time between picking up the endotracheal tube and ETI verification via the visualisation of three expiratory carbon dioxide waveforms. In another study [21], they reported that the intubation time was 14.9 $\pm$ 12.89 s with the C-MAC VL. Similarly, they defined the intubation time as the time from the insertion of the blade beyond the incisors until the visualisation of four square wave patterns of $EtCO_2$ on the monitor. Singh et al. [34] claimed that the intubation times were 12.3 s and 10.7 s with the C-MAC and Macintosh laryngoscopes, respectively. They defined the intubation time as the time between the laryngoscope entering the patient's mouth and the placement of the endotracheal tube in the trachea [33]. In our study, the intubation times of the Macintosh, McGRATH MAC, and C-MAC laryngoscopes were 23.88 $\pm$ 1.60 s, 35.50 $\pm$ 7.87 s, and 30.80 $\pm$ 5.56 s, respectively. It is showed that the differences in the intubation durations were caused by the different definitions of the intubation time or the differences in the usage experience.

There are a few limitations to this study. First, unexpected increases in the IOP can occur due to an increased intubation time and difficult manipulation in patients with difficult airways. Therefore, patients with difficult airways should also be studied. Second, we conducted this study in patients with no comorbidities, such as glaucoma. Third, the researchers who performed the intubations could not be blinded; only the ophthalmologist and anaesthesiologists responsible for recording were blinded. Finally, the study was performed in young patients. However, diseases such as glaucoma that increase intraocular pressure are more common in elderly patients. In addition, since blood pressure values were measured non-invasively, instantaneous blood pressure values could not be measured.

5. Conclusion

In this study, we showed that an ETI using a Macintosh laryngoscope might cause more haemodynamic responses when compared to the C-MAC and McGRATH MAC VLs. However, the IOP increased significantly after intubation using the Macintosh laryngoscope when compared with the McGRATH MAC and C-MAC VLs. Additionally, the IOP increased significantly after intubation using the McGRATH MAC VL when compared to the C-MAC VL. Therefore, we concluded that the C-MAC VL might be preferable when compared to the Macintosh and McGRATH MAC laryngoscopes for use in ophthalmic patients in whom a rise in the IOP is undesirable. However, further clinical trials are required in patients with glaucoma to support our results.

Institute registration

This study was approved by the Local Ethics Committee of Inonu University Medical Faculty, Malatya, Turkey (approval no: 2018/57 on 18.04.2018).

Trial registration

The trial is registered at the US National Institutes of Health (ClinicalTrials.gov) # NCT03589638.

Information

This study was presented as an oral presentation at the 52nd National Congress of the Turkish Society of Anesthesiology and Reanimation (07th–11th of November 2018, Antalya, Turkey).

Human and animal rights

The authors declare that the work described has been carried out in accordance with the Declaration of Helsinki of the World Medical Association revised in 2013 for experiments involving humans as well as in accordance with the EU Directive 2010/63/EU for animal experiments.

Informed consent and patient details

The authors declare that this report does not contain any personal information that could lead to the identification of the patient(s).

The authors declare that they obtained a written informed consent from the patients and/or volunteers included in the article. The authors also confirm that the personal details of the patients and/or volunteers have been removed.

Disclosure of interest

The authors declare that they have no known competing financial or personal relationships that could be viewed as influencing the work reported in this paper.

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Author contributions

Conceptualisation; ASO, SA - Data curation; EK, SA - Formal analysis; ASO - Funding acquisition; None - Investigation; ASO, SA, NP - Methodology; ASO, NP - Project administration; ASO, SA - Resources; ASO, SA - Software; ASO, SA - Supervision; ASO, SA - Validation; SA, EK - Visualisation; SA, ASO - Roles/Writing - original draft; ASO, SA - Writing - review & editing; ASO, EK, NP, Scribendi Editing and Proofreading Service.

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