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Original Article

Comparison of Mallampati scores and hemodynamic responses between elderly and younger patients: Prospective cohort study

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S U M M A R Y

Background: This study aimed to evaluate the effect of aging on the Mallampati score, intubation time, and hemodynamic response for endotracheal intubation during induction of anesthesia.
Methods: One hundred and twenty patients were enrolled and allocated according to age to either group N (35–49 years, n = 60) or group E (65–74 years, n = 60). Patients were administered 3 MAC (minimum alveolar concentration) of sevoflurane for 5 min to induce anesthesia. Systolic blood pressure (SBP), mean arterial pressure (MAP), diastolic blood pressure (DBP), pulse pressure (PP), and heart rate (HR) were recorded before (baseline), immediately after (T_0), and at 1-min intervals during the first 4 min after endotracheal intubation (T_1–T_4). The Mallampati score and intubation time were also recorded.
Results: There were significant differences between groups with regard to overall changes in SBP, MAP, DBP, and HR. The change in SBP and MAP was higher in group E than in group N at T_0 and T_1. HR was significantly lower in group E than in group N at T_0, T_1, and T_2. The Mallampati score and intubation time were significantly higher in group E than in group N. After controlling for the Mallampati score, there were no significant differences between the groups; however, HR was significantly lower in group E than in group N.
Conclusion: After intubation, the changes in SBP, MAP and DBP, Mallampati score, and intubation time were higher, and changes in HR were lower in elderly patients. The changes in SBP, MAP and DBP in elderly patients are associated with the changes in Mallampati score.

1. Introduction

As life expectancy increases with the development of new medical technology, the proportion of the total elderly population has increased and accounted for 13.8% of the population in South Korea in 2015.[1] Accordingly, the proportion of elderly patients requiring medical and/or surgical care has increased; currently, the number of elderly patients aged 65 years and over account for more than 30% of the total number of patients undergoing surgeries in our hospital.

Endotracheal intubation performed under laryngoscopy, as required for general anesthesia, can increase the reactivity of the upper airway because of manipulation of the laryngoscope and intubation, potentially resulting in laryngospasm. It may also increase sympathetic tone and lead to temporary hypertension, tachycardia, and arrhythmia.[2]

In order to prevent these excessive cardiovascular responses to endotracheal intubation, the spraying of a local anesthetic over laryngeal structures or intravenous administration of medications such as lidocaine, opioids, beta-blockers, vasodilators, calcium channel blockers, or an overpressure technique that uses 2–3 MAC of the anesthetic agent have been used.[3–5] However, these techniques cannot completely prevent cardiovascular and/or laryngeal responses. These cardiovascular reactions can lead to serious complications such as heart failure, myocardial infarction, or subarachnoid hemorrhage.[6,7]

Particularly in elderly patients, as their age increases, arterial stiffness, systemic vascular resistance, and the release of

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catecholamines to external stimuli increase and arterial compliance and the activity of baroreceptors decrease, causing severe hemodynamic responses to endotracheal intubation in elderly patients.[8–10] Mallampati score, most commonly used clinical test to predict for difficult endotracheal intubation, was also reported to increase with age.[11] Further, tooth decay and a decreased range of motion in the neck make intubation more difficult,[7] which can cause elderly patients to be more vulnerable to the possible risks of endotracheal intubation.

Therefore, the authors compared the differences in the hemodynamic responses, Mallampati score, and intubation time between young adults and elderly patients during intubation by controlling the amount of sevoflurane administered while inducing anesthesia. The authors also evaluated the relations between the Mallampati score, intubation time, and hemodynamic responses.

2. Materials and methods

2.1. Study design and patients

The present study used a prospective cohort design, and was conducted and written according to the STROBE statement.[12]

The study protocol was approved by the Institutional Review Board of Samsung Changwon Hospital **(2015-SCMC-032-00)**. This study was carried out according to the principles of the Declaration of Helsinki, 2013 and written informed consent was obtained from all participants before their inclusion in this study.

The inclusion criteria were patients scheduled for surgery under general anesthesia, with ASA physical status I or II, and those who agreed to participate in this study. Exclusion criteria included the following: a history of hypertension, diabetes, cardiovascular disorder-related drug use, neurologic disease, and patients who were expected to have a difficult intubation.

One hundred and twenty patients were assigned into two groups of 60 each, with one group of young adults aged from 35 to 49 years (group N), and the other group of elderly patients aged 65–74 years (group E). These patients were enrolled consecutively from January 1, 2015, until the required number of patients was reached.

2.2. Anesthesia

The patients received 0.05 mg/kg of midazolam 30 min prior to entering the operating room (OR). After placement of the standard monitoring systems (electrocardiography, noninvasive arterial blood pressure, and pulse oximetry), anesthesia was induced using 2 mg/kg of intravenous propofol and 0.15 mg/kg of vecuronium.

Ventilation was controlled via a facemask with 100% oxygen at 6 L/min and 3 MAC (minimum alveolar concentration) of sevoflurane for 5 min. Patients in group E were given a lower amount of sevoflurane because after 40 years of age, the MAC of volatile anesthetics decreases by 4% every 10 years. The formula used to calculate the necessary amount of sevoflurane was $\left(3\,MAC \times \left(2 - \frac{2\times0.04\times(age-40)}{10}\right)\right)$.[13] Thereafter, endotracheal intubation was performed using a Macintosh blade. All intubations were performed by a single anesthesiologist with more than 10 years of experience. After intubation ventilation was controlled at a tidal volume of 8 mL/kg and at a respiratory rate of 12 breaths/min. Maintenance fluids were given according to “4-2-1” formula.[14]

2.3. Study variables

For each patient, we recorded their age, sex, weight, body mass index (BMI), ASA physical status, Mallampati score, and intubation time. The Mallampati score was measured just prior to intubation.[15–17] Intubation time, predefined as the time from the laryngoscope blade coming into contact with the body to the inflation of the endotracheal tube cuff, was measured by a nurse who did not otherwise participate in this study.

The hemodynamic variables (systolic blood pressure (SBP), mean arterial pressure (MAP), diastolic blood pressure (DBP), pulse pressure (PP) and heart rate (HR)) were measured at the pre-anesthetic care unit (PACU), after arrival at the OR (Pre), immediately after intubation (T_0), and 1 min after (T_1), 2 min after (T_2), 3 min after (T_3), and 4 min after (T_4) intubation. The change in hemodynamic variables was calculated by comparisons with the hemodynamic variables (pre). Patients showing more than 20% increase in SBP at the PACU compared with SBP in the ward despite premedication, and patients with an SBP more than 180 mmHg during measurement were given anti-hypertensive medication and excluded from the study.

2.4. Statistical analysis

The primary outcome measure of this study was the change in SBP. In order to estimate the required sample size, a pilot study (n = 10; group N) was conducted. The average change in T_0, T_1, T_2, T_3, and T_4 were 18.9, 13.3, 9.2, 6.8 and 2.8, respectively. The standard deviation of the change in SBP ranged from 2.4 to 6.4, and the autocorrelation between adjacent measurements in the same individual was 0.7. For our power calculation, we assumed that the first-order autocorrelation adequately represented the autocorrelation pattern. We aimed to detect a 20% increase in group E compared with group N. With $\alpha = 0.05$ and a power of 80%, we needed 54 patients per group. Considering a loss-to-follow-up rate of 10%, we required 120 patients for the study.

For continuous variables, the normality of the data distribution was first evaluated using the Shapiro-Wilk test. Normally distributed data are presented as the mean ± standard deviation and were analyzed using parametric methods, and non-normally distributed data are presented as median (Q_1–Q_3), which were analyzed using non-parametric methods. Changes in SBP, MAP and HR showed a normal distribution, while changes in DBP and PP did not. Therefore, we also used a q-q plot, which did not indicate any significant deviation from linearity, allowing normal assumptions for the repeated measures analysis of variance (ANOVA). Mauchly's sphericity test indicated that the assumption of sphericity had been violated for SBP(χ^2 (9) = 462.15, P < 0 0.001, W = 0.013), MAP (χ^2 (9) = 584.65, P < .001, W = 0.004), DBP(χ^2 (9) = 637.02, P < .001, W = 0.003), PP(χ^2 (9) = 342.90, P < .001, W = 0.040) and HR (χ^2 (9) = 413.93, P < .001, W = 0.020). Therefore, we used a Wilk's lambda multivariate analysis of variance (MANOVA), followed by Student's *t*-tests with Bonferroni corrections.

To assess the association of the changes in hemodynamic variables with age, gender and Mallampati score, multi-variable linear regression analysis was performed.

Analysis of covariance (ANCOVA) models were utilized to examine group differences in the change in hemodynamic variables, while controlling for the Mallampati score.

Descriptive variables were analyzed using χ^2 analyses or Fisher's exact tests. Data in the figure are expressed as mean ± standard error. P < .05 was considered statistically significant. All statistical analyses were performed using SPSS 23(IBM Corp, Armonk, NY).

3. Results

Out of the 120 participants, 60 were assigned to group N and 60 to group E. Of those, three from group N and seven from Group E received anti-hypertensive medication because their SBP was over

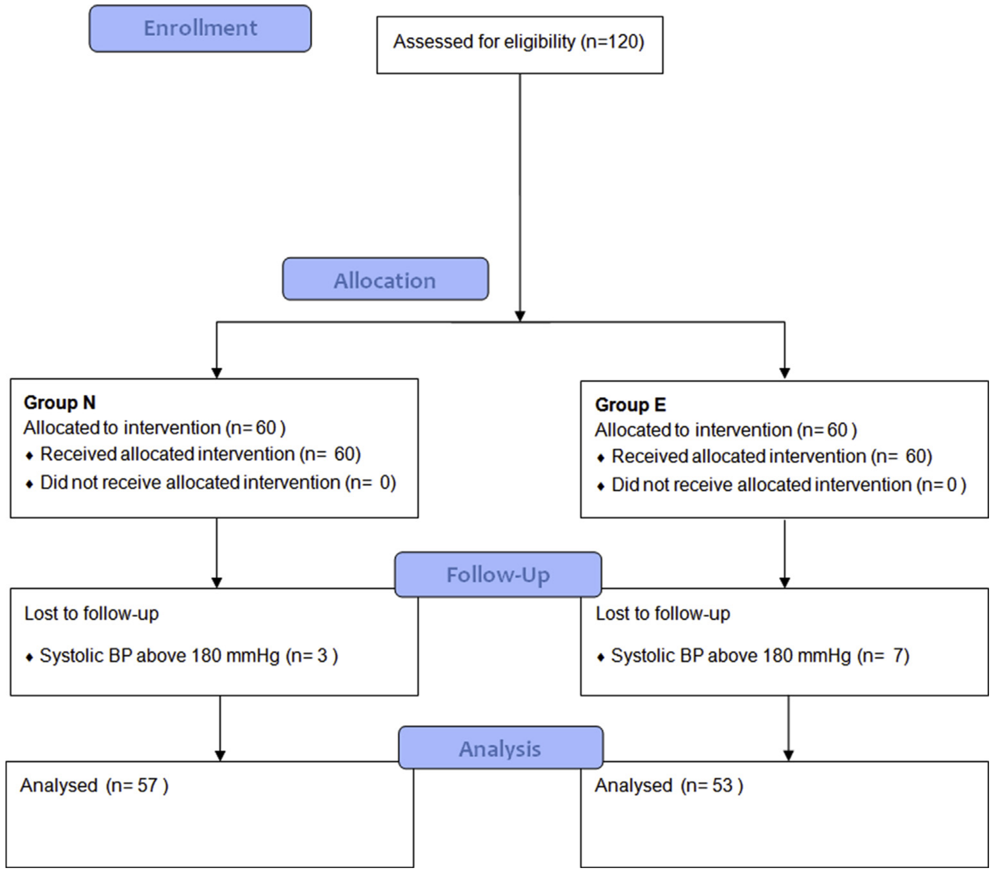

Fig. 1. Flow diagram.

180 mmHg, and they were excluded from the analysis (Fig. 1). Thus, 57 patients in group N and 53 patients in group E were analyzed.

As shown in Table 1, there were no significant differences between groups with respect to demographic and hemodynamic variables other than age. The average age of the patients was 42.2 years in group N and 69.1 years in group E.

While patients were ventilated with 3 MAC of sevoflurane for 5 min, SBP, MAP, DBP and PP decreased and HR increased. However, no significant hypotension was observed.

Fig. 2A, B and 2C shows the change in SBP, MAP and DBP. The MANOVA demonstrated a statistically significant difference between groups in SBP(F (5,104) = 5.337, $P < .001$, $\lambda = 0.796$), MAP(F(5,104) = 11.989, $P < .001$, $\lambda = 0.634$) and DBP(F (5,104) = 9.365, $P < .001$, $\lambda = 0.690$). The change in SBP and MAP was statistically significantly higher in group E when compared with group N at T_0 and T_1. However, there were no differences at each time point in DBP.

Fig. 2D shows the change in PP. The MANOVA did not show significant difference between groups (F (5,104) = 1.639, $P = .156$, $\lambda = 0.927$).

Fig. 2E shows the change in HR. The MANOVA demonstrated a statistically significant difference between groups (F (5,104) = 161.56, $P < .001$, $\lambda = 0.114$). Changes in HR were statistically significantly lower in group E compared with group N at T_0, T_1, and T_2.

The Mallampati score and intubation time were significantly higher in Group E than in Group N($P < .001$) (Table 1).

The intubation time was significantly longer in patients with Mallampati score 3 than those with Mallampati score 1 and 2 in

Table 1
Patient characteristics.

	Group N (n = 57)	Group E (n = 53)	p-value
Age (yr)	42.0 (39.5–45.5)	69.0 (67.0–71.0)	<.001[a,b]
Gender M/F(n)	30/27	29/24	.676
Weight (kg)	62.0 (54.5–73.5)	64.0 (56.0–72.0)	.820[b]
BMI(kg/m^2)	25.4 ± 4.7	24.1 ± 4.8	.155
Pre SBP(mmHg)	122.7 ± 9.2	127.3 ± 8.2	.006[a]
Pre MAP (mmHg)	92.7 ± 7.8	96.3 ± 5.9	.007[a]
Pre DBP(mmHg)	77.7 ± 7.4	80.8 ± 5.1	.012[a]
PrePP(mmHg)	29.9 ± 2.8	31.0 ± 3.2	.070
Pre HR (beats/min)	82.0 ± 8.9	80.2 ± 8.3	.286
Hgb(g/dL)	13.0 (12.0–15.0)	12.1 (11.0–12.6)	.312
Fasting glucose (mg/dL)	83.0 (77.0–89.3)	87.0 (80.0–93.0)	.162
EF (%)	63.0 (60.0–70.0)	62.0 (57.0–66.5)	.321
Creatinine (mg/dL)	0.93 (0.80–1.11)	0.89 (0.62–1.01)	.154
Surgical department(n)			.911
GS	21	24	
OS	16	12	
OBGY	8	6	
URO	5	5	
ENT	7	6	
Mallampati score (n) I	22 (38.6)	6 (11.3)	<.001[a]
II	29 (50.9)	32 (60.4)	
III	6 (10.5)	15 (28.3)	
IV	0 (0.0)	0 (0.0)	
Intubation time (sec)	20.0 (16.5–23.0)	26.0 (20.0–31.0)	<.001[a]

Values are presented as mean ± SD, median (Q_1–Q_3) or number.
Yr; year, n; number, BMI; body mass index, SBP; systolic blood pressure, MAP; mean arterial pressure, DBP; diastolic blood pressure, PP; pulse pressure, HR; heart rate, EF; ejection fraction, GS; general surgery, OS; orthopedic surgery, OB; obstetrics and gynecology, URO; urology, ENT: Otorhinolaryngology-Head and Neck Surgery.
[a] $P < .05$ between group comparison.
[b] Values are presented as median (Q_1–Q_3) and compared using Mann–Whitney *U* test, because of abnormal distribution.

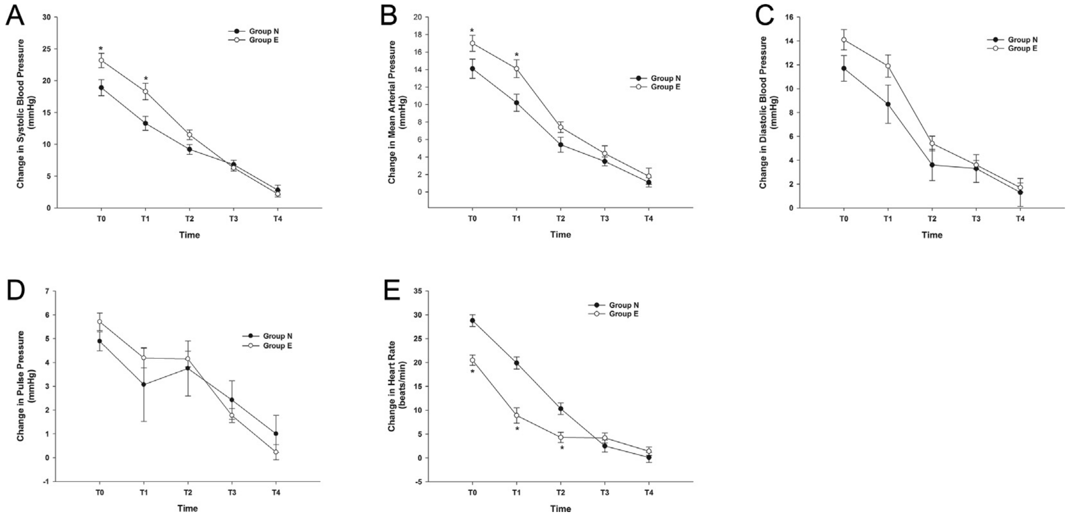

Fig. 2. Changes in hemodynamic variables. Data are presented as mean ± standard error. *P < .05 compared with group N.

group E, and longer in patients with Mallampati score 3 than those with Mallampati score 1 in group N (Fig. 3).

The change in SBP at T_0 was significantly lower in patients with Mallampati score 1 than those with Mallampati score 2 or 3 in both group E and group N (Fig. 4).

In the multi-variable regression analysis, the change in SBP, MAP and DBP at T_0 was associated with Mallampati score and the change in PP and HR was associated with Age (Table 2).

An ANCOVA was conducted to examine the effect of the differences in the groups on the change in SBP, MAP, DBP, PP and HR at T_0 while controlling for the Mallampati score. The results indicated that there were no significant differences between groups in the change in SBP(F (1,113.7) = 1.579, P = .212), change in MAP(F(1,24.4) = 0.483, P = .488), change in DBP(F (1,7.7) = 0.167, P = .684) or. change in PP(F (1,32.8) = 3.51, P = .132). However, there was a significant group difference in HR (F (1,2148.5) = 29.253, $P < .001$).

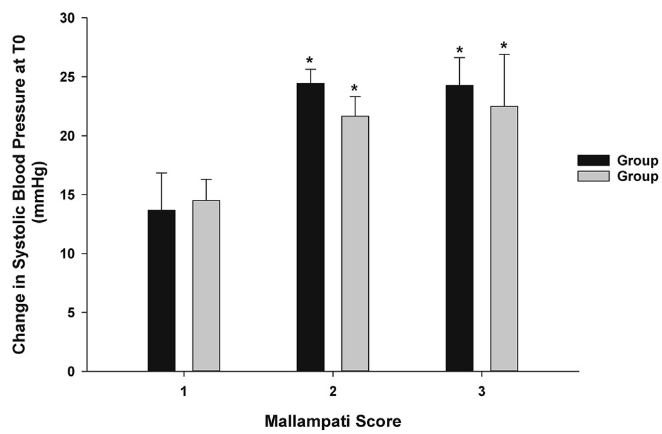

Fig. 4. Change in systolic blood pressure. *P < .05 compared with Mallampati score 1.

4. Discussion

This study compared the changes in the hemodynamic responses, Mallampati score, and intubation time between young adult and elderly patients. The changes in SBP, MAP and DBP, Mallampati score, and intubation time are higher and the change in HR is lower in elderly patients. When controlling for the Mallampati score, the difference in the change in SBP, MAP and DBP at T_0 between groups was no longer apparent. However, the change in HR at T_0 was lower in elderly patients, even after controlling for the Mallampati score.

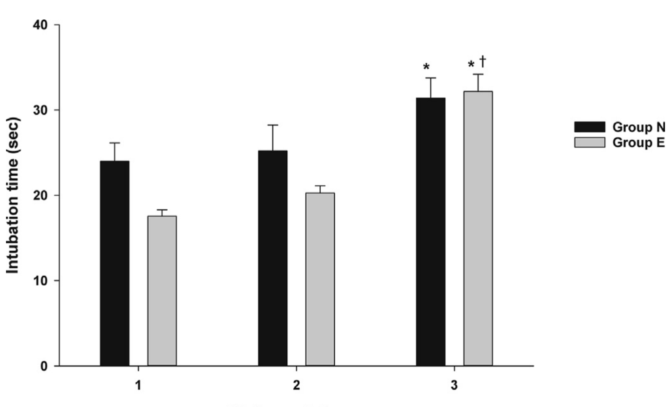

Fig. 3. Intubation time. *P < .05 compared with Mallampati score 1. †P < .05 compared with Mallampati score 2.

Preoperative assessment of the patient's airway is important in order to predict difficult airway management. Difficult intubation can be anticipated through the evaluation of the oral opening and tongue protrusion.[18] The Mallampati score correlates with the ratio of tongue size to pharyngeal size, and can be used as a predictor to prepare for advanced airway management.[15–17]

In this study, the Mallampati score was significantly higher in elderly patients (Table 1). This finding is consistent with other studies, which have shown that the Mallampati score increase with age,[19] which may be related to changes in bone joints and soft tissue, resulting in an increase in cervical joint rigidity.[11,19]

During the induction, the use of a laryngoscope and intubation with an endotracheal tube can cause severe hypertension, tachycardia, and arrhythmia. The increase in arterial blood pressure starts after 5 s of using the laryngoscope, peaks after 1–2 min, and usually returns to a controlled phase within 5 min in healthy patients, and is generally not an issue. However, in the case of patients with heart disease, with a limited myocardial reserve or coronary artery capacity, these changes can be fatal and lead to myocardial

Table 2
Results of multiple linear regression analysis to identify factors affecting hemodynamic change.

Model	Regression coefficient	95% confidence interval	p-value
SBP change at T0			
Constant	6.757	−0.321−13.835	.061
Age	0.103	−0.020−0.227	.100
Gender	1.231	−2.078−4.539	.462
M-score	4.067	1.431−6.703	.003
MAP change at T0			
Constant	4.232	−1.673−10.137	.158
Age	0.057	−0.045−0.160	.271
Gender	1.761	−0.999−4.521	.209
M-score	3.674	1.476−5.873	.001
DBP change at T0			
Constant	2.636	−3.021−8.294	.358
Age	0.039	−0.060−0.137	.436
Gender	2.012	−0.633−4.656	.134
M-score	3.589	1.482−5.695	.001
PP change at T0			
Constant	2.525	0.104−4.946	.041
Age	0.046	0.004−0.088	.033
Gender	−0.530	−1.662−0.601	.355
M-score	0.393	−0.508−1.294	.389
HR change at T0			
Constant	38.212	31.066−45.357	<.001
Age	−0.338	−0.463−−0.214	<.001
Gender	2.675	−0.665−6.015	.115
M-score	1.961	−0.700−4.621	.147

SBP; systolic blood pressure, M-score; Mallampati score, MAP; mean arterial pressure, DBP; diastolic blood pressure, PP; pulse pressure, HR; heart rate.

infarction or heart failure,[7] and other severe complications such as subarachnoid hemorrhage. It is known that after the general anesthesia and surgery, the incidence of a stroke due to hypertension is 0.08−0.4% and increases with increasing age.[13]

In this study, the rise of SBP, MAP and DBP was significant in group E. This may be associated with the fact the Mallampati score was higher in elderly patients (Table 1), which may contribute to the longer intubation time (Figs. 3 and 4). Therefore, we performed ANCOVA analysis to examine the effect of the group differences on the hemodynamic change while controlling for the Mallampati score, and these differences are disappeared after controlling. Further, multi-variable regression analysis revealed Mallampati score was a significant factor for change in SBP, MAP and DBP.

In our study, the baseline SBP, MAP and DBP were higher in group E than group N. This may be owing to the fact that with increasing age, there is greater fibrosis of the vascular middle layer of major vessels and a subsequent loss of elasticity. Therefore, the blood pressure rises and results in decreased arterial compliance, increased afterload, and increased SBP, MAP and DBP.[8] Gribbin et al.[9] found that baroreceptor activation decreases with age, causing arterial stiffness and a rise in the SBP.

In elderly patients, the increase in blood pressure when intubation is performed is more pronounced. Bullington et al.[10] found that intubation increases the release of catecholamines and subsequently affects the hemodynamic response. Pleşea et al.[20] found that arterial hypertension increases with age, and can cause hyalinosis and sclerosis of the capillaries and arterioles in the brain, and cause brain hemorrhage and the rupture of blood vessels.

HR was significantly lower in group E than in group N until T_3 (Fig. 2E). The change in HR at T_0 was lower in group E than in group N, even after controlling for the Mallampati score. In the multi-variable regression analysis among age, Mallampati score and change in HR revealed age was significant factor. The lower increase in HR in the elderly group may be attributed to the decreased sensitivity of the heart to beta-adrenergic stimulation despite the higher level of noradrenaline as part of the aging process.[21]

When designing this study, we planned to exclude patients for ethical reasons. Patients with a greater than 20% increase in SBP when measured in the pre-anesthetic care unit compared with their SBP measured on the ward despite any premedication and patients with a SBP more than 180 mmHg during measurement were excluded. In these patients, additional antihypertensive agents were administered. Three patients from group N and seven from Group E were excluded. If these patients were enrolled, the significance of the hemodynamic changes may have been higher.

Compared with the study of Ismail et al., which used halothane as the volatile anesthetic agent,[22] this study was performed using sevoflurane, which has a blood/gas partition coefficient of 0.65 which is lower than that of both halothane and isoflurane. This may lead to faster induction and a more hemodynamically stable condition after intubation, without the need to use additional opioids.

This study has some limitations. First, although it was a prospectively designed study, it was not a randomized controlled study. However, age is a variable that cannot be randomized. Hence, to minimize a selection bias, we enrolled consecutive patients from the beginning of study. Furthermore, we additionally analyzed the results using statistical methods such as ANCOVA and muli-variable regression analysis to control for other covariates. Second, we excluded patients with a history of hypertension, diabetes, or cardiovascular-related drug use, and patients who were expected to have a difficult intubation. These patients were expected to experience a rapid rise in blood pressure, which would pose a risk for the patient. Therefore, all patients could not be included in this study. Consequently, the results cannot be extrapolated to all patients, nor can rare complications be definitively ruled out.

Notwithstanding these limitations, our study also demonstrated certain strengths, since it compared hemodynamic variables, Mallampati score, and intubation time prospectively, and applied a vigorous methodology and statistical analysis.

In conclusion, Mallampati score, intubation time, and the changes in SBP, MAP and DBP after intubation were significantly higher, and the change in HR was lower in elderly patients when compared with younger adults. The changes in SBP, MAP and DBP in elderly patients may be associated with the changes in the Mallampati score. However, before the induction of anesthesia in elderly patients, various monitoring devices and emergency medications must be prepared, and during the induction, hemodynamic changes must be anticipated and carefully managed.

Conflicts of interest

None to declare.

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