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Original Article

Hemodynamic responses to endotracheal intubation performed with video and direct laryngoscopy in patients scheduled for major cardiac surgery

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Abstract: This study aims to compare the hemodynamic responses to endotracheal intubation performed with direct and video laryngoscope in patients scheduled for cardiac surgery and to assess the airway and laryngoscopic characteristics. One hundred ten patients were equally allocated to either direct Macintosh laryngoscope (n = 55) or indirect Macintosh C-MAC video laryngoscope (n = 55). Systolic, diastolic, and mean arterial pressure, and heart rate were recorded prior to induction anesthesia, and immediately and two minutes after intubation. Airway characteristics (modified Mallampati, thyromental distance, sternomental distance, mouth opening, upper lip bite test, Wilson risk sum score), mask ventilation, laryngoscopic characteristics (Cormack-Lehane, percentage of glottic opening), intubation time, number of attempts, external pressure application, use of stylet and predictors of difficult intubation (modified Mallampati grade 3-4, thyromental distance < 6 cm, upper lip bite test class 3, Wilson risk sum score ≥ 2, Cormack-Lehane grade 3-4) were recorded. Hemodynamic parameters were similar between the groups at all time points of measurement. Airway characteristics and mask ventilation were no significant between the groups. The C-MAC video laryngoscope group had better laryngoscopic view as assessed by Cormack-Lehane and percentage of glottic view, and a longer intubation time. Number of attempts, external pressure, use of stylet, and difficult intubation parameters were similar. Endotracheal intubation performed with direct Macintosh laryngoscope or indirect Macintosh C-MAC video laryngoscope causes similar and stable hemodynamic responses.

Keywords: Macintosh C-MAC video laryngoscope, endotracheal intubation, hemodynamic response, cardiac surgery

Introduction

Hemodynamic changes that occur during the cardiac surgery may lead to myocardial ischemia. Perioperative myocardial ischemia that develops in the presence of hemodynamic disturbance is associated with tachycardia rather than hypotension and hypertension [1, 2]. Laryngoscopy and endotracheal intubation contribute significantly to hemodynamic changes. Laryngoscopy, and more specifically endotracheal intubation, may cause different hemodynamic responses [3, 4]. Furthermore, surgery-independent difficult laryngoscopy seems to be more in the patients scheduled for cardiac surgery compared to the patient population of general surgery [5]. The reflex responses to stimulation of oropharyngeal and upper airway receptors include glottic closure, hypertension, and reflex bronchoconstriction. These reflexes can be modified by reducing the sensory receptor stimulation (technical or pharmacological) or the efferent responses (parenteral agents) [6]. Video laryngoscopes (VL) are devices that have come into clinical use recently. Among these, C-MAC with Macintosh blade is recommended for use in difficult airways [7-9]. There are very limited studies that have evaluated hemodynamic responses to VL-guided endotracheal intubation in patients scheduled for cardiac surgery [10] and the airway characteristics and difficult laryngoscopy in such patient population [5]. This prospective, randomized clinical trial was planned (1) to compare the hemody-

Table 1. Patients'characteristics

	Group DL (n = 55)	Group VL (n = 55)	*P* value
Gender (Male, n, %)	37 (67.2)	33 (60)	0.42
Age (year)	58.5 ± 16.2	61.3 ± 13.3	0.45
Height (cm)	164.7 ± 9.7	163.3 ± 10.4	0.48
Weight (kg)	73.7 ± 14.3	73.8 ± 15.6	0.97
BMI (kg/m^2)	27.1 ± 4.2	27.7 ± 5.9	0.51
Medication (n, %)			
Beta blocker	52 (94.5)	55 (100)	0.97
Calcium channel blocker	11 (20.0)	13 (23.6)	0.72
ACE	10 (18.1)	8 (14.5)	0.65
Comorbidity (n, %)			
Hypertension	30 (54.5)	34 (61.8)	0.52
Diabetes mellitus	22 (40)	25 (45.4)	0.77
Others	31 (56.3)	27 (49.0)	0.50
Operation (n, %)			
CABG	39 (71.0)	34 (62.0)	0.60
Valve	13 (23.6)	16 (29)	
Other	3 (5.4)	5 (9.0)	

Data are expressed as mean ± standard deviation, number (percentage). SD: Standard deviation; BMI: Body mass index; ACE: Angiotensin converting enzyme; CABG: Coronary artery bypass graft.

namic responses to endotracheal intubation performed with direct Macintosh laryngoscope (DL) and indirect Macintosh C-MAC video laryngoscope (VL), and (2) to assess the airway and laryngoscopic view.

Materials and methods

Approval was obtained from University Ethics Committee, and written consent from each patient. The study included 110 patients (70 males, 40 females; mean ages 59.9 ± 14.8 years; range 19-84 years) older than 18 years of age with good ventricular function, who were scheduled for elective cardiac surgery and would be operated in the morning. Patients with systolic blood pressure > 160 mmHg at the baseline measurements in the operating room, with airway anomaly and apparent neck pathology were excluded. All intubations were performed by two anesthesiologists with experience in using VL. Premedication was administered orally with 0.5 mg alprazolam only at night. Beta blockers were administered at the morning doses. Since VL was not available within the unit, the patients were divided into two groups through weekly randomization as direct laryngoscope (DL) (Macintosh blade size = 3-4) (group DL; n = 55) and video laryngoscope (VL) (C-MAC®, Storz, Tuttlingen, Germany; Macintosh blade size = 3) (group VL; n = 55).

After taking into the operating room, the airway characteristics in the sitting position were evaluated as the following:

Modified Mallampati: The Samsoon and Young [11] modification of the Mallampati airway score [12] (grade 1: soft palate, uvula, and tonsillar pillars visible; grade 2: soft palate and uvula visible; grade 3: soft palate and base of uvula visible; grade 4: soft palate invisible).

Thyromental distance: from thyroid notch to the mentum.

Sternomental distance: from the upper border of the sternal manubrium to the mentum.

Mouth opening: between interincisor gap.

Upper lip bite test (ULBT): [13] class 1: lower incisors can bite the upper lip above the vermilion line; class 2: lower incisors can bite the upper lip below the vermilion line; and class 3: lower incisors cannot bite the upper lip.

Wilson risk sum score: [14] five risk factors (head/neck movement, jaw movement, receding mandible, prominent maxillary incisors, and body weight) evaluated with a score of 0-2 (total score of 0-10).

Then, the patient was placed into the supine position by placing a cushion under the head and shoulders. Following standard monitorization (lead II and V electrocardiogram, pulse oximetry, non-invasive blood pressure, and neuromuscular monitoring with train-of-four), fluid infusion was initiated in a manner that the intravenous vascular access would remain open. Anesthesia was induced by intravenous sufentanil (0.5 μg/kg), etomidate (0.3 mg/kg), and rocuronium (0.6 mg/kg). When there were no responses to verbal stimuli, mask ventilation was initiated using 100% oxygen. Endotracheal intubation was performed when a train-of-four response was not achieved.

Ventilation and laryngoscopic characteristics were recorded as (1) mask ventilation (easy/assist), (2) laryngoscopic view Cormack-Lehane

Table 2. Hemodynamic changes

	Group DL (n = 55)	Group VL (n = 55)	*P* value
HR (beats/min)			
Prior to induction anesthesia	68.5 ± 13.6	68.3 ± 15.8	0.93
Immediately after intubation	71.6 ± 13.1	71.0 ± 15.0	0.81
Two minutes after intubation	69.3 ± 12.5	68.2 ± 14.3	0.67
SAP (mmHg)			
Prior to induction anesthesia	127.7 ± 21.7	129.0 ± 16.4	0.74
Immediately after intubation	126.5 ± 29.8	122.6 ± 23.9	0.45
Two minutes after intubation	124.5 ± 30.2	120.4 ± 31.7	0.48
DAP (mmHg)			
Prior to induction anesthesia	72.6 ± 12.6	70.8 ± 11.2	0.41
Immediately after intubation	77.2 ± 18.9	73.4 ± 17.1	0.27
Two minutes after intubation	73.0 ± 17.4	67.6 ± 16.8	0.09
MAP (mmHg)			
Prior to induction anesthesia	94.3 ± 15.7	93.7 ± 12.5	0.82
Immediately after intubation	95.1 ± 21.5	91.8 ± 18.5	0.38
Two minutes after intubation	91.5 ± 21.3	88.8 ± 24.1	0.52

Data are expressed as mean ± standard deviation. SD: Standard deviation; HR: Heart rate; SAP: Systolic arterial pressure; DAP: Diastolic arterial pressure; MAP: Mean arterial pressure.

(C-L) [15] (grade 1: full view of glottis; grade 2: partial view of glottis; grade 3: only epiglottis seen; grade 4: epiglottis not seen, (3) percentage of glottic opening (POGO) [16]; any interval percentage from 0% to 100%. (POGO score was considered 100% if there was a full view of glottis and 0% if there was no view of glottic opening), (4) intubation time (time when the laryngoscope passes through the patient's lips and when it is removed), (5) intubation attempts, (6) external pressure application, and (7) use of stylet.

For endotracheal intubation, the diameter of the endotracheal tube was 9 mm in males and 8 mm in females. Following the intubation, the tube cuff was inflated with cuff pressure control so that the pressure was 25 mmHg. After the intubation, mechanical ventilation (oxygen = 100%, tidal volume = 6 mL/kg, frequency = 12 breaths/min, positive end expiratory pressure = 0) was initiated. Anesthetic gas was not used during the two minutes when the hemodynamic recordings were taken.

Difficult intubation parameters were established as modified Mallampati grade 3-4, thyromental distance < 6 cm, ULBT class 3, Wilson risk sum score ≥ 2, and C-L grade 3-4.

Measuring variables

Hemodynamic assessment was made using non-invasive blood pressure measurements since the invasive blood pressure monitorization was performed after the intubation. Heart rate (HR), systolic arterial pressure (SAP), diastolic arterial pressure (DAP), and mean arterial pressure (MAP) were recorded at prior to induction anesthesia (mean of three consecutive measurements), immediately (min 0), and two minutes after intubation. Patient intervention was not allowed during the measurements.

Statistical analysis

Statistical analysis was performed using SPSS software version 21.0 (IBM® SPSS® Statistics V21). The number of population that would provide a change of 10 mmHg in the mean arterial pressure and a change of 10 beats/min in the heart rate at 95% confidence (alpha = 0.05) and 90% (1-beta = 90) power was calculated as 51 patients using a formula (G-Power 3.1). The plan was to include 55 patients for each group. Categorical variables were analyzed using the chi-square test. For repeated measurements, the independent t-test was used for intergroup comparisons. The Bonferonni correction was used when necessary. The significance level was considered P < 0.05.

Results

Out of 110 patients, 73 patients had coronary artery bypass graft, 29 patients had valve and 8 patients had other cardiac operations. The patient characteristics were similar in both groups (**Table 1**). There were minor changes in the cardiac hemodynamics throughout the study in both groups. Hemodynamic responses were similar between the groups at all time points of measurements (**Table 2**). Airway characteristics and mask ventilation were similar between the groups, whereas the laryngoscopic view as assessed by C-L and POGO, and the intubation time were different. The time required for endotracheal intubation was longer in the VL group compared to the DL group (P

Table 3. Airway assessment and intubation data

	Group DL (n = 55)	Group VL (n = 55)	*P* value
Modified Mallampati grade (n, %)			0.70
1	7	15	
2	38	27	
3	10	13	
4	0	0	
Tyromental distance (cm)	7.6 ± 1.5	7.1 ± 1.8	0.17
Sternomental distance (cm)	13.5 ± 2.7	13.3 ± 12.3	0.60
Mouth opening (cm)	4.8 ± 0.7	4.6 ± 0.7	0.21
ULBT class (n, %)			0.51
1	44 (80.0)	47 (85.4)	0.51
2	10 (18.2)	7 (12.8)	0.51
3	1 (1.8)	1 (1.8)	0.49
WRSS (n, %)			0.51
0	11 (20)	10 (18.2)	0.03*
1	21 (38.2)	13 (23.6)	0.03*
2	20 (36.4)	28 (51.0)	0.31
3	2 (3.6)	3 (5.4)	0.63
4	1 (1.8)	1 (1.8)	0.82
Mask ventilation (easy/asist) (n, %)	53 (96.4)/2 (3.6)	55 (100)/0 (0.0)	0.49
C-L grade (n, %)			0.01
1	28 (51.0)	49 (89.1)	
2	21 (38.1)	4 (7.3)	
3	6 (10.9)	2 (3.6)	
4	0 (0.0)	0 (0.0)	
POGO[1] (n, %)			0.03
1	30 (54.5)	44 (80)	
2	6 (10.9)	2 (3.6)	
3	7 (12.7)	3 (5.4)	
4	12 (21.9)	6 (11)	
Intubation time (s)	16.8 ± 11.2	21.4 ± 14.3	0.03
Intubation attempts (n, %)			0.31
1	53 (96.4)	50 (90.9)	
2	1 (1.8)	5 (9.1)	
3	1 (1.8)	0 (0.0)	
External pressure (yes/no) (n, %)	45 (81.8)/10 (18.2)	43 (78.2)/12 (21.8)	0.63
Stylet use (n, %)	13 (23.6)	14 (25.4)	0.82

Data are expressed as mean ± standard deviation, number (percentage). SD: Standard deviation; *: Statistically significant; ULBT: Upper lip bite test; WRSS: Wilson risk sum score; C-L: Cormack-Lehane; POGO: Percentage of glottic opening; [1]: (1 = 100%, 2 = 75%, 3 = 50%, 4 = 25%).

= 0.03). There was a higher number of patients with glottic view as assessed by C-L (grade 1) and POGO (1 = 100%) in the VL group (P = 0.01, 0.03 respectively) (**Table 3**). C-L grade 4 was not observed in any patient; whereas the number of patients with grade 3 was higher in the DL group than the VL group (6 vs. 2); there was not a significant difference between the groups (P > 0.05) (**Table 4**). All patients were intubated successfully.

Discussion

The present study found that C-MAC VL extended the duration of laryngoscopy in patients scheduled for major cardiac surgery; however,

Table 4. Difficult intubation parameters

	Group DL (n = 55)	Group VL (n = 55)	*P* value
Modified Mallampati (n, %)			0.48
Grade 3	10 (18.1)	13 (23.6)	
Grade 4	0 (0.0)	0 (0.0)	
Tyromental distance (< 6 cm) (n, %)	8 (14.5)	14 (25.4)	0.15
ULBT (class 3) (n, %)	1 (1.8)	1 (1.8)	
WRSS ≥ 2 (n, %)	23 (41.8)	32 (58.1)	0.86
C-L (n, %)			0.75
Grade 3	6 (10.9)	2 (3.6)	
Grade 4	0 (0.0)	0 (0.0)	

Data are expressed as mean ± standard deviation, number (percentage). ULBT: Upper lip bite test; WRSS: Wilson risk sum score; C-L: Cormack-Lehane.

the hemodynamic responses to endotracheal intubation were similar to those with DL.

Both laryngoscopy and endotracheal intubation causes increased blood pressure and catecholamine concentrations; however, endotracheal intubation has more effects on heart rate [3]. The hemodynamic responses during laryngoscopy and endotracheal intubation may vary by premedication, social habits, preoperative medications, narcotic, and neuromuscular blocker doses and speed of anesthetic agent administration [17]. Furthermore, some drugs may affect only the heart rate or the blood pressure. Drug combinations may be required in order to minimize both heart rate and blood pressure effectively [18]. Therefore, the selection and combination of anesthetic agents is important to suppress the hemodynamic responses during laryngoscopy and endotracheal intubation.

Weiss-Bloom et al [19] showed reduced hemodynamic responses to endotracheal intubation with induction by 5-10 μg/kg fentanyl and 0.3 mg/kg etomidate in patients scheduled for coronary artery bypass graft surgery. Sufentanil is an analgesic ten times more potent than fentanyl [20]. The present study used sufentanil (0.5 μg/kg) at an equivalent dose to fentanyl in the above-mentioned study and etomidate (0.3 mg/kg) at a similar dose. The efficacy of neuromuscular blocker was monitored, as well. Similar and stable hemodynamic responses were achieved with both laryngoscopes. Sufficient anesthetic depth and muscle relaxation may facilitate laryngoscopy and suppress hemodynamic responses.

In this regard, the design of laryngoscopic blade may affect intubation as well as hemodynamic responses. Video laryngoscopes (VLs) are intubation devices providing an indirect view of the upper airways via a video camera located at the blade tip. VLs have various designs. Among these, C-MAC has an original standard Macintosh blade shape (sizes 2, 3, 4), but it is designed as flat proximal finish. It reduces the mouth opening required for intubating a patient and minimizes the risk for damaging the teeth [21]. When compared to standard laryngoscope, there is less force applied to the maxillary incisors with C-MAC [22]. Less blade contact with the maxillary teeth allows for a greater distance to lift the epiglottis (fewer maneuvers) [8]. Macintosh blade C-MAC, which the anesthesiologists are more familiar with, is easy to use, causes fewer attempts, and has a shorter intubation time compared to other VLs (McGrath) in Mallampati grade ≥ 3 patients [23]. Additionally, there is less need for a stylet in normal airways compared to other VLs [24]. The force applied to lift the epiglottis by the laryngoscope blade may also affect the hemodynamic response. However, some studies have shown a weak correlation between the force applied during laryngoscopy and the hemodynamic changes [4]. Although the force applied to lift the epiglottis is lower with C-MAC, [8] its contribution to avoid hemodynamic responses may not be as important as the anesthetic agent combination.

The duration of laryngoscopy is also important for the cardiovascular responses to endotracheal intubation [25]. The intubation time is longer with various VLs than DL [9, 10]. The present study found a longer intubation time with C-MAC, too. However, this did not affect the hemodynamic parameters for a long time. It was also similar to the study by Kanchi and colleagues [10].

A study by Ezri et al. [5] found that the ratio of C-L laryngoscopic grade 3 and 4 was 5.2% in the overall patient population compared to 10% in patients who had cardiac surgery due to various reasons such as age and restricted neck movement. In the present study, the ratio of the C-L grade 3-4 patients was 10.9% in the DL group, which was consistent with the study by Ezri and colleagues. In both groups, the grade 3 patients were intubated without any problems using external pressure and/or a stylet. On the other hand, VLs provide a better laryngeal view; however, an improved laryngeal view does not always mean an easy and successful intubation [24]. The present study found the glottic view (POGO and C-L) was better in the VL group, whereas the use of a stylet, external pressure, and the number of attempts were similar in both groups.

There are a few limitations to this study. First, the intubating anesthesiologists were not blind, but the intubation time and hemodynamic measurements were recorded by an independent observer. Second, the hemodynamic measurement was made as non-invasive since the invasive blood pressure monitoring was performed after the intubation in our routine practice. Therefore, it did not reflect the instant temporary changes. Third, the complications associated with airway were not investigated.

Conclusion

VL improves the glottic view, however, there is still a need for a stylet and external pressure in order to obtain a good glottic view. On the other hand, without hemodynamic disturbance, C-MAC VL may be used as an alternative airway tool in cardiac surgery patients with poor glottic view via DL.

Disclosure of conflict of interest

None.

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