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A Randomized Prospective Study Comparing C-Mac D-Blade, Airtraq, and Fiberoptic Bronchoscope for Intubating Patients with Anticipated Difficult Airway

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Abstract

Background: Several complications may be correlated with difficult airway up to death. Fiberoptic bronchoscope is the gold stander to deal with difficult intubation. Airtraq laryngoscope and C-MAC® video laryngoscope are new devices that are used successfully for tracheal intubation. We compared using C-MAC D-blade video laryngoscope, Airtraq laryngoscope, and Fiberoptic bronchoscope for intubation of patient likely to have difficult intubation.

Patients and methods: Ethical committee permission was obtained before 120 adult patients (ASA I-III) with expected difficult intubation were incorporated in this prospective study. Participants were randomly distributed to 3 equal groups to be intubated using either C-MAC D-blade (group 1), Airtraq (group 2), or Fiberoptic technique (group 3) after anesthesia was induced. Our primary outcome was time to tracheal intubation. Intubation data, hemodynamics, and SpO2 were evaluated.

Results: Time to visualize the vocal cords (T1) and time to tracheal intubation (T2) were significantly shorter in C-MAC D-blade group (group 1) and Airtraq group (group 2) than Fiberoptic group (group 3) and there was insignificant variance between group 1 and group 2. All participants were intubated in the 1st attempt except one in C-MAC Dblade group who needed 2 intubation attempts. There were insignificant variances between the 3 groups regarding number of successful trial (success rate), and manipulation used to improve vocal cord visualization or intubation. Sore throat grades were significantly lower in group 2 and 3 than group 1. Lowest SpO2 was significantly lower in group 3 than the other 2 groups. Mean arterial blood pressure and heart rate measured at 1 min and 3 min after intubation were significantly higher in group 1 than group 2 and 3.

Conclusion: When compared to Fiberoptic bronchoscope both C-mac D-blade and Airtraq comparably showed shorter time to visualize vocal cords and intubate patients with anticipated difficult intubation.

Keywords: C-mac D-blade; Airtraq; Fiberoptic bronchoscope; Anticipated difficult airway

Introduction

Difficult airway is correlated with many problems ranging from trauma to death [1]. Several methods help to diagnose patients predicted to have difficult airway before anesthesia [2,3]. The gold standard to deal with difficult intubation is Fiberoptic intubation using Fiberoptic bronchoscope [4].

The Airtraq laryngoscope (Prodol Meditec S.A., Vizcaya, Spain) [5] and the C-MAC® video laryngoscope (Karl Storz GmbH & Co. KG, Tuttlingen Germany) [6] are new instruments that are used successfully for intubation of ordinary and difficult airway. Airtraq has special curve and complicated optical system that allow anaesthesiologist to intubate trachea without changing the axes of different parts of the airway [5]. The C-MAC system introduced a recent blade with high angulation (D-Blade) to boost visualization of difficult airway [7].

Our target in this research was to compare the three devices (C-MAC D-blade video laryngoscope, Airtraq laryngoscope, and Fiberoptic bronchoscope) for intubation of predicted difficult airways during anesthesia practice.

Patients and Methods

After its approval by our institution ethical committee, this randomized prospective research was conducted in Tanta University Hospital for 6 months from March 2016 to September 2016 on 120 adult patients (ASA I-III) prepared for surgery and predicted to have difficult airways. Every patient received an explanation to the research goal and signed a written and informed consent. To ensure privacy to participant and data, a secret code number was used for each patient.

Inclusion criteria

We included patients in the research if they had ASA classification of I-III with predicted difficult intubation as determined by the presence of one or more clinical predictor of the coming: Mallampati score ≥ 3, mouth opening (inter-incisor distance)<3.5 cm, thyromental distance<6 cm, movement at the atlanto-occipital joint less than 15° [8].

To detect Mallampatti grade the patient's tongue should be maximally protruded with fully extended head while sitting [2]. Inter-incisor distance was measured while sitting , also thyromental distance was measured with the head fully extended [9].

Exclusion criteria

We excluded patients if they required nasal intubation, were less than 18 years old , had respiratory tract disease or coagulation disorders, or were at risk to aspirate (history of reflux, hiatus hernia, or not fasted). Also, we excluded patients with predicted impossible intubation (as patients with mouth opening<2 cm, history of impossible intubation, or cervical spine fixed in flexion).

Patients were randomly distributed into 3 equal groups (40 patients/group) to be intubated using either C-MAC D-blade (group 1), Airtraq (group 2), or Fiberoptic technique (group 3).

A computer was used for block randomization by creating a list of numbers, each number refer to one group. Then each number was included in opaque envelope. Each patient was allowed to choose one envelope and give it to a person who compared the number with the list generated by computer and accordingly assigned him to one group only.

After reaching of the patients to the operating theatre, monitor was connected which included pulse oximetry, blood pressure (noninvasive), five leads electrocardiogram, end-tidal carbon dioxide, and Bispectral (BIS) index. After pre-oxygenation for 4 min using 100% oxygen, the participant was given fentanyl (Sunny pharmaceutical, Egypt under license of Hameln pharmaceutical, Germany) 1 μg/kg, propofol (Astra Zeneca UK) 2 mg/kg, then if ventilation was good using face mask, succinylcholine (1 mg/kg) was given. Then after 1 min ventilation with 100% O2 and sevoflorane (Kahira pharmaceuticals and chemical industries company, Egypt under license of Abbvie UK) 2-3%, intubation was performed by experienced anesthesiologists. If BIS index was >60 before tracheal intubation, additional bolus dose (50 mg) of propofol was injected to decrease BIS below 60. Other devices to deal with difficult airway (including laryngeal mask airways (LMA), intubating laryngeal mask, Combi tubes, and cricothyroidotomy sets) were always immediately available.

If tracheal intubation (using any of the studied devices) couldn't be achieved after three attempts, the trial was classified as 'failed', and the airway was managed as indicated. The attempt was classified as failed if intubation of tracheal was not possible within 90 s after insertion of the device into the mouth, if the device was removed for repositioning or if SpO_2 decreased below 92% before intubation. Mask ventilation was maintained (with O2 100% and sevoflorane 2-3%) in between attempts.

After intubation, atracurium (GlaxoSmithKline, UK) (0.5 mg/kg^{-1}) was given, and all participants were ventilated mechanically with sevoflurane (1.2-2%) in 100% oxygen. No other drugs were administered, and no procedures were performed for 5 min while collecting data.

Jaw thrust was applied with Fiberoptic intubation to facilitate laryngeal exposure. When C-MAC D-blade was used, a semi rigid stylet was used to modify the shape of the tube and allow for easy intubation ("hockey-stick configuration")

The following data were collected:

1. The primary end point: Time to tracheal intubation (defined as: the time passed from introducing the device in the mouth until the tube passed the vocal cords (excluding the time of mask ventilation in-between attempts)). The attempt was not considered successful until the tube position was proved with capnography and chest auscultation.

2. The secondary end points included: Time to visualize the vocal cords (defined as: the time passed from introducing the device in the mouth until the vocal cords were well seen), number of intubation attempts, number of successful trials (success rate), and manipulation used to improve vocal cords visualization or intubation (use of bougie, manual protrusion of the tongue, head position readjustment, or laryngeal pressure).

Complications was recorded as oxygen desaturation (oxygen saturation ≤ 90%), trauma (lips, teeth, mouth, tongue, and pharynx), bronchospasm, or bleeding (After intubation, the oropharynx was suctioned, and the volume of suctioned blood was qualitatively graded as none, trace, moderate, or copious). Mean arterial blood pressure (MABP), heart rate (HR) and oxygen saturation (SpO_2), was recorded before and after induction, and 1, 3 and 5 min after intubation. Lowest SpO_2 was also reported. At discharge from recovery room patients quantitatively graded the intensity of sore throat using visual analogue scale VAS (0=free of pain and 100=worst pain).

Sample size calculation

Time to tracheal intubation was used as a base for sample size calculation. Sample size was found to be 37 per group assuming a standard deviation of 6.5 s (from our pilot study), a power of 80%, α error of 0.05, and β error of 0.2. We aimed to include 40 patients per group.

Statistical analysis

We used Statistical Program for Social Science (SPSS) version 20.0 to analyze data. Quantitative data were recorded as mean ± standard deviation (SD). Qualitative data were recorded as frequency and percentage.

The following tests were done: A one-way analysis of variance (ANOVA) was used when comparing between more than two means. Post Hoc test was used for multiple comparisons between different variables. Chi-square (χ^2) test was used when comparing proportions between two qualitative data. A $P<0.05$ was regarded to be statistically significant.

Results

No patient was excluded (120 patients were studied in this research (40 patients/group)). All groups were comparable regarding patient characteristics (Table 1) or baseline airway parameters (Table 2).

Table 3 showed that the time to visualize the vocal cords (T1) and time to tracheal intubation (T2) were 14.25 ± 3.59 and 23.55 ± 3.63 s respectively for group 1 (C-MAC D-blade group), 12.25 ± 5.68 and 20.15 ± 6.95 s respectively for group 2 (Airtraq group), and 29.77 ± 12.77 and 39.07 ± 13.27 s respectively for group 3 (Fiberoptic group). Group 1 and group 2 showed insignificant variances regarding T1and T2 but T1 and T2 were significantly shorter in group 1 (C-MAC D-blade group) and group 2 (Airtraq group) compared to group 3 (Fiberoptic group) (Table 3).

	Group 1	Group 2	Group 3
Age	44.45 ± 12.19	46 ± 13.13	44.92 ± 13.14
Sex	30M/10 F	31M/9 F	31M/9 F
Weight	76.17 ± 12.99	80.52 ± 18.96	77.57 ± 14.39
ASA			
1	7 (17.5%)	6 (15%)	7 (17.5%)
2	23 (57.5%)	22 (55%)	22 (55%)
3	10 (25%)	12 (30%)	11 (27.5%)
No significant differences between groups P>0.05			

Table 1: Patients characteristics.

	Group 1	Group 2	Group 3
Mouth opening			
>3.5 cm	27 (67.5%)	29 (72.5%)	27 (67.5%)
<3.5 cm	13 (32.5%)	11 (27.5%)	13 (32.5%)
Mallampati score			
1	1 (2.5%)	2 (5%)	1 (2.5%)
2	7 (17.5%)	6 (15%)	6 (15%)
3	24 (60%)	23 (57.5%)	25 (62.5%)
4	8 (20%)	9 (22.5%)	8 (20%)
Thyromental distance			
≥ 6 cm	11 (27.5%)	13 (32.5%)	13 (32.5%)
<6 cm	29 (72.5%)	27 (67.5%)	27 (67.5%)
Mobility at the atlanto-occipital joint			
<15°	25 (62.5%)	27 (67.5%)	26 (65%)
>15°	15 (37.5%)	13 (32.5%)	14 (35%)
No significant differences between groups P>0.05			

Table 2: Airway parameters.

All participants in Airtraq group and Fiberoptic group were intubated in the 1st attempt. One patient in C-MAC D-blade group needed 2 attempts (to be intubated) as the anesthesiologist cannot intubate in the 1st attempt and removed the tube which was inserted using bougie (Table 3).

All groups showed insignificant variances regarding number of successful trial (success rate), complications (except sore throat) and manipulation applied to help vocal cords visualization or intubation (bougie was used once in group 1, pressure on the larynx was used once in group 2, and manual tongue protrusion was used once in group 3) (Table 3).

Sore throat grades (Table 3) showed insignificant variance in group 2 (Airtraq group) (35 ± 12.6) and group 3 (Fiberoptic group) (33.2 ± 11.8) but sore throat grades in group 2 and 3 were significantly lower compared to group 1 (C-MAC D-blade group) (45 ± 12.1). Lowest SpO_2 (Table 3) was significantly lower in group 3 (Fiberoptic group) (97.9 ± 1) compared to group 1 (C-MAC D-blade group) (98.67 ± 0.57) and group 2 (Airtraq group) (98.75 ± 0.63) without significant variance between C-MAC D-blade group and Airtraq group (Table 3).

	Group 1	Group2	Group3
Time (T1) to visualize the vocal cords (s)	14.25 ± 3.59**	12.25 ± 5.68***	29.77 ± 12.77
Time (T2) to tracheal intubation (s)	23.55 ± 3.63**	20.15 ± 6.95***	39.07 ± 13.27
Number of intubation attempts			
1	39	40	40
2	1	0	0
3	0	0	0
Number of successful trial (success rate)	40 (100%)	40 (100%)	40 (100%)
Manipulation	1 (bougie)	1 (external laryngeal pressure)	1 (manual protrusion of the tongue)
Complications			
- O_2 desaturation (SPO_2<90%)	0	0	0
- Trauma	0	0	0
- Bleeding			
Non	39	39	39
Trace	1	1	1
Moderate	0	0	0
Copious	0	0	0
- Bronchspasm	0	0	0
- Sore throat	45 ± 12.1(**)(*)	35 ± 12.6	33.2 ± 11.8
Lowest O_2 saturation	98.67 ± 0.57**	98.75 ± 0.63***	97.9 ± 1
*=P is significant (<0.05) between group 1 and 2 **=P is significant (<0.05) between group 1 and 3 ***=P is significant (<0.05) between group 2 and 3			

Table 3: Intubation Data.

MABP and HR (Figures 1 and 2) measured at one min and three min post intubation were significantly higher in group 1 (C-MAC D-blade group) compared to group 2 (Airtraq group) and group 3 (Fiberoptic group) without significant variances between group 2 (Airtraq group) and group 3 (Fiberoptic group). All groups showed insignificant variances regarding MABP and HR before induction, after induction, and five min post intubation.

Also all groups showed insignificant variances regarding SpO_2 before induction, after induction, and 1, 3, and 5 min post intubation (Figure 3).

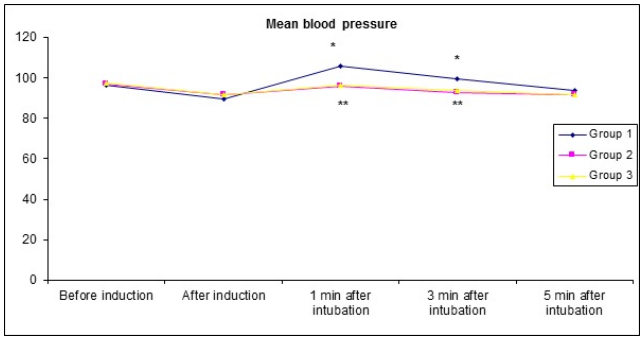

Figure 1: Mean blood pressure measured at different times in the 3 groups. Vertical line represents mean blood pressure reading (mean) and horizontal line represents time (*=P is significant (<0.05) between group 1 and 2 **=P is significant (<0.05) between group 1 and 3).

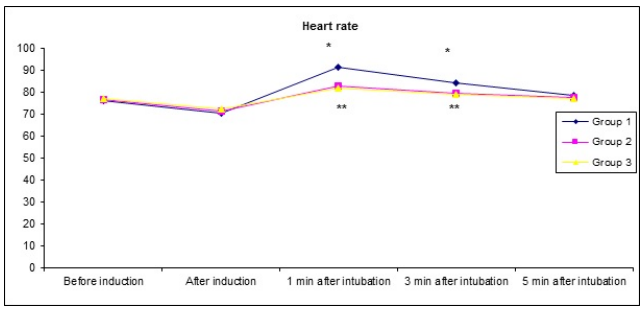

Figure 2: Heart rate measured at different times in the 3 groups. Vertical line represents heart rate reading (mean) and horizontal line represents time (*=P is significant (<0.05) between group 1 and 2 **=P is significant (<0.05) between group 1 and 3.

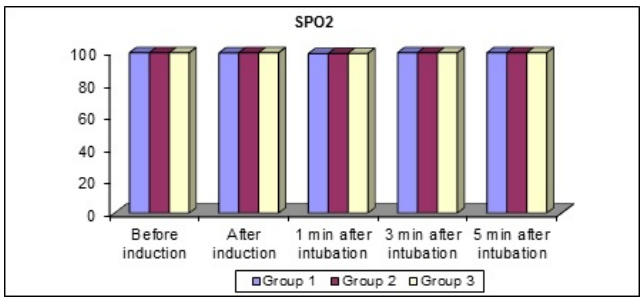

Figure 3: SpO_2 measured at different times in the 3 groups. Vertical line represents SpO2 reading (mean) and horizontal line represents time (No significant differences between groups).

Discussion

Difficult or unsuccessful intubation of the tracheal is an important cause of complications and death while practicing anesthesia [10] this leads to the invention of several instruments and devices to assist difficult intubation and decrease the complications. If the direct glottic view cannot be obtained, indirect laryngoscopes are found to be useful to the anesthesiologist to view the cords and increase the success of intubation [11] Various laryngoscopes (as C mac D-blade and Airtraq) were invented recently, which differ in shape and imaging technologies. Fiberoptic bronchoscope is the gold stander to deal with difficult intubation [4].

In this research we compared C-mac D-blade, Airtraq and Fiberoptic bronchoscope for tracheal intubation in patient predicted to have difficult intubation. Intubation of trachea is consisted of two main parts the first is to view the vocal cords the second is to insert the tube through vocal cord.

The main finding of our study is that T1 and T2 were significantly shorter in C-MAC D-blade group and Airtraq group compared to Fiberoptic group while C-MAC D-blade group showed insignificant variance compared to Airtraq group.

These variances in T1 and T2 between groups may be linked to the fact that the three instruments have different structure, shape, methods of insertion into oral cavity and intubation method i.e., outside in the C-MAC D-blade, a preloaded side channel in the Airtraq, and instrument inside the tube when using Fiberoptic bronchoscope. Also the D-blade of the C-MAC has angulation of 40 degree, this allows better visualization of the cords but also required the use of special stylet to facilitate intubation. Regarding Airtraq it has special optical system and its blade has special curvature and channel to accommodate tracheal tube, this allows the anestheiologist to intubate trachea without changing the axes of the airway. Fiberoptic bronchoscope required more manipulations and special skills to intubate trachea.

In this research, intubation of the trachea was performed in the first attempt in all patients except one patient in C-mac D-blade group who needed 2 attempts and boguie was used to aid intubation. One participant in every group needed additional manipulations other than that mentioned in patient and methods. Sore throat grade was significantly higher in group I compared to the other 2 groups.

The lowest O_2 saturation was significantly lower in Fiberoptic group compared to C-mac D-blade group and Airtaq group but this difference has no clinical significance.

The 3 groups showed insignificant variances regarding MABP and HR except at 1 min and 3 min post intubation where MABP and HR were significantly higher in group 1 in contrast the other 2 groups.

To our knowledge, the three instruments (C-MAC D-blade, Airtraq and Fiberoptic bronchoscope) studied in this trial were not formerly compared in studies, so this is the first study to compare the three instruments with each other.

Cavus E et al. used C-MAC D-blade for to intubate trachea (routine and difficult) and reported that the time needed to visualize the larynx in patient with difficult intubation ranged from 5 to 45 s (median time 11 s) and that needed for intubation ranged from 3 to 80 s (median time 17 s) [7]. Trachea was intubated in the 1st attempt in 14 patients, in the 2nd attempt in 1 patient, in the 3rd attempt in 3 patients, and in the fourth attempt in 2 patients. But Our results showed that time to visualize the vocal cords (T1) and time to tracheal intubation (T2) were 14.25 ± 3.59 and 23.55 ± 3.63 s respectively for group 1 (C-MAC D-blade group) and all patients except one (needed 2 attempts) were intubated in the 1st attempt.

Serocki G et al. [12] used C-mac D-blade for intubation of patients suspected to have difficult intubation and reported that laryngoscopy time was 10.8 ± 4.3 s and intubation time (time from touching the tube until cuff inflation) was 17.7 ± 9.7 s. They reported also that 84% of the participants were intubated from the first attempt, 13% from the second attempt, and 3% from the third attempt. The difference in intubation time in our study and Serocki ,s study may be due to the way of calculating intubation time (in our study (the time passed from introducing the device in the mouth until the tube passed the vocal cords) but in Serocki ,s study (time from touching the tube until cuff inflation)).

Kramer A et al. [13] compared Fiberoptic versus C-MAC D-BLADE for awake nasal intubation and concluded that the time to tracheal intubation was significantly shorter with C-MAC D-BLADE (38 s for D-BLADE *vs.* 94 s for Fiberoptic) and the 2 instruments showed insignificant variance regarding success rate. They showed that C-MAC D-BLADE was superior to Fiberoptic and this was similar to our results but the details were different as they used awake nasal intubation but we used oral intubation under general anaesthesia.

In their manikin study Maharaj CH et al. [14] compared Airtraq and Macintosh laryngoscope and reported that using the Airtraq to intubate trachea during difficult laryngoscopy scenarios was accompanied with less time and higher success rate.

Ali QE et al. [15] compared Airtraq and McCoy laryngoscopes and concluded that Airtraq showed shorter intubation time (28.73 ± 6.39 s) than McCoy laryngoscope (39.11 ± 14.01 s) during difficult laryngoscopy.

Maharaj CH et al. [5] compared Airtraq and Macintosh laryngoscopes for intubation expected to be difficult, and reported that Airtraq group showed that intubation time (mean (SD)); was 13.4 (6.3), 100% of participants were intubated (95% required one attempt and 5% required 2 attempts) lowest SPO_2 was 99.1 ± 0.9, the degree of hemodynamic (HR and mean arterial pressure) stimulation was less (as compared to Macintosh laryngoscopes) and complications were 0%.

McElwain J et al. [16] used C-MAC, Airtraq, and Macintosh laryngoscopes for intubation of patients whose cervical spines were immobilized and reported that Airtraq was used successfully to intubate all participants (97% required one attempt and 3% required 2 attempts). They also reported that laryngoscopy time and intubation time for Airtraq group were 11 (8-16) s and 19 (14-27) s respectively. Their results regarding laryngoscopy time and intubation time are close to our results.

McElwain J et al. in their manikin study reported that time required for the 1st intubation attempt with Airtraq in difficult intubation scenario was 22 ± 14 s (which is close to our result) [17].

Alvis BD et al. compared rigid and flexing laryngoscope (RIFL) and Fiberoptic bronchoscope (FOB) for intubation of patients whose airways were expected to be difficult and reported that time needed for intubation was significantly longer in FOB group compared to the RIFL group (64 *vs.* 49 s) [18]. Regarding lowest SpO_2 or airway trauma, the differences between groups were insignificant. In our study intubation time was 39.07 ± 13.27 s.

Langeron O et al. [19] used Fiberoptic bronchoscope for oral intubation of patients expected to have difficult intubation and reported that 92% of patients (45 patients) were intubated, time to tracheal intubation was 110 (75-175) s and intubation attempts number were 1 in 75% of patients (32 patients), 2 in 22% of patients (12 patients), and three in 3% of patients (1 patient). Adverse events were noticed in 8 out of 49 patients (SPO_2 less than 90% (5 patients), soft tissue trauma 2 patients, and bronchospasm 1 patient).

Abdelmalak BB et al. used flexible Fiberoptic scope to intubate obese patients and reported that time to tracheal intubation was 43 (26–96) s, hypoxemia occurred in 5% of patients, trace bleeding occurred in 3% of patients, sore throat appeared in 17% of patients, tracheal was intubated in the 1st attempt in the 86% of patients, in the 2nd attempt in 3% of patients, in the 3rd attempt in 1% of patients, and in the 4th attempt in 1% of patients [20].

Tong JL and his colleges [21] used Fiberoptic scope to intubate trachea and reported that both blood pressure and HR decreased after induction, then increased after intubation. Total intubation time (defined as: the time from mask removal to CO_2 detection by capnogrphy) was 35.1 (± 4.2) s.

There were a few limitations of this study. Firstly, blinding was impossible amongst the persons performing laryngoscopy. Secondly this study was executed by anesthesiologists with good experience in dealing with difficult airway and in using the studied devices. The results seen may vary in less experienced hands.

In conclusion when used for intubation of patients expected to have difficult intubation, both C-mac D-blade and Airtraq were comparable to each other but they showed advantage over Fiberoptic bronchoscope with shorter times to visualize vocal cords and to intubate.

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