Ergonomic Risk Assessment of Musculoskeletal Disorders During Simulated Endotracheal Intubation Using Direct Laryngoscopy and Video Laryngoscopy Among Doctors in Emergency and Trauma Department of a Teaching Hospital

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Abstract

Endotracheal intubation is one of the commonest procedures done in Emergency and Trauma Department but the association of different type of laryngoscopy on risk of musculoskeletal disease (MSD) on operator is still unclear. To determine the effect of direct and video laryngoscopy on risk of musculoskeletal disorders on operators. We conducted a cross-sectional manikin-simulated study among emergency medicine residents in a teaching university hospital in Kelantan, Malaysia. Rapid Upper Body Assessment (REBA) score was used to assess risk of musculoskeletal disorders among operators who performed direct and video laryngoscopy in a randomized manner. We recruited a total of 67 participants in this study. Direct laryngoscopy had a higher mean (SD) REBA score of 4.58 (1.68) and video laryngoscopy scored 1.98 (1.09) with p value <0.001. Based on this, risk of MSD is moderate with direct laryngoscopy and low with video laryngoscopy. There is significant increased risk of developing MSD in operators performing direct laryngoscopy as compared to video laryngoscopy.

Keywords:
Ergonomic, laryngoscopy, intubation, REBA score.

1. Introduction

The word ‘ergonomic’ originated from two Greek words, ‘ergon’ meaning work, and ‘nomos’, which means natural law with aim to optimize human well-being and system performance. In the medical field, ergonomic is still an under-researched area. The knowledge of ergonomics among health-care workers (HCW) is also limited and this leads to increase risk of musculoskeletal disorders (MSD) (Zakerian, et al., 2013; Shafiezadeh, 2011).

Emergency and Trauma Department (ETD) is an example of a working area that provides multiple different procedures which at times require awkward positioning of operators, use large amount of force and consumes a lot of time. Endotracheal intubation (ETI) is one of the life-saving procedures commonly performed but the effect of different aspects of it (table height, types of laryngoscopy, etc.) on risk of MSD on operators are still not fully explored.

In the wake of COVID-19 pandemic which is affecting a lot of countries, ETI is one of the managements employed especially in patients with severe diseases (Wang, et al., 2020). With increasing number of intubations needed to be performed, the risk of MSD among HCW also increases. With that introduction, we aim to investigate the effect of direct laryngoscopy (DL) and video laryngoscopy (VL) on risk of MSD among doctors working in ETD of a teaching hospital in Malaysia. With this study, we not only hope to add to the limited data and evidence available on effect of different type of laryngoscopy on risk MSD, but we also intend to find an ergonomic technique which can be used by health-care providers worldwide.

Primary objective
1. To compare REBA score of operators during endotracheal intubation using direct laryngoscopy and video laryngoscopy
2. To compare the risk of musculoskeletal disorders of operators during endotracheal intubation using direct and video laryngoscopy

2. Literature Review

According to International Ergonomic Association, ergonomic is defined as as the "scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design in order to optimize human well-being and overall system performance" (Karwowski, 2006).

In health care sector, improving ergonomics do not only benefit employer and employee but it also improves quality of health care delivered to patients. To the operating surgeons for example, improving operating table and chair height improves surgeons overall comfort allowing them to perform longer surgery better (Azimuddin, et al., 2017). To the organization, improving employer's ergonomics will result in less sick leave, improved productivity and lower health care coverage cost (Busse & Bridger, 1997). For the patients, if we take ETI for example, improving table height allows better laryngeal view resulting in higher chance of successful intubation at first attempt (Lee, et al., 2014). By doing so, risk of failed intubation, multiple attempts and airway trauma is decreased (Sakles, et al., 2013).

First introduced in 1995, Rapid Upper Body Assessment (REBA) score is a universal tool that can be used to evaluate risk of MSD (Hignett & McAtamney, 2000). It is a simple and easy to learn system whose result is reproducible. REBA score is a 3-parts scoring system whose final score would later define whether a work process is at very low risk, low risk, medium risk, high risk or very high risk of MSD. Based on these risk levels, it would suggest the urgency of intervention needed to be taken in order to improve the ergonomic of the said work process.

Endotracheal intubation (ETI) refers to the process of insertion of a definitive airway, usually in the form of a plastic tube called endotracheal tube (ETT) into the trachea of a patient. The main indications of ETI in emergency settings include; 1. Inability to maintain a patent airway (e.g. severe head trauma, angioedema) 2. Failure to oxygenate or ventilate (e.g. life threatening exacerbation of bronchial asthma or pulmonary embolism) 3. Expected clinical deterioration (e.g. severe metabolic acidosis, failure of non-invasive ventilation) (Walls & Murphy, 2008).

ETI can be performed by a lot of methods including direct laryngoscopy and video laryngoscopy. Direct laryngoscopy (DL) refers to direct visualization of the larynx of the patient and video laryngoscopy (VL) is a form of indirect laryngoscopy which visualizes the patient's larynx via a live camera-feed. Besides the method of laryngoscopy, there are different type of blades which in turn exist in different sizes available for use for each type of laryngoscopy. For example, Macintosh blade and Miller blade are available for direct laryngoscopy and for video laryngoscopy, there are Macintosh and hyper-angulated blades. Besides the devices, the method of operating both laryngoscopes are also different with VL requiring more exposure and training for the operator to be proficient with the device.

Since the emergence of corona virus disease 2019 (COVID-19) in late 2019, the number of severely ill patients is increasing resulting in increased number of patients requiring ETI and mechanical ventilation (Health, 2021). Besides this, intubation is also required by certain group of patients undergoing surgeries and procedures. Thus, finding a laryngoscopy technique which is ergonomic becomes a more important subject.

The literature available on ergonomic of intubation is however limited. Using REBA score, Grundgeiger et al compared these two methods of laryngoscopy and found VL is associated with lower risk of MSD among both novice and expert operators (Grundgeiger, et al., 2015). The force generated by these two methods were also

found to be different. In a simulated manikin study, the force generated by operator on mannikin's tongue peaked to 3.9 N when using Glidescope® VL as compared to 8.5 N with DL. (Russell, et al., 2012). However, when comparing force on different body parts in different simulated situations, CMAC® VL generated more force on the manikin's incisors (52 N) as compared to tongue (7 N) while DL generated lower force on the incisor's (26 N) with slight increase in pressure on tongue (12 N) (Nakanishi, et al., 2016). The author also found that these forces were further increased in situations with difficult intubation.

Height of the table in which patient is also important to the ergonomic of the operator and this table height should be individualized to suit personal needs. Wahab et al have previously demonstrated that positioning the patient at operator's sub-xiphoid level provided best ergonomic intubation environment (Wahab, et al., 2018). This height is not only ergonomic to operator but also resulted in optimum laryngeal view to increase first pass intubation success attempt (Lee, et al., 2014).

3. Methods

We conducted a cross-sectional observational study in a teaching university hospital in Kelantan, Malaysia. This centre was chosen as it is a training centre for Emergency Medicine speciality which also covers management of advanced airways in ill patients including DL and VL. The study took a period of 2 months and it was conducted in the simulation room of the ETD. This short study period was due to maximum number of participants was available during this time for intensive course for upcoming examination as we also had out-campus students in other states. Recruitment of participants from other hospitals was difficult due to central government COVID-19 movement control order. We recruited emergency medicine residents from Year 1 to Year 4 currently working in the department. For the sake of homogeneity of the sample, we excluded house officers, medical officers, specialists and consultants.

For our study, we included all consented emergency medicine residents from Year 1 to Year 4 in the said university. We excluded those residents with history of or active ongoing musculoskeletal issues which may limit their movement during the study and those who had no previous experience with handling the video laryngoscopy. Participation was voluntary and no sampling method of participants was done. Sample size was calculated using a sample size calculator (Ariffin, 2017). The conventional significance level (α) of 0.05 used and power of the study was set at 80%. The mean, standard deviation and proportion of outcome variables were referred from the literature. By using Grundgeiger et al study as reference, the sample size calculated was 67 (Grundgeiger, et al., 2015).

A pre-designed data collection form was used to collect data needed for the study. Equipment used were; a. A Laerdal intubating mannikin, b. An adult size bag valve mask (1.5L) with reservoir and a mask (BVM), c. A Macintosh direct laryngoscope with Macintosh blade size 3, d. A CMAC® video laryngoscope with Macintosh blade size 3, d. A disposable endotracheal tube size 7.5 (ETT), e. A 10cc syringe, f. A pliable stylet, size 10 Fr (3.3mm), g. Lubricating gel, h. Bed with adjustable height, i. A stop watch and j.2 digital cameras with stand.

We defined endotracheal intubation (ETI) as placement of a definitive airway, ETT, into the trachea of the mannikin (Walls & Murphy, 2008). We defined direct laryngoscopy (DL) as direct visualization of larynx. For this study, we used direct laryngoscope with Macintosh blade size 3. We defined video laryngoscopy (VL) as indirect visualization of larynx through a life feed video. For this study, we used CMAC VL with Macintosh blade size 3.

Following approval by the university ethical body, participants were recruited by voluntary basis. In order to curb the spread of COVID-19, safety precautions were taken including temperature and symptoms check, keeping a log of participants, limiting number of individuals present at a particular time in the simulation room, compulsory use of face mask and hand sanitizer pre and post study.

All participants were given brief introduction to the study and given a 10 minutes period to familiarize themselves with the equipment to be used. For the record, all our participants were familiar with both type of laryngoscopies especially CMAC VL as this device was used frequently in the department.

Two cameras were used with first camera placed on the left-hand side of the operator to record the posture of the participant from the lateral side and second camera was placed on the 90° to the first camera to record from posterior side.
Manikin was placed at the head end of the table. The height of table was adjusted so that the face level of the manikin is at the xiphoid process level of the operator in standing position. This height was individualized according to each operator. Movement of neck of manikin was not limited and no difficult scenarios were

applied. Laryngoscopes were placed on the left-hand side of the operator (monitor of the VL was also on the left-hand side) and ETT was positioned on the right-hand side. An assistant was provided and stood on the right-hand side of the operator to assist during the whole process.

As participation was voluntary and blinding to device was not possible, randomization of order of intubation was done in order to decrease performance bias (Allen, 2017). A freely available online randomizer programme was used to create a list to decide on the order of intubation (Urbaniak & Plous, 1997). Thus, participant either intubated with DL first followed by VL or VL first followed by DL.

Participants started from manual ventilation position and proceeded to intubation until confirmation of correct ETT placement was done by manual ventilation. Throughout the process, the two cameras recorded the posture of the operator during the whole event. Participants were given 5-10 minutes rest in between before proceeding to the remaining laryngoscopy technique.

Video analysis was done following completion of study. The video at which the operator was passing the ETT was frozen and analysed. REBA score sheet was used as reference and goniometer was used to measure angulation of the concerned body parts. Any ambiguity was resolved by consulting a second person who was also well versed with REBA scoring. Based on final REBA score, the risk of MSD was later determined.

Statistical analysis was done using Statistical Package for the Social Sciences (SPSS) version 26.0 Paired t-test was used for analysis of REBA score in both groups.

4. Results

In total, we managed to enrol 67 participants. The mean age of our participants was 33.4 (1.77) years. 36 participants where females with remaining 31 participants were males. Out of 67 participants, 20 participants were Year 1 residents, 24 were Year 2 residents, 9 were Year 3 residents and remaining 14 were Year 4 residents. The mean working experience of our participants was 5.90 (1.72 years) (Table 1).

Following random assignment of intubation, we had 33 participants who performed DL first followed by VL with remaining participants performed VL first followed by DL (Table 2).

Table 1. Participant's demographics and characteristics (n = 67)

Variable	n (%)	Mean (SD)
Age (years)		33.42 (1.77)
Gender		
Male	36 (53.7)	
Female	31 (46.3)	
Post graduate year		
Year 1	20 (29.9)	
Year 2	24 (35.8)	
Year 3	9 (13.4)	
Year 4	14 (20.9)	
Working experience (years)		5.90 (1.72)

Table 2. Participant's order of intubation

Order of intubation	n (%)
Direct laryngoscopy followed by video laryngoscopy	33 (49.2)
Video laryngoscopy followed by direct laryngoscopy	34 (50.8)

Figure 1-4 showed the example of posture of some of our participants when performing DL and VL. Figure 1 and 2 showed the posture attained by 1 of our participants during DL and figure 3 and 4 were the posture attained during VL. Note the striking difference in neck and trunk posture during DL which were more flexed as compared to that during VL.

Figure 1. Lateral view during direct laryngoscopy

Figure 2. Posterior view during direct laryngoscopy

Figure 3. Lateral view during video laryngoscopy

Figure 4. Posterior view during video laryngoscopy

Table 3 showed the REBA score of DL and VL. Direct laryngoscopy had mean REBA score of 4.58 (1.68) while video laryngoscopy had mean REBA score of 1.98 (1.09). Using paired t-test, VL had statistically significant lower REBA score with p value <0.001. Based on these mean REBA scores, DL recorded moderate risk of MSD while VL recorded low risk of MSD.

Table 3. Comparison of mean REBA score during endotracheal intubation

Variable	Mean (SD)		Mean difference (95% CI)	t-statistics (df)	p-value
	Direct laryngoscopy	Video laryngoscopy			
REBA score	4.58 (1.68)	1.98 (1.09)	2.66 (2.22, 3.09)	12.22 (66)	<0.001

*paired t-test

5. Discussion

Our study studied the effect of two different type of laryngoscopy techniques, DL and VL on risk of MSD on operators. Based on our study, there was significant difference in risk of MSD between these two techniques. DL recorded higher mean REBA score as compared to VL and the difference was statistically significant. Co-relating the final REBA score and risk of MSD, DL had moderate risk of MSD while VL had low risk of MSD.

When we compare the captured images of DL and VL, we found that in DL, our operators tend to bend their trunk and neck in order to view the larynx better. This was followed by bending of lower limbs in order to lower body position. Awkwardly, there was also tilting and twisting of trunk among some of the operators. The upper arm had more angulation as compared to lower arm. Overall, these postural changes resulted in higher individual component score and ultimately higher REBA score and risk of MSD.

As compared to DL, operators that performed VL tend to have a more erect and straight neck, trunk and lower limbs positioning. This was coupled with upper arms brought closer to trunk but at the expense of lower arm having to be bent more in order to correctly positioned the laryngoscope. Although there was minimal neck flexion, there was neck angulation in order to look at the screen of the video laryngoscope. Ultimately these striking different in posture resulted in lower REBA component scores and lower risk of MSD.

The finding of our study is similar to another study published earlier. The study concluded that VL scored lower mean REBA score as compared to DL. The author also found that in both novice and expert operators, VL improved mean REBA score (Grundgeiger, et al., 2015). The risk of MSD in our study is similar to the expert group in this study.

The mean REBA score in our DL is higher as compared to another study even though the manikin was positioned at the same height (Wahab, et al., 2018). This difference may be due to methodological difference. In our study, the use of two cameras allowed better recording of posture from different views.

It is interesting to note that although both Emergency Medicine and Anaesthesia Departments deal with intubation frequently, the posture attained by personnel from both disciplines are different. Anaesthesia doctors tend to adopt a more erect posture even when performing DL as compared to our participants who had a more crouched position (Walker, 2002).

The use of manikin in our study was acceptable although manikin may not always represent true human anatomy of the upper airway (Schalk, et al., 2015; Schebesta, et al., 2012). The studies concluded which such differences, the outcome of trials may be affected. It is however noteworthy that in ETD, the nature of ETI is almost always emergency and the protection of operators against infectious aerosol droplets in the era of COVID-19 is of utmost importance.

To this date, the amount of data available to look into ergonomic of laryngoscopy is limited. It is interesting to see in the future if we have more data and comparisons can be made more accurately. Besides technique of laryngoscopy, table height, experience, level of airway difficulties and numerous other factors may affect the ergonomic of operators.

The strength of our study was the use of two cameras which allowed detailed analysis of participant's posture from two different views. This resulted in better analysis and more accurate marking of the posture. There are few improvements that can be made for future study. These include blinding of purpose of the study to the participants so that they will perform more naturally and use of actual patient instead of manikin.

6. Conclusion

We concluded that direct laryngoscopy recorded a higher mean REBA score and higher risk of MSD. Thus, it is less ergonomic as compared to video laryngoscopy. Thus, we recommend the use of VL among doctors and paramedics in all departments which deal with intubation day in and day out. VL do not only improve ergonomics and lower risk of MSD, it also improves success rate of ETI and decrease direct exposure of operators to infectious aerosol droplets during the process. This way, we do not only protect our health care providers, we also improve the quality of healthcare delivered to our patients.

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