REVIEW ARTICLE

A review of hemodynamic response to the use of different types of laryngoscopes

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ABSTRACT

Endotracheal intubation is the gold standard in airway management either as a means to administer general anesthesia or for mechanical ventilation in critically ill patients for protecting the airway when the airway reflexes are dysfunctional. Macintosh laryngoscope is the standard laryngoscope used for intubation though advances in science have resulted in development of laryngoscopes of different designs. The process of laryngoscopy and intubation (L&I) can result in significant hemodynamic response and this is a topic of debate and research in anesthesia. A comprehensive review of hemodynamic responses to various laryngoscope designs has been undertaken here. Tracheal intubation contributes to more hemodynamic response compared to laryngoscopy alone. The hemodynamic responses to L&I are exaggerated in the elderly and those with uncontrolled hypertension. Orotracheal intubation causes less hemodynamic response as compared to nasotracheal intubation. Laryngoscope design, duration of L&I and the forces applied on the laryngoscope all contribute to hemodynamic fluctuations. McCoy blade and videolaryngoscopes where L&I can be performed without the aid of stylets provide better attenuation of hemodynamic response compared to intubation using the Macintosh laryngoscope. Fibreoptic orotracheal intubation with the aid of combined lingual traction and jaw thrust maneuver provides superior attenuation of hemodynamic response compared to use of laryngoscope.

Key words: Airway Management; Laryngoscopy; Laryngoscopes; Intubation; Intratracheal; Cardiovascular Physiological Phenomena; Hemodynamics; Stress; Physiological; Physiological Stress Reaction

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INTRODUCTION

Endotracheal intubation (ETI) is well recognized to be the gold standard in airway management to administer general anesthesia (GA). The indications for mechanical ventilation in critically ill patients include relieving airway obstruction, respiratory failure, prevent aspiration, airway protection, etc. The Macintosh laryngoscope is the standard laryngoscope used for ETI though advances in science have resulted in the development of several laryngoscopes of different designs.[1,2,3] The process of laryngoscopy and intubation (L&I) can result in significant hemodynamic response and therefore, limiting or taming this response is a topic of debate and research in anesthesia.

The hemodynamic response to L&I is regulated by the hypothalamo-pituitary-adrenocortical and sympathetic adreno-medullary response.[4] As a result of which there is secretion of cortisol, norepinephrine and epinephrine. The consequence of this neuro–endocrine system may vary from milder problems such as tachycardia, hypertension and occasional dysrhythmias to life threatening problems such as angina, myocardial infarction, stroke, *etc.* The hemodynamic response to L&I was first enunciated by King *et al* in 1951, although ETI was being practiced since its inception into anesthetic practice by Rowbotham and Magil in 1921.[5,6]

Prior to the invention of muscle relaxants, the hemodynamic response to L&I was little known, probably because the patients were intubated under deep cyclopropane or ether anesthesia and may be

their cardiovascular responses were obtunded due to much deeper planes of anesthesia that were necessary to render the patient immobile during the surgical procedure in the absence of neuromuscular blockade. Further, the monitoring for the hemodynamic response also was suboptimal. Shortly after the introduction of d-tubocurarine, there was a considerable change in the scenario as the hemodynamic response to L&I started becoming obvious due to considerable decrease in the depth of the anesthesia with regular use of neuromuscular blockade. It was also recognized that simply increasing the anesthetic depth afforded considerable protection from these responses.[6]

Several drugs have been used, different laryngoscope designs have evolved and anesthetic techniques have been modified to attenuate these reflexes. A comprehensive review of hemodynamic responses to various laryngoscope designs has been undertaken here.

Literature search: Systemic search of literature was done using key words; laryngoscopy response; ETI and response; hemodynamic response and intubation; sympathetic response and laryngoscopy or intubation; laryngoscopes and hemodynamics; and pressor response and laryngoscopy or intubation. We have also attempted to search articles using names of various types of laryngoscopes in association with hemodynamic response/pressor response/intubation response.

Hemodynamic response and the receptor location:

Mechanical stimulation of the upper respiratory tract, mainly: the nose, the epipharynx, and the tracheobronchial tree induce reflex cardiovascular responses associated with enhanced neuronal activity in cervical sympathetic efferent fibres. While stimulation of the epipharynx elicits maximum response, tracheobronchial tree elicits least response.[7] Cardiovascular response to ETI is initiated by glossopharyngeal nerve (stimulus superior to anterior surface of epiglottis) and by vagus nerve (stimulus below posterior epiglottis down into the lower airway). Hemodynamic response to L&I results in diffuse autonomic response with a widespread release of norepinephrine from adrenergic nerve terminals and secretion of epinephrine from adrenal medulla along with activation of the renin angiotensin system.[8]

Physiology of hemodynamic response:

This is maximum at approximately 30-45 seconds after L&I.[9] Blood Pressure (BP), Heart Rate (HR), plasma adrenaline, noradrenaline and vasopressin concentrations increase slightly in response to L&I; all returning to baseline within 5 min with no change in angiotensin converting enzyme activity in normotensives. However, a three-fold increase in plasma noradrenaline levels which returned to baseline nearly 10 minutes following L&I was observed in hypertensives. Further, an increase in plasma adrenaline level was observed in hypertensives 1 minute after laryngoscopy. [10,11,12,13]

Effects of hemodynamic responses on organ systems:

A rate pressure product (RPP) in excess of 11000 has been associated with signs of myocardial ischemia in patients with coronary artery disease.[14] Sudden increase in blood pressure may cause rupture of aortic / cerebral aneurysm, increase cerebral blood flow due to increased cerebral metabolic activity and systemic cardiovascular effects, dysrhythmias, transient increase in choroid blood flow which can force vitreous gel forward into the anterior chamber during open eye surgery or can increase intraocular pressure in an intact eye[15]. The normal autoregulation mechanism may not be effective because of disease. Patients with raised intracranial pressure who have minimal reserve in intracranial compliance are at a risk for brainstem herniation and sudden death during L&I[16].

Hemodynamic response in relation to age

In infants and small children, response may manifest initially as bradycardia owing to an increased vagal tone.[8] In geriatric patients, SBP and MAP increased significantly though the tachycardia response was less severe as the age advanced which was attributed to impaired β response with normal β responsiveness. It was also noted that the mean plasma norepinephrine concentrations were significantly less in the elderly.[17]

Effect of force applied, duration and number of attempts

Various forces applied onto a Macintosh laryngoscope (the forces acting along the axis of the handle, as well as forces exerted by anesthetist to prevent the laryngoscope from turning) were studied for their influence on hemodynamics. A modified laryngoscope was designed to measure these forces and four different parameters were determined:

1. The duration of laryngoscopy
2. The maximally applied forces
3. The mean force
4. The integral of the force over the time (area under the curve)

The duration of laryngoscopy, the forces applied parallel to the axis of the handle and the increased stretching of the tissues were found to be responsible for the hemodynamic changes.[18,19]

HEMODYNAMIC RESPONSE TO VARIOUS LARYNGOSCOPES (TABLE 1)

Miller and McCoy Laryngoscope

When the stress response during laryngoscopy without intubation was compared among Macintosh, Miller and McCoy laryngoscopes, the maximum response was obtained with the use of Miller and minimum response with the McCoy laryngoscope. The tip of the Miller's blade which is inserted posterior to the epiglottis stimulating the vagus, causes maximum response.[20]

In order to get a superior glottic view at first attempt itself, the McCoy laryngoscope was designed. The design of the blade of this laryngoscope is such that the tip of the blade though rigid is mobile which can be lifted up using a lever available at the handle of the laryngoscope. When a poor view of glottis is obtained despite best efforts at laryngoscopy, the laryngoscopist presses this lever which results in the epiglottis being lifted away due to upward movement of the tip of the laryngoscope, contributing to better view of the glottis. The stress response to laryngoscopy appears to be less marked with the McCoy blade probably due to a reduction in the force necessary to obtain a clear view of the larynx.[21,22]

Intubating Laryngeal Mask Airway (ILMA)

ILMA guided orotracheal intubation does not distort the base of the tongue or directly stimulate the receptors of the larynx. In patients undergoing coronary artery surgery, a significant decrease in mean norepinephrine concentration was observed with both ILMA guided intubation and L&I. However, this drop was more marked in the patients intubated via ILMA than in patients undergoing direct laryngoscopy. RPP showed similar response. Similar results were obtained by Garg *et al*. But the trial conducted by Sener *et al* failed to attenuate the hemodynamic response with the use of ILMA, where, in contrary, there was higher response. The longer duration, repeated airway manipulation, stimulation of supralaryngeal area which is rich in nociceptive receptors, removal of ILMA and using stabilizing rod to advance the tracheal tube may have induced greater pressor response in these patients. [23,24,25]

Fibreoptic Intubation:

The fibreoptic endoscope enables the visualization of the glottis with minimum force, but the need of maneuvers or instruments to clear the airway result in hemodynamic response.

Hemodynamic response was found to be more severe with the use of Macintosh laryngoscopy as an aid for fibreoptic orotracheal intubation as compared to a combined maneuver of lingual traction and jaw thrust. Factors like prolonged tracheal stimulation, jaw thrust maneuver in fibreoptic intubation and external neck manipulation also contribute to the hemodynamic response. Effective suppression of hemodynamic response was achieved by combining fibreoptic intubation with 4% lidocaine spray of the larynx and glossopharyngeal nerve block. [26,27] But the study by Aghdaii *et al*. showed no advantage with the use of fibreoptic scope for intubation in patients undergoing coronary artery bypass graft (CABG).[28]

Nasotracheal Intubation

The hemodynamic response after nasotracheal intubation is significantly greater than that after orotracheal intubation as there would be considerable stimulation of the irritant receptors in the nostrils.[29]

Videolaryngoscopes (VLS)

The VLS have been introduced in 2002 to aid the intubation without the need for the alignment of oral, pharyngeal and laryngeal axes. In most of the VLS the blades have been angulated to enhance the visualization of the glottis. This necessitates the use of stylet or laryngeal manipulation to aid the successful intubation. The use of stylet or laryngeal manipulations has been shown to increase the hemodynamic response.

Glidescope

The Glidescope that consists of a blade with 60ª curvature and a handle in one piece does not require alignment of oropharyngeal axis to visualize the vocal chords. The laryngoscope is devised in such a way that less upward lifting force is required during L&I thereby reducing the stimulus on to the oropharyngeal structures.[30] However, some studies failed to show the advantage of Glidescope compared to Macintosh in attenuating stress response to intubation as manipulation due to stylet in Glideview laryngoscopy resulted in higher stimulus offsetting the advantage.[31,32] When the technique of intubation was standardized with the use of stylet in both groups, the hemodynamic response was found to be similar in Glidescope, trachlight and direct laryngoscopy groups. Authors opined that the hemodynamic response was mainly because of tracheal irritation rather than laryngeal irritation.[33] In studies where the hemodynamic response was more in the Glidescope compared to Macintosh, the cause was attributed to either longer time of intubation or as a result of less expertize or due to response to endotracheal tube in trachea.[34] Glidescope VLS is a better option in patients with untreated hypertension.[35] The hemodynamic response to intubation were similar with both the Glidescope and the McGrath VLS.[36]

Pentax-AWS

A VLS with anatomically shaped blade provides high

Table 1: Hemodynamic response and various laryngoscopes

Serial No.	Author Year Country	Design	Sample size	Airway	Results	Reasons cited
1	McCoy EP et al 1995[22] Belfast	RCT	Macintosh N=10 McCoy N=10		Stress response to laryngoscope with McCoy was less compared to Macintosh	McCoy requires less force than Macintosh for visualization of larynx
2	Garg S et al 2003[23] India	RCT	Macintosh N=40 Intubating LMA N=40	Patients with restricted mouth opening were excluded	Less pressor response on ETT insertion using ILMA compared to the conventional laryngoscope	
3	Sener EB et al 2012[24] Turkey	RCT	ILMA N=21 Macintosh N=21	Patients with difficult intubation were excluded	The SBP, DBP and RPP was higher in ILMA group	The intense and repeated oropharyngeal and tracheal stimulation resulting from ILMA induces greater pressor response
4	Kavitha J et al 2011[25] India	RCT	ILMA N=30 Macintosh N=30		ILMA offers no advantage in attenuating the hemodynamic response compared to direct laryngoscope	Direct laryngoscopy is comparatively a faster method to secure tracheal intubation when compared to ILMA
5	Aghdaii et al 2012[28] Iran	RCT	Direct laryngoscope N=25 Fibreoptic scope N=25			Fibreoptic intubation has no advantage in attenuating hemodynamic response to intubation in patients undergoing CABG
6	Pournajafian AR et al 2014[34] Tehran	RCT	Macintosh N=53 GlideScope®VLS N=53	Airway up to Mallampati class III	No significant difference between the two groups in hemodynamic response	Longer intubation time using GlideScope®VLS
7	Dashti et al 2014[35] Iran	RCT	GlideScope®VLS N=30 Macintosh N=29	Normal airway	Hemodynamic changes during tracheal intubation were less significant with GlideScope® than Macintosh	Upward lifting force required to expose the glottis is much less with GlideScope®
8	Woo et al 2012[43] Korea	RCT	Pentax AWS®VLS N=50 Macintosh N=50	Burns patients up to Mallampati class III	Less increase in hemodynamic response with Pentax-AWS®VLS compared to Macintosh	Pentax AWS®VLS requires less force to lift structures in oral cavity to expose the glottis
9	Heeseung Lee et al 2013[42] Korea	RCT	Pentax AWS® N=20 Macintosh N=20	Normal anatomy	Pentax AWS® provides greater hemodynamic stability during tracheal intubation compared to Macintosh	Pentax AWS® causes minimal displacement of the tongue and other soft tissue of airway structures
10	Ko et al 2012[45] Korea	RCT	Optiscope™ N=30 Macintosh N=30	Mallampati class IV excluded	Optiscope™ does not modify hemodynamic response.	Optiscope™ provides better view of the vocal cords though there is no benefit on hemodynamic response
11	Koh et al 2010[47] Seoul	RCT	Airtraq N=25 Macintosh N=25	Mallampati class IV were excluded	Hemodynamic changes were not significantly different between the two groups	
12	Kitamura et al 2001[49] Tokyo	RCT	StyletScope N=13 Macintosh N=11		StyletScope caused less hemodynamic response compared to Macintosh	The stimulus from direct laryngoscopy is eliminated
13	Kanchi et al 2011[44] India	RCT	Macintosh N=15 Pentax AWS VLS		No difference in the hemodynamic response	Time taken for intubation using VLS was longer
14	Maassen RL et al 2012[57] Netherlands	RCT – cross over	VLS Vs Conventional laryngoscope		Hemodynamic responses during endotracheal intubation using VLS was less compared to direct laryngoscopy	

RCT=Randomized control trial; VLS= Videolaryngoscope;N=number; ETT= endotracheal tube; LMA= laryngeal mask airway; ILMA= intubating laryngeal mask airway; SBP=systolic blood pressure; DBP=diastolic blood pressure; RPP= rate pressure product; CABG=coronary artery bypass graft; AWS= airway scope

resolution image of the glottis. [37] It requires considerably less lifting force during laryngoscopy with this device and hence it causes less movement of the upper cervical spine with minimum displacement of the tongue and other soft tissues of the airway structures.[38,39,40,41] Pentax– AWS provides greater hemodynamic stability than Macintosh blade laryngoscope and seems to be a safe alternative especially for patients susceptible to hemodynamic stress and for patients with severe burns.[42,43] The use of Pentax AWS did not provide any benefit in attenuating hemodynamic response to L&I in patients undergoing primary coronary artery bypass graft surgery.[44]

Optiscope

It is a semi rigid fiberscope with adjustable angle tip. Although ETI performed using Optiscope gave a better view of vocal cords, it did not modify the hemodynamic response.[45]

Airtraq ® Optical Laryngoscope

It is a single use rigid VLS that has been used to intubate patients with normal and difficult airways. It incorporates video or fibreoptic imaging into the blade or stylet and hence provides an improved glottis view without the need for alignment of oral, pharyngeal and laryngeal axes. The Airtraq ®optical laryngoscope resulted in clinically negligible rise in heart rate while the blood pressure was not affected. [46]Airtraq® also produces a superior laryngeal view over the Macintosh laryngoscope in patients with Philadelphia collar without any difference in hemodynamics or intubation time.[47]

StyletScope

It is a fibreoptic intubation device with a lightweight stylet, maneuverability of the distal tip, a built in light source. Distal tip of the stylet, together with the ETT, can be flexed 75 degree anteriorly. The intubation with StyletScope does not require direct laryngoscopy. Hence the Stylet Scope caused less hemodynamic response compared to Macintosh laryngoscope.[48, 49]

C-MAC VLS

This VLS has an original standard Macintosh blade shape, but with a flat proximal finish. Force applied on the maxillary teeth is minimum. The less force applied to lift the epiglottis should theoretically cause less hemodynamic response. However the study by Sarkilar *et al.* showed similar response in both C-MAC and Macintosh intubation. The author attributed the results to the use of various anesthetic agents. [50]

Truview VLS

Truview EVO2 laryngoscope has an integrated optical lens system with unique angulated blade which provides optimal indirect view of the glottis. The hemodynamic response was less with Truview [PCD] when compared with Macintosh in the study by Bag *et al.*[51]

McGrath Series 5 VLS

McGrath Series 5 has a video camera with angulated blade and a light source at the end of the blade. Although this VLS provides better glottis view compared to the Macintosh laryngoscope, there was significant hemodynamic response to L & I with both Macintosh and McGrath Series in the study by Arici *et al.* in obstetric patients. [52] The study by Gupta *et al.* comparing Macintosh with McGrath VLS did not show any benefit with the use of McGrath VLS in attenuating the hemodynamic response in patients with normal airway.[53]

When the hemodynamic response in patients with normal airway, undergoing coronary artery bypass grafting (CABG) were compared among Truview PCD™, McGrath® and Macintosh, the VLS did not provide any advantage over the Macintosh laryngoscope. The VLS is usually introduced into the center of the mouth unlike the conventional Macintosh laryngoscope. This reduces the space available to insert the ETT, necessitating additional maneuvers to negotiate the tube. This also prolongs the time for intubation. These factors might neutralize the advantages provided by the VLS such as less lifting force needed to obtain a good view of the glottis.[54]

However the hemodynamic response with GlideScope VLS showed promising results when compared with fibreoptic scope and Macintosh laryngoscope.[55]

In the study by Tsai *et al.* where they compared the hemodynamic response of the Airway Scope®, Glidescope and Macintosh laryngoscopes, the response was less with the Airway Scope®. Although the intubation time was significantly longer with Airway Scope® and Glidescope, when compared to the Macintosh, the authors attributed the result to the more invasiveness of the Glidescope laryngoscope. [56]

Optical Stylets

Various optical stylets have been used to ease intubation. Rigid optical stylets include bonfils, Levitans FPS where the operator can look through the ocular, like in a fiberscope and observe the entrance to larynx. Bonfils intubation endoscope is a semi-rigid optical stylet, 40 cm in length with a fixed anterior curvature of its tip of 40[a]. Flexible fibreoptic intubation and the bonfils rigid endoscope guided intubation require a similar time for successful orotracheal intubation and cause a similar magnitude of hemodynamic response in female adults under general anesthesia.[58]

The hemodynamic response to intubation using the Levitan FPS device was greater than that of the Lary-Flex rigid videolaryngoscope. The authors implicated this to the use of Macintosh laryngoscope while using the Levitan FPS device. [59]

CONCLUSION

Tracheal intubation contributes to more hemodynamic response compared to laryngoscopy alone. The hemodynamic responses to L&I are exaggerated in the elderly and those with uncontrolled hypertension. Orotracheal intubation causes less hemodynamic response as compared to nasotracheal intubation. Laryngoscope design, duration of L&I and the forces applied on the laryngoscope all contribute to hemodynamic fluctuations. McCoy blade and videolaryngoscopes where laryngoscopy and intubation can be performed without the aid of stylets provide better attenuation of hemodynamic response compared to intubation using the Macintosh laryngoscope. Fibreoptic orotracheal intubation with the aid of combined lingual traction and jaw thrust maneuver provides superior attenuation of hemodynamic response compared to the use of laryngoscope.

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