

Haemodynamic response to laryngoscopy with and without tracheal intubation

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SAJAA 2008; 14(3): 23-26

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ABSTRACT

Introduction

Tracheal intubation is accompanied by an increased blood pressure and heart rate. The aim of this study was to find the most important source of this haemodynamic response, namely laryngoscopy or intubation.

Method

A standard induction technique was used for all patients. Eighty patients were randomly allocated to one of two groups, one group to undergo laryngoscopy followed by intubation (Group I), and the other laryngoscopy only of duration similar to intubation (Group L). Blood pressure and heart rate were recorded in the ward, before induction of anaesthesia and one, two, three, and four minutes after instrumentation.

Results

The instrumentation times did not differ significantly ($p = 0.20$). Over time mean arterial pressures were significantly higher in Group I than in Group L ($p = 0.038$). Over time the ratios of mean blood pressure and heart rate relative to the preoperative heart rate were significantly greater in Group I than in Group L ($p < 0.01$).

Conclusion

Blood pressures and heart rates were significantly greater after laryngoscopy followed by intubation than after laryngoscopy of the same duration not followed by intubation. The induction technique, consisting of lignocaine, alfentanil, and propofol, may have attenuated expected increases in blood pressure but not increases in heart rate after intubation.

Introduction

Tracheal intubation is one of the most important procedures in anaesthetic practice. Laryngoscopy with intubation is known to have profound cardiovascular effects, namely increased blood pressure, heart rate, and catecholamine levels. This haemodynamic response, known as the intubation response,¹ may be associated with detrimental effects and should be blunted, especially in the presence of cardiovascular and cerebrovascular disease.^{2,3}

Many studies treat laryngoscopy and intubation as a single stimulus. A better understanding of the source and characteristics of the intubation response should lead to more effective prevention thereof. The aim of this study was to find the major source and pattern of the intubation response. The hypothesis was that the haemodynamic response to intubation following laryngoscopy does not differ from the response to laryngoscopy of similar duration that is not followed by intubation.

Patients and methods

This was an experimental, randomised, single-blinded study. Written informed consent was obtained from all participants. Eighty ASA I and II patients aged 18 to 65 years scheduled for elective surgery and requiring general anaesthesia with tracheal intubation were recruited. The following exclusion criteria were applied: body mass index (BMI) ≥ 35 kg/m², Mallampati grade \geq III, facial features that clinically predicted a difficult laryngoscopy, cardiovascular medication, hypertension, delayed gastric emptying, a history of gastro-oesophageal reflux, and asthma. Patients

were randomised (using the closed envelope technique) into two groups: Group L (Laryngoscopy group) and Group I (Intubation group).

Patients were pre-oxygenated for one minute followed by lignocaine 1.5 mg/kg, alfentanil 15 μ g/kg, propofol 2 mg/kg, and rocuronium 0.5 mg/kg. Induction was followed by manual ventilation with isoflurane in oxygen and air to a MAC of 1.5. Laryngoscopy was done after adequate muscle relaxation (Train of Four = 0).

Duration of intubation (Group I) or laryngoscopy (Group L) was recorded from insertion of the laryngoscope blade into the mouth to the time that the blade was removed. We have previously determined the time required for laryngoscopy and intubation to be of the order of 10 seconds. Therefore, if intubation or visualisation of the vocal cords took less than 10 seconds, the blade was kept in position for a minimum of 10 seconds.

Blood pressure and heart rate were recorded in the ward. In the operating room these measurements were made prior to induction of anaesthesia and thereafter at one-minute intervals after airway instrumentation (at 1, 2, 3, and 4 minutes after intubation or laryngoscopy), using a Datex S/5 monitor (Datex Ohmeda, Instrumentarium, Helsinki, Finland). In Group I these measurements were made after intubation. Group L patients were ventilated by mask after airway instrumentation for four minutes, during which time the data were gathered prior to endotracheal intubation.

The required sample size was calculated from previous similar studies¹⁸ to detect a difference in haemodynamic response accepting an alpha-error of 5% ($p < 0.05$). A sample size of 40 in each group rendered a power of 95% to detect a difference in change in mean arterial pressure of 10 mm Hg between Group L (mean change of 25 mm Hg) and Group I (mean change of 35 mm Hg), assuming a standard deviation of 12 mm Hg.

Intra-operative mean blood pressures (MBP) and heart rates are expressed as *ratios relative to preoperative* values. Data are summarised by means, standard deviations, and 95% confidence intervals of the differences between groups. Statistical analysis employed the Statistix Version 8 statistical software (Analytical Software, Tallahassee, USA). In an appropriate repeated analysis of variance (ANOVA), groups were compared in the between subject component of the ANOVA, times were compared in the within subject component of the analysis, while the interaction between groups and times was also tested for. Specific differences between the times of measurement (from preoperative to 4 minutes after instrumentation) were assessed from pairwise comparisons by making use of Fisher's least significant difference procedure.⁴ Further to the latter an analysis of covariance (ANCOVA) was done to determine if age, body mass, and Cormack Lehane grade⁵ were covariates. In the presence of interaction groups were compared at each time using Student's two-sample t-test. Categorical data were compared using the two-sided Fisher's exact test.

Results

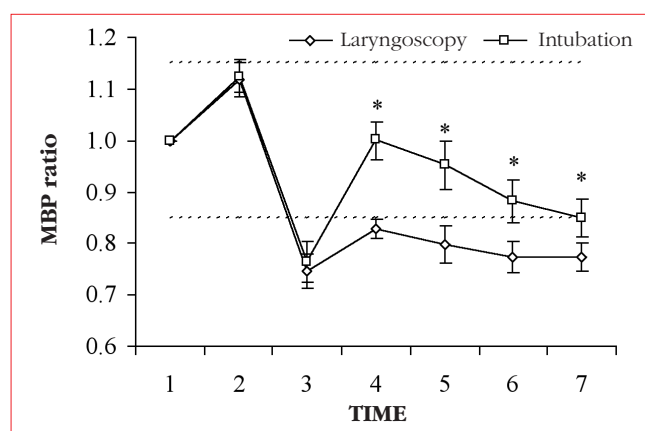
The sample consisted of 40 patients in Group L and 40 patients in Group I. Summary statistics are presented in Table I. Following a repeated measures ANOVA, for both BP and HR, groups ($p < 0.01$) and also times ($p < 0.0001$) were significantly different. The interactions were, however, also significant ($p < 0.0001$) and hence Student's two-sample t-tests along with the 95% confidence intervals (95% CI) for the differences between the groups were employed to facilitate interpretation (Table D). Since the Cormack Lehane grade, age, and body mass were not found to be significant covariates, groups were compared using Student's two-sample t-test as adjusting for covariates were not required. There were no differences with regard to the gender, ages and weights of the patients. The mean time of laryngoscopy and intubation did not differ significantly between Groups I and L ($p = 0.2016$). After the induction of anaesthesia there was a

significant decrease of MBP in both groups ($p < 0.0001$), while heart rates did not change significantly ($p > 0.4$). Following instrumentation, blood pressure and heart rate increased significantly in both groups ($p < 0.0001$).

Mean blood pressure

Over time MBP ratios were significantly higher in Group I than in Group L ($p < 0.0001$); at all the respective times after instrumentation MBP ratios were significantly higher in Group I than Group L ($p < 0.002$). In Group L MBP was significantly lower than preoperatively from after induction to 4 minutes after laryngoscopy ($p < 0.0001$). In Group I MBP ratios after induction was significantly lower than preoperatively ($p < 0.0001$), not significantly different 1 minute after intubation ($p = 0.9868$), but significantly lower than preoperatively from two to four minutes after intubation ($p < 0.05$) (Table I, Figure 1).

Figure 1: Ratio of intraoperative to preoperative mean blood pressure.



Bars depict the 95% confidence interval (mean \pm 2.023 x standard error); *significant differences between groups ($p < 0.05$); --- MBP ratio = 0.85 or 1.15; Time 1 = preoperative; Time 2 = before induction; Time 3 = after induction; Times 4 to 7 = 1, 2, 3, and 4 minutes after instrumentation respectively.

Table I: Patient characteristics, instrumentation times, and haemodynamics

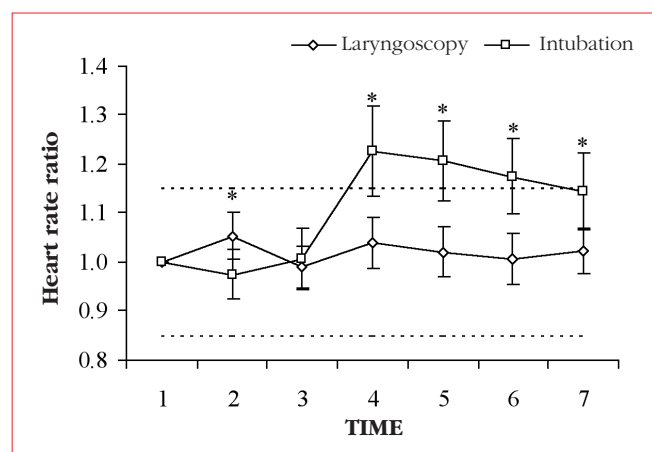
Variable	Group L (n = 40) Mean (SD)	Group I (n = 40) Mean (SD)	95% CI for difference between groups	p*
Gender (male/female)	24/16	21/19		0.6525
Age (year)	37.8 (14.1)	37.7 (11.8)	-5.7; 5.9	0.9727
Body mass (kg)	68.5 (9.9)	68.3 (13.3)	-4.8; 5.6	0.8864
Instrumentation time (s)	12.4 (2.7)	11.5 (3.4)	-0.5; 2.2	0.2016
Mean BP ratio				
Pre-induction	1.12 (0.10)	1.12 (0.10)	-0.05; 0.04	0.7837
After induction	0.75 (0.11)	0.76 (0.13)	-0.07; 0.03	0.4976
Post-laryngoscopy 1 min	0.83 (0.12)	1.00 (0.21)	-0.25; -0.09	< 0.0001
Post-laryngoscopy 2 min	0.80 (0.12)	0.95 (0.15)	-0.21; -0.09	< 0.0001
Post-laryngoscopy 3 min	0.77 (0.10)	0.88 (0.13)	-0.16; -0.06	0.0001
Post-laryngoscopy 4 min	0.75 (0.09)	0.85 (0.12)	-0.12; -0.03	0.0015
Heart rate ratio				
Pre-induction	1.05 (0.15)	0.97 (0.16)	0.01; 0.15	0.0236
After induction	0.99 (0.14)	1.01 (0.20)	-0.09; 0.06	0.6224
Post-laryngoscopy 1 min	1.04 (0.17)	1.23 (0.30)	-0.29; -0.08	0.0008
Post-laryngoscopy 2 min	1.02 (0.16)	1.21 (0.26)	-0.28; -0.09	0.0003
Post-laryngoscopy 3 min	1.01 (0.17)	1.17 (0.24)	-0.26; -0.07	0.0007
Post-laryngoscopy 4 min	1.02 (0.14)	1.14 (0.25)	-0.21; -0.03	0.0098

* All p values refer to the Student's two-sample t-test, except gender where use was made of the Fisher exact test.

Heart rate

Over time heart rate ratios were significantly higher in Group I than in Group L ($p = 0.0096$) (Figure 2). HR ratios were significantly higher in Group I than in Group L from 1 minute to 4 minutes after instrumentation ($p < 0.009$). In Group L all heart rate ratios were at the same level at the different times. In Group I the heart rate ratios preoperatively, before induction, and after induction were at the same level but significantly higher from 1 minute to 4 minutes after intubation (Table I, Figure 2).

Figure 2: Ratio of intraoperative to preoperative heart rate.



Bars depict the 95% confidence interval (mean \pm 2.023 x standard error); *significant differences between groups ($p < 0.007$); --- Heart rate ratio = 0.85 or 1.15; Time 1 = preoperative; Time 2 = before induction; Time 3 = after induction; Times 4 to 7 = 1, 2, 3, and 4 minutes after instrumentation respectively.

We regarded an *increase* of the ratios of ≥ 0.15 (ratio ≥ 1.15) to be *clinically significant*. Heart rate and MBP were highest one minute after instrumentation. In Group L and Group I the incidences of clinically significant increases were 1/40 patients vs 8/40 patients respectively for MBP ratios ($p = 0.0289$) and 12/40 patients vs 23/40 patients respectively for heart rate ratios ($p = 0.0236$). More patients therefore had clinically significant increases in blood pressure and heart rate after intubation than after laryngoscopy only.

If *decreases* in ratios of ≥ 0.15 (ratio ≤ 0.85) are regarded as *clinically significant*, the following were found for Group L and I one minute after instrumentation: MBP ratio 23/40 vs 11/40 ($p = 0.0123$) and heart rate 4/40 patients vs 2/40 patients respectively ($p = 0.6752$). More patients in Group L therefore experienced clinically significant decreases in blood pressure than in Group I, whereas neither group exhibited clinically significant decreases in heart rates.

After instrumentation of the airway the haemodynamic response in *Group L* was thus mainly characterised by significant *decreases in blood pressure* in the majority of patients, while the majority of patients in *Group I* experienced an *increase in heart rate*.

Discussion

We investigated the haemodynamic changes after laryngoscopy alone compared to laryngoscopy followed by tracheal intubation. We have confirmed the alternative hypothesis, namely that the haemodynamic response during laryngoscopy differs from that when laryngoscopy is followed by tracheal intubation. If laryngoscopy was not followed by intubation the haemodynamic response was characterised by a relatively constant heart rate but clinically significant decreases in blood pressure. If

laryngoscopy was followed by intubation the haemodynamic response was characterised by a relatively constant blood pressure but a significant increase in heart rate (Figures 1 and 2).

The significance of the blood pressure observations is that hypotension following induction of anaesthesia may be alleviated by tracheal intubation, but that hypotension may recur without further stimulation. In Group I MBP ratio at one minute through four minutes after intubation were significantly higher than after induction. However, whereas MBP ratios were still clinically acceptable (changes in ratio > 0.15) up to three minutes after intubation, MBP ratios at four minutes after intubation decreased clinically significantly [MBP ratio = 0.85 (0.12)]. Hypotension following induction of anaesthesia may recur even after instrumentation of the upper airway (Figure 1).

In Group I heart rate increased to above clinically acceptable levels (increase $> 15\%$). In Group L heart rates were similar to preoperative (ward) values throughout (Figure 2). The heart rate ratio findings demonstrate that, in contrast to tracheal intubation, laryngoscopy not followed by intubation, did not have a significant effect on heart rate ratios (Figure 2).

The study by Shribman⁶ was very similar to our study. However, they found a significant but similar increase in arterial pressure and circulating catecholamine concentrations following laryngoscopy with or without intubation. If laryngoscopy was followed by intubation, there was a significant increase in heart rate, which did not occur in the laryngoscopy only group. They concluded that the laryngoscopy was the major source of the rise in blood pressure, while intubation was responsible for the increased heart rate. That conclusion is questionable since they, similar to our findings, also found that increases in blood pressures were greater when laryngoscopy was followed by intubation. The heart rate response to laryngoscopy was much smaller than that found in our study. They had a smaller study population (48 patients), and used a different induction technique (thiopentone and fentanyl), which may account for the different findings.

Several investigators have tried to determine the source of the intubation response by avoiding stimulation of the pharynx. Barak and colleagues compared the response to orotracheal intubation using either a Macintosh laryngoscope blade or a fiberoptic laryngoscope through a Williams oropharyngeal airway.⁷ The stress response did not differ significantly between groups. They were not able to ascribe the most important cause of the intubation response.

Adachi and colleagues examined the effectiveness of reducing the intubation response by using a fibre optic technique that would avoid laryngoscopy. They concluded that endotracheal intubation itself is the major stimulus to cardiovascular responses.⁸

Laryngoscopy before tracheal intubation may be circumvented by using the intubating laryngeal mask airway (ILMA). Zhang et al studied haemodynamic responses to orotracheal intubation with either an ILMA or direct laryngoscopy (DLS).⁹ There were no significant differences in blood pressure and heart rate between groups. In their study the mean intubation time in the ILMA group was longer than that in the DLS group. The blood pressure and heart rate increased significantly after intubation in the two groups compared to the post-induction values. Similar to our findings in Group I, the maximum value of blood pressure during the observation period did not exceed the baseline value, while the maximum value of heart rate was higher than the baseline.

Hollande et al found greater mean arterial pressures and heart rates after orotracheal intubation than after insertion of a laryngeal mask airway (LMA).¹⁰ Rooke et al studied the haemodynamic effects of intubation and insertion of an LMA. Their findings concur with those in our Group I. Blood pressure and heart

rate decreased equally in both groups after induction of anaesthesia. However, after tracheal intubation, heart rate, but not blood pressure, increased above baseline levels.¹¹

Oczenski et al studied the haemodynamic and catecholamine stress responses to insertion of the Combitube (CT), LMA or tracheal intubation.¹² They showed that haemodynamic and stress hormone levels increased significantly in all three groups with CT > tracheal intubation > LMA. This study also demonstrates that manipulation of the lower airway or vocal cords is responsible for significant stress responses.

In our study the instrumentation times were similar between groups. An exaggerated haemodynamic response is often observed during difficult intubations. The duration of instrumentation and force applied probably influence the response to laryngoscopy and intubation. This may explain the augmented haemodynamic response often observed during airway management in patients with difficult airways. Both nerves supplying the airway (glossopharyngeal and vagal nerves) carry sympathetic afferent fibres,^{13,14} stimulation of which results in the intubation response. Stoelting showed that the duration of laryngoscopy also affects the intubation response. There was a positive correlation between the time of laryngoscopy and the pressor response.¹⁵

We used propofol and alfentanil for induction. Both drugs are known to cause hypotension and/or bradycardia. Induction of anaesthesia using propofol causes a decrease in blood pressure, while heart rate is not affected significantly.^{16,17} Alfentanil 15 µg/kg two minutes before intubation causes a decrease in blood pressure but heart rate does not decrease significantly.¹⁸ Propofol and alfentanil also suppress upper airway reflexes. They are therefore often used concomitantly to attenuate the haemodynamic response to intubation.¹⁹

This study illustrates that additional measures should be taken to contain increases in heart rate in patients in whom increases may be detrimental, i.e. ischaemic heart disease. This can be done using a short-acting blocker such as esmolol. On the other hand, when propofol and an opioid are used to facilitate upper airway management, including only laryngoscopy or insertion of an LMA, the anaesthetist must be prepared to treat hypotension.

We cannot explain the statistically significant higher heart rate that occurred in Group I before induction of anaesthesia. This difference is, however, not regarded clinically significant as the heart rate in both groups was within ± 0.15 of the preoperative heart rate ratios.

Our study had some shortcomings. The same anaesthetist did all laryngoscopies and intubations. This study was therefore single-blinded which might have given rise to bias; blinding of the investigator was, however, not possible. Furthermore, patients with cardiovascular disease were excluded. Depending on the cardiovascular drugs these patients may be taking, their sensitivity to the effects of induction agents, laryngoscopy, and intubation may vary.

The significance of this study is that it segregated the components of tracheal intubation (laryngoscopy and intubation) and of the intubation response (blood pressure and heart rate). The intubation component is the major cause of the intubation response and the major response is an increase in heart rate. During tracheal intubation prevention of an increase in heart rate is more important than of hypertension.

Conclusions

After induction with propofol and alfentanil, and at an end-tidal concentration of 1.5 MAC of isoflurane, the main observation after laryngoscopy was a decrease in blood pressure, while the main effect of intubation was an increased heart rate. The induction technique, consisting of lignocaine, alfentanil and propofol, may have attenuated expected increases in blood pressure but not increases in heart rate after intubation. **SAJAA**

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