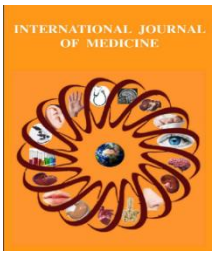

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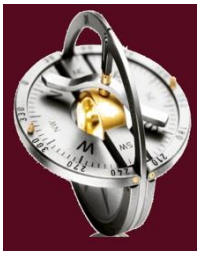

Original Research

Haemodynamic Responses to Laryngoscopy and Endotracheal Intubation in Normotensive and Hypertensive Patients: A Comparative Observational Study.

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Abstract

Background: Direct laryngoscopy and tracheal intubation activate the sympathoadrenal system and produce transient tachycardia and hypertension. These changes can be greater and more persistent in patients with pre-existing hypertension. *Objectives:* To compare the magnitude and temporal pattern of haemodynamic responses to laryngoscopy and endotracheal intubation in normotensive and controlled hypertensive patients undergoing elective surgery. *Methods:* This prospective comparative observational study included 60 adults from October 2022 to July 2023. Thirty normotensive patients formed Group N and 30 controlled hypertensive patients formed Group H. Heart rate, systolic blood pressure, diastolic blood pressure and mean arterial pressure were recorded at baseline, immediately after intubation, and at 1, 3, 5 and 10 minutes. Data were analysed using between-group and repeated-measures tests. *Results:* Peak responses occurred at one minute. Heart rate increased to 104.2±11.7 beats/min in Group N and 112.8±13.2 beats/min in Group H (p=0.004). Peak systolic blood pressure was 156.8±13.9 versus 187.9±16.4 mmHg, diastolic blood pressure was 95.6±8.8 versus 112.4±10.3 mmHg, and mean arterial pressure was 116.0±9.4 versus 137.6±11.2 mmHg, respectively (all p<0.001). A mean arterial pressure increase exceeding 20% occurred in 53.3% of Group N and 80.0% of Group H (p=0.028). Tachycardia above 100 beats/min was also more frequent in Group H (66.7% versus 40.0%; p=0.038). *Conclusion:* Laryngoscopy and endotracheal intubation produced significant transient haemodynamic stimulation in both groups. Hypertensive patients experienced higher peak values, a greater frequency of clinically relevant responses and slower recovery towards baseline, supporting intensified monitoring and anticipatory haemodynamic control during airway instrumentation.

Keywords: *Endotracheal intubation; haemodynamic response; hypertension; laryngoscopy; mean arterial pressure; tachycardia.*

Introduction

Direct laryngoscopy and endotracheal intubation are essential components of general anaesthesia, but both are potent noxious stimuli. Mechanical stimulation of the epipharyngeal and laryngotracheal structures produces a reflex sympathetic discharge, resulting in abrupt increases in heart rate, systemic vascular resistance and arterial pressure. Classic clinical investigations demonstrated that the pressor response begins during laryngoscopy, becomes maximal shortly after passage of the tracheal tube and generally declines within several minutes.[1,2] Although this response is brief in many healthy adults, its magnitude varies with the force and duration of laryngoscopy, depth of anaesthesia, airway difficulty, baseline autonomic tone and cardiovascular status.

The physiological basis of this response is closely linked to sympathoadrenal activation. Investigators have documented increases in circulating adrenaline and noradrenaline after airway manipulation, accompanied by parallel rises in heart rate and mean arterial pressure.[3-6] Laryngoscopy appears to provide the dominant stimulus through pressure exerted at the base of the tongue and supraglottic tissues, while tracheal tube placement contributes additional stimulation. The resulting increase in myocardial oxygen demand is reflected by the rate-pressure product and can become clinically important when coronary reserve is limited.

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Patients with chronic hypertension represent a particularly vulnerable perioperative population. Long-standing elevation of arterial pressure is associated with altered baroreceptor function, increased vascular reactivity, left ventricular hypertrophy and impaired cardiovascular reserve. Consequently, even patients whose blood pressure is controlled before surgery can show an exaggerated response during induction and airway instrumentation. Severe hypertension, tachyarrhythmia, myocardial ischaemia, acute ventricular failure and cerebrovascular complications have been reported in susceptible individuals during the peri-intubation period.[7,8] The risk is influenced not only by the peak pressure attained but also by the speed of increase and the duration for which myocardial workload remains elevated.

Previous studies comparing airway devices or pharmacological attenuation strategies have consistently shown that hypertensive patients require careful haemodynamic management.[9-13] However, the magnitude of the untreated or routinely managed response differs across populations because of variations in age, antihypertensive therapy, anaesthetic technique, timing of measurements and definitions of clinically important change. Data from routine tertiary-care practice in Indian patients remain useful for identifying the period of greatest risk and for planning monitoring and preventive measures.

The present study was therefore undertaken to compare haemodynamic responses to direct laryngoscopy and endotracheal intubation between normotensive and controlled hypertensive adults undergoing elective surgery under general anaesthesia. The primary objective was to compare serial changes in heart rate and mean arterial pressure from baseline to 10 minutes after intubation. The secondary objectives were to compare systolic and diastolic blood pressure responses and to determine the frequency of clinically relevant events, including a mean arterial pressure increase greater than 20%, heart rate above 100 beats/min, systolic blood pressure above 180 mmHg and requirement for rescue medication.

METHODOLOGY

Study design and setting: This prospective comparative observational study was conducted in the Department of Anaesthesiology at Vijayanagara Institute of Medical Sciences (VIMS), Bellary, Karnataka, India, from October 2022 to July 2023. Reporting was planned in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology recommendations.[14] Necessary Permissions were obtained before starting the study, and written informed consent was obtained from every participant.

Participants: Adults aged 30-65 years scheduled for elective non-cardiac surgery under general anaesthesia with oral endotracheal intubation were screened. Group N included patients without a history of hypertension and with preoperative blood pressure below 140/90 mmHg. Group H included patients with previously diagnosed hypertension receiving treatment and having controlled preoperative blood pressure. Patients with uncontrolled hypertension, anticipated difficult airway, ischaemic heart disease, heart failure, significant valvular disease, arrhythmia, cerebrovascular disease, severe renal or hepatic dysfunction, pregnancy, emergency surgery, more than one intubation attempt or laryngoscopy lasting longer than 30 seconds were excluded.

Sample size and grouping: The sample size was calculated to detect a 12-mmHg between-group difference in post-intubation mean arterial pressure, assuming a common standard deviation of 16 mmHg, 80% power and a two-sided alpha error of 5%. The minimum requirement was 28 patients per group; 30 participants were included in each group to compensate for incomplete recordings. Consecutive eligible patients were enrolled and classified according to their pre-existing blood pressure status. No intervention was allocated by the investigators.

Anaesthetic technique and measurements: Routine antihypertensive medication was managed according to institutional practice. After arrival in the operating room, electrocardiography, non-invasive blood pressure and pulse oximetry were applied. Baseline values were recorded after five minutes of undisturbed rest. Patients received intravenous midazolam 0.02 mg/kg and fentanyl 2 micrograms/kg. Anaesthesia was induced with propofol 2 mg/kg, and neuromuscular blockade was achieved with vecuronium 0.1 mg/kg. After three minutes of ventilation, direct laryngoscopy was performed with a Macintosh blade by an anaesthesiologist experienced in airway management. An appropriately sized cuffed tracheal tube was inserted in a single attempt. Anaesthesia was maintained with oxygen, nitrous oxide and sevoflurane. Surgical stimulation was avoided during the initial observation period whenever clinically feasible. Heart rate, systolic blood pressure, diastolic blood pressure and mean arterial pressure were recorded at baseline, immediately after intubation, and at 1, 3, 5 and 10 minutes. Rescue treatment was administered for persistent severe hypertension or tachycardia according to the attending anaesthesiologist.

Outcomes and statistical analysis: The primary outcomes were serial heart rate and mean arterial pressure. Secondary outcomes included systolic and diastolic blood pressure and predefined haemodynamic events. Continuous variables were expressed as mean±standard deviation and categorical variables as number and percentage. Normality was examined using the Shapiro-Wilk test. Independent-samples t test, chi-square test or Fisher exact test was applied as appropriate. Serial measurements were evaluated using repeated-measures analysis of variance with assessment of time, group and group-by-time effects. Analyses were performed using standard statistical software, and a two-sided p value below 0.05 was considered statistically significant.

Results

A total of 65 patients scheduled for elective surgery under general anaesthesia were screened. Three patients did not fulfil the eligibility criteria, and two had incomplete haemodynamic recordings. The remaining 60 patients were included in the analysis, with 30 normotensive patients in Group N and 30 controlled hypertensive patients in Group H.

Patients in Group H were significantly older and had a higher mean body mass index than those in Group N. Sex distribution, duration of laryngoscopy and duration of surgery were comparable. Baseline systolic blood pressure, diastolic blood pressure and mean arterial pressure were significantly higher in Group H, while baseline heart rate did not differ significantly (Table 1).

Table 1. Baseline demographic and clinical characteristics of the study groups

Characteristic	Group N (n=30)	Group H (n=30)	p value
Age, years	45.9±9.8	57.6±8.4	<0.001
Sex, n (%)			0.793
Male	17 (56.7)	18 (60.0)	
Female	13 (43.3)	12 (40.0)	
Body mass index, kg/m²	24.8±3.2	27.1±3.4	0.009
Duration of laryngoscopy, seconds	19.7±4.1	20.5±4.4	0.469
Duration of surgery, minutes	83.6±22.4	87.9±24.1	0.477
Baseline heart rate, beats/min	78.4±8.6	80.2±9.1	0.433
Baseline systolic blood pressure, mmHg	122.6±8.7	143.8±10.9	<0.001
Baseline diastolic blood pressure, mmHg	76.4±6.9	86.9±7.8	<0.001
Baseline mean arterial pressure, mmHg	91.8±6.8	105.9±7.9	<0.001

Values are presented as mean±standard deviation or number (percentage). Group N: normotensive; Group H: controlled hypertensive.
Heart rate increased following laryngoscopy and intubation in both groups and reached its maximum at one minute. The peak value was 104.2±11.7 beats/min in Group N and 112.8±13.2 beats/min in Group H (p=0.004). Group H had significantly higher heart rates immediately after intubation and at 1, 3 and 5 minutes. At 10 minutes, the difference was not statistically significant. Systolic blood pressure also peaked at one minute, reaching 156.8±13.9 mmHg in Group N and 187.9±16.4 mmHg in Group H. Values remained significantly higher in Group H at

every observation point (Table 2). Repeated-measures analysis showed significant changes over time for heart rate and systolic blood pressure (both p<0.001). The group-by-time interaction was significant for heart rate (p=0.018) and systolic blood pressure (p<0.001).

Table 2. Comparison of heart rate and systolic blood pressure at different time points

Time point	Heart rate, beats/min			Systolic blood pressure, mmHg		
	Group N	Group H	p value	Group N	Group H	p value
Baseline	78.4±8.6	80.2±9.1	0.433	122.6±8.7	143.8±10.9	<0.001
Immediately after intubation	101.7±11.1	108.9±10.4	0.011	151.4±13.2	180.6±15.8	<0.001
1 minute	104.2±11.7	112.8±13.2	0.004	156.8±13.9	187.9±16.4	<0.001
3 minutes	95.1±10.2	103.7±11.4	0.003	144.2±12.8	174.5±15.1	<0.001
5 minutes	86.9±9.3	93.6±10.1	0.009	133.1±10.7	160.7±13.9	<0.001
10 minutes	80.6±8.4	84.9±9.2	0.065	125.4±9.6	148.6±12.1	<0.001

Values are presented as mean±standard deviation. Group N: normotensive; Group H: controlled hypertensive.

Diastolic blood pressure increased from 76.4±6.9 to 95.6±8.8 mmHg in Group N and from 86.9±7.8 to 112.4±10.3 mmHg in Group H at one minute. Mean arterial pressure showed a corresponding rise from 91.8±6.8 to 116.0±9.4 mmHg in Group N and from 105.9±7.9 to 137.6±11.2 mmHg in Group H. Both variables were significantly higher in hypertensive patients throughout the observation period. By 10 minutes, the normotensive group had approached baseline, whereas residual elevation persisted in Group H (Table 3). Significant group-by-time interactions were observed for diastolic blood pressure (p=0.002) and mean arterial pressure (p<0.001).

Table 3. Comparison of diastolic blood pressure and mean arterial pressure at different time points

Time point	Diastolic blood pressure, mmHg			Mean arterial pressure, mmHg		
	Group N	Group H	p value	Group N	Group H	p value
Baseline	76.4±6.9	86.9±7.8	<0.001	91.8±6.8	105.9±7.9	<0.001
Immediately after intubation	92.8±8.2	108.7±9.6	<0.001	112.3±8.7	132.7±10.4	<0.001
1 minute	95.6±8.8	112.4±10.3	<0.001	116.0±9.4	137.6±11.2	<0.001
3 minutes	88.9±7.9	104.6±9.2	<0.001	107.3±8.5	127.9±10.1	<0.001
5 minutes	82.3±7.2	96.8±8.7	<0.001	99.2±7.6	118.1±9.3	<0.001
10 minutes	77.8±6.8	89.4±7.9	<0.001	93.7±7.1	109.1±8.2	<0.001

Values are presented as mean±standard deviation. Group N: normotensive; Group H: controlled hypertensive.
Clinically relevant responses were more frequent among hypertensive patients. An increase in mean arterial pressure exceeding 20% occurred in 24 (80.0%) patients in Group H and 16 (53.3%) in Group N (p=0.028). Heart rate above 100 beats/min occurred in 20 (66.7%) and 12 (40.0%) patients, respectively (p=0.038). Systolic blood pressure above 180 mmHg was documented in 13 (43.3%) hypertensive patients but only one (3.3%) normotensive patient (p<0.001). Rescue medication was required in five patients in Group H and one patient in Group N; this difference was not statistically significant (Table 4). No severe bradycardia, clinically significant arrhythmia, myocardial ischaemia, cerebrovascular event or other major peri-intubation complication was recorded. Overall, hypertensive patients demonstrated greater peak haemodynamic values and a slower return towards baseline, particularly during the first three minutes after intubation.

Table 4. Clinically relevant haemodynamic events following intubation

Haemodynamic event	Group N (n=30)	Group H (n=30)	p value
Increase in mean arterial pressure >20%	16 (53.3)	24 (80.0)	0.028
Heart rate >100 beats/min	12 (40.0)	20 (66.7)	0.038
Systolic blood pressure >180 mmHg	1 (3.3)	13 (43.3)	<0.001
Rescue medication required	1 (3.3)	5 (16.7)	0.085

Values are presented as number (percentage). Group N: normotensive; Group H: controlled hypertensive.

Discussion

The present comparative observational study demonstrated that direct laryngoscopy and endotracheal intubation caused a clear transient pressor and tachycardic response in both normotensive and controlled hypertensive patients. The response peaked at one minute after intubation, followed by a gradual decline. However, hypertensive patients had higher post-intubation heart rate and arterial pressure, more frequent clinically relevant events and a slower return towards baseline. The most striking difference was observed for systolic blood pressure above 180 mmHg, which occurred in 43.3% of hypertensive patients compared with 3.3% of normotensive patients.

The observed temporal pattern agrees with the early work of Forbes and Dally and Prys-Roberts and colleagues, who described abrupt hypertension during induction and tracheal intubation, with a greater response in patients with hypertension.1,2 The rise in heart rate and blood pressure is biologically consistent with the documented release of circulating catecholamines after laryngoscopy and passage of the tracheal tube.3-6 Peak stimulation within the first minute also reflects the immediate autonomic response to supraglottic tissue displacement and tracheal receptor activation. The subsequent decline suggests rapid withdrawal of the stimulus and increasing anaesthetic effect, although haemodynamic recovery remained incomplete at 10 minutes in the hypertensive group.

Our findings are particularly consistent with Nishikawa et al., who directly compared normotensive and hypertensive patients and reported stronger circulatory responses after conventional laryngoscopic intubation in the hypertensive population.9 Yoo et al. similarly observed substantial cardiovascular activation after tracheal intubation in hypertensive elderly patients.10 Studies evaluating conventional laryngoscopy and pharmacological attenuation in hypertensive cohorts have also shown that airway instrumentation can generate clinically important increases in pressure and myocardial workload despite treatment of baseline hypertension.11,12 A later meta-analysis confirmed that reducing sympathetic activation around intubation lowers both heart rate and blood pressure, supporting the clinical relevance of preventive strategies in high-risk patients.13

The higher baseline blood pressure in Group H accounts for part of the absolute intergroup difference, but the significant group-by-time interactions and greater frequency of threshold events indicate that the distinction was not limited to baseline status. Chronic hypertension is associated with baroreflex resetting, arterial stiffness and enhanced vascular responsiveness, which can amplify rapid sympathetic stimulation. The older age and higher body mass index of Group H could also have strengthened the observed response and should be considered when interpreting the comparison.

From a practical perspective, the first three minutes after intubation represented the period of greatest haemodynamic stress. Continuous electrocardiographic observation, frequent blood pressure measurement, adequate anaesthetic depth, minimisation of laryngoscopy duration and readiness to administer a short-acting agent are therefore important in hypertensive patients. The absence of major complications in this sample does not diminish the clinical significance of the recorded pressure surges because uncommon cardiovascular or cerebrovascular events require substantially larger cohorts for reliable estimation.

LIMITATIONS

This study was conducted at a single centre with a modest sample and non-random group allocation. Hypertensive participants were older and had higher body mass index and baseline pressures, creating residual confounding. Antihypertensive drug classes were not analysed separately, and invasive arterial pressure or catecholamine measurements were not used. The ten-minute follow-up did not assess later intraoperative cardiovascular outcomes or long-term clinical consequences.

Conclusion

Direct laryngoscopy and endotracheal intubation produced marked but transient increases in heart rate and arterial blood pressure in both normotensive and controlled hypertensive patients. The hypertensive group showed higher peak systolic, diastolic and mean arterial pressures, more frequent tachycardia and pressure elevations above clinically relevant thresholds, and slower recovery towards baseline. The first three minutes after intubation constituted the period of greatest cardiovascular stress. These findings support careful preoperative optimisation, adequate depth of anaesthesia, brief and atraumatic laryngoscopy, close haemodynamic monitoring and immediate availability of short-acting rescue medication when intubating patients with hypertension, even when their preoperative blood pressure is controlled, during elective procedures requiring conventional direct laryngoscopy and intubation.

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