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Original Research Article

COMPARATIVE EVALUATION OF PHYSIOLOGICAL CARDIOVASCULAR VARIATIONS DURING GENERAL ANAESTHESIA IN PATIENTS UNDERGOING ELECTIVE SURGICAL PROCEDURES: A PROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT

Background: General anaesthesia is associated with significant physiological alterations in cardiovascular parameters during induction, laryngoscopy, intubation, maintenance, and recovery phases. These haemodynamic changes may contribute to perioperative complications if not appropriately monitored and managed. This study was designed to evaluate physiological variations in cardiovascular responses during different phases of general anaesthesia among patients undergoing elective surgical procedures.
Materials and Methods: A total of 156 patients aged 18–65 years belonging to ASA physical status I and II undergoing elective surgeries under general anaesthesia were included. Heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) were recorded at baseline, after premedication, post induction, and at multiple intervals following endotracheal intubation.
Results: Significant haemodynamic variations were observed throughout the perioperative period. Mean heart rate decreased following induction and increased markedly one minute after intubation (92.86 ± 10.64 beats/min). Similarly, systolic blood pressure decreased after induction and subsequently increased following intubation (134.52 ± 14.27 mmHg). Comparable trends were observed in DBP and MAP. Hypotension was observed in 12.2% of patients, while tachycardia and hypertension occurred in 10.9% and 8.3% respectively. All cardiovascular variations across different perioperative intervals were statistically significant (p<0.001).
Conclusion: General anaesthesia produces significant transient cardiovascular variations, particularly during induction and airway manipulation. Vigilant haemodynamic monitoring and appropriate anaesthetic management are essential to maintain perioperative cardiovascular stability and minimize complications.
Keywords: General Anaesthesia, Cardiovascular Responses, Haemodynamic Changes; Endotracheal Intubation, Anaesthesia Induction.

INTRODUCTION

General anaesthesia is an essential component of modern surgical practice and is associated with multiple physiological alterations involving the cardiovascular, respiratory, and neuroendocrine systems. Among these, cardiovascular responses during induction of anaesthesia, laryngoscopy, endotracheal intubation, and maintenance of anaesthesia remain clinically significant because of their potential to influence perioperative morbidity and mortality. Haemodynamic fluctuations occurring during these phases are primarily mediated through sympathetic nervous system

activation, catecholamine release, myocardial depression, and alterations in systemic vascular resistance. These responses may be transient in healthy individuals but can precipitate serious complications in patients with pre-existing cardiovascular disorders.[1]

Induction agents commonly used during general anaesthesia, particularly propofol and inhalational agents, are known to produce varying degrees of myocardial depression and vasodilation, resulting in reductions in arterial blood pressure and cardiac output. Previous studies have demonstrated that these haemodynamic changes are influenced by patient age, baseline cardiovascular status, type of anaesthetic agent, airway manipulation, and surgical stress response. Propofol-induced hypotension has been extensively documented and is attributed to decreased sympathetic activity and reduced systemic vascular resistance.[2-6]

Laryngoscopy and endotracheal intubation are among the most potent noxious stimuli during administration of general anaesthesia. Mechanical stimulation of the larynx and trachea activates sympathetic reflexes leading to transient tachycardia, hypertension, and increased myocardial oxygen demand. These cardiovascular responses are usually short-lived; however, exaggerated haemodynamic reactions may predispose susceptible patients to arrhythmias, myocardial ischemia, heart failure, and cerebrovascular events. Several investigators have therefore emphasized the importance of minimizing intubation-related haemodynamic stress through pharmacological and non-pharmacological interventions.[7-9]

Recent studies have focused on perioperative cardiovascular stability as a major determinant of surgical outcomes. Studies conducted in different populations have reported varying degrees of haemodynamic fluctuations during general anaesthesia, highlighting the need for continuous monitoring and individualized anaesthetic management. Advancements in monitoring systems, balanced anaesthetic techniques, and newer pharmacological agents have improved haemodynamic control; nevertheless, cardiovascular instability remains a frequent perioperative challenge.[10]

Understanding physiological cardiovascular responses during general anaesthesia is important for optimizing patient safety and perioperative care. The present study was designed to evaluate and compare cardiovascular variations occurring during different phases of general anaesthesia among patients undergoing elective surgical procedures.

MATERIALS AND METHODS

A prospective observational study was conducted in the Department of Anaesthesiology in association with Department of Physiology at RVM Institute of Medical Sciences and Research Centre from January 2025 to March 2026. A total of 156 patients scheduled for elective surgeries requiring general anaesthesia that are fulfilling the predefined inclusion criteria were recruited.

Inclusion Criteria

Patients aged between 18 -65 years of both genders, ASA grade I and II, undergoing elective surgical procedures under general anaesthesia and patients willing to provide informed written consent.

Exclusion Criteria

Patients with hypertension, ischemic heart disease, arrhythmias, severe respiratory disorders, endocrine disorders affecting cardiovascular physiology, chronic renal diseases, hepatic disease, receiving medications known to influence heart rate, pregnant women, emergency surgical cases, anticipated difficult intubation and not willing to participate.

Written informed consent was obtained from study participants and study protocol was approved by the institutional ethics committee.

A detailed clinical history and demographic information including were recorded for all participants. Routine pre-anaesthetic assessment was performed one day prior to surgery. Necessary laboratory investigations including complete blood count, renal function tests, liver function tests, blood glucose estimation, electrocardiography, and chest X-ray when indicated were reviewed.

Patients were kept nil per oral according to standard preoperative fasting guidelines. On arrival in the operation theatre, standard monitoring was established using multiparameter monitoring devices. Baseline cardiovascular parameters including heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), and oxygen saturation (SpO_2) were recorded before induction of anaesthesia.

General anaesthesia was induced using intravenous induction agents according to institutional protocols. Following adequate preoxygenation with 100% oxygen for three minutes, induction was performed using propofol along with an opioid analgesic. Neuromuscular blockade was achieved using an appropriate muscle relaxant to facilitate endotracheal intubation. Following induction and successful endotracheal intubation, anaesthesia was maintained.

Cardiovascular parameters including HR, SBP, DBP, and MAP were recorded at the baseline, after premedication, immediately following induction, 1 min after intubation, 3 min after intubation, 5 min after intubation, 10 min after intubation, at regular intraoperative intervals of fifteen minutes until completion of surgery and during recovery from anaesthesia. Any significant haemodynamic event including bradycardia, tachycardia, hypotension, or hypertension was documented and managed according to standard institutional protocols.

Statistical Analysis

The collected data were extracted to Microsoft Excel sheet and analysed using SPSS v.26.0. Using descriptive statistics, continuous variables were

expressed as mean, and standard deviation, whereas categorical variables were represented as frequencies and percentages. Comparison of continuous variables across repeated measurements was performed using repeated measures ANOVA. Post hoc analysis was performed where applicable. Categorical variables were analysed using Chi-square test. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Table 1: Demographic characteristics of study participants (n=156)

Demographic variable	To no of cases (n=156)	
	Frequency	**Percentage**
Age group (years)		
18–30	42	26.9%
31–45	58	37.2%
46–60	39	25.0%
>60	17	10.9%
Gender		
Male	91	58.3%
Female	65	41.7%
ASA grade		
ASA I	94	60.3%
ASA II	62	39.7%
Weight (In kg)	64.82±10.57	
BMI (Kg/m2)	24.26±3.84	

Table 2: Baseline Characteristics of Study Participants

Baseline levels	Mean ± SD
heart rate (beats/min)	81.43 ± 9.21
systolic blood pressure (mmHg)	124.82 ± 13.68
diastolic blood pressure (mmHg)	79.52 ± 8.41
mean arterial pressure (mmHg)	94.62 ± 7.84
Baseline SpO_2 (%)	98.64 ± 1.03

Table 3: Comparison of mean SBP and DBP at different perioperative time periods

Time interval	DBP (mmHg)	DBP (mmHg)	Mean arterial pressure
	Mean±SD	**Mean±SD**	**Mean±SD**
Baseline	124.82±13.68	79.52±8.41	94.62±7.84
After premedication	121.54±12.96	77.46±8.12	92.15±7.48
Post induction	111.76±11.64	71.54±7.96	84.95±7.26
1 minute	134.52±14.27	87.28±8.91	103.03±8.65
3 minutes	128.93±13.88	83.14±8.62	98.41±8.23
5 minutes	123.42±12.64	80.56±7.98	94.84±7.92
10 minutes	121.86±11.76	79.21±7.74	93.16±7.53
Recovery period	123.34±12.02	80.02±8.06	94.26±7.68
p-value	0.001	0.001	0.001

Table 4: Adverse events recorded among study participants

Haemodynamic event	Frequency	Percentage
Hypotension	19	12.2%
Hypertension	13	8.3%
Bradycardia	8	5.1%
Tachycardia	17	10.9%
No significant event	99	63.5%

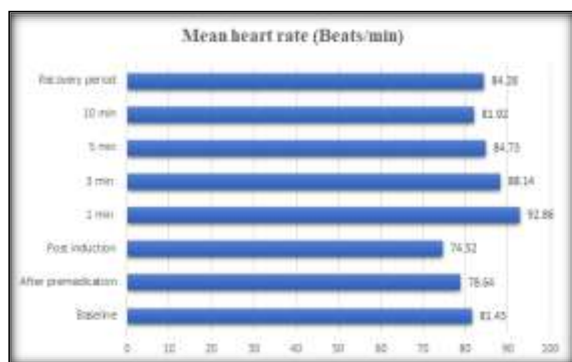

Figure 1: Comparison of mean heart rate at different perioperative time periods

DISCUSSION

The present study evaluated physiological variations in cardiovascular responses during general anaesthesia among 156 patients undergoing elective surgical procedures. In the present study, the mean baseline heart rate was 81.43 ± 9.21 beats/minute, which decreased following induction of anaesthesia and subsequently increased sharply after intubation. The maximum increase in heart rate was recorded one minute after laryngoscopy and intubation. This physiological response can be attributed to sympathetic nervous system activation caused by

airway manipulation and catecholamine release. Similar observations were reported by Teong et al., who demonstrated significant tachycardic responses immediately following endotracheal intubation during general anaesthesia.[11]

The reduction in heart rate following induction in the present study may be explained by the myocardial depressant and vasodilatory effects of induction agents such as propofol. Propofol is known to decrease sympathetic tone and systemic vascular resistance, leading to transient cardiovascular depression. Kawasaki et al. also observed prominent haemodynamic fluctuations following induction with propofol, particularly reductions in arterial pressure and cardiac performance.[12]

The present study demonstrated a significant decrease in systolic, diastolic, and mean arterial pressure immediately after induction of anaesthesia. Mean systolic blood pressure decreased from 124.82±13.68 mmHg at baseline to 111.76 ± 11.64 mmHg after induction. This finding is in accordance with previous studies that documented hypotensive responses following induction due to vasodilation, myocardial depression, and reduced venous return associated with intravenous anaesthetic agents. Kasaba et al. reported profound reductions in mean arterial pressure after propofol administration during general anaesthesia, supporting the haemodynamic findings observed in the present study.[13] A significant rise in blood pressure was observed immediately after laryngoscopy and endotracheal intubation in the present study. Systolic blood pressure increased to 134.52 ± 14.27 mmHg one minute after intubation, while mean arterial pressure increased to 103.03 ± 8.62 mmHg. These findings are attributable to reflex sympathoadrenal stimulation resulting from mechanical stimulation of the pharynx, larynx, and trachea during airway instrumentation. Similar haemodynamic responses were reported by Savitha et al., who observed significant elevations in heart rate and arterial pressure during intubation and surgical stimulation.[14]

The transient nature of the haemodynamic response observed in the current study is consistent with previous evidence indicating that cardiovascular changes related to laryngoscopy and intubation generally return toward baseline within several minutes in healthy individuals. However, exaggerated responses may contribute to perioperative complications in patients with underlying cardiovascular disease, hypertension, or cerebrovascular disorders. Recent evidence from randomized and observational studies has highlighted the clinical importance of attenuating these stress responses during induction and airway manipulation. [15,16]

In the present study, hypotension was observed in 12.2% of patients, whereas tachycardia and hypertension occurred in 10.9% and 8.3% of patients respectively. These findings suggest that although general anaesthesia is generally well tolerated in ASA I and II patients, significant haemodynamic instability may still occur during the perioperative period. Similar peri-intubation cardiovascular fluctuations have been described in multiple studies evaluating airway management and anaesthetic induction techniques.[17] The present study also demonstrated that haemodynamic parameters gradually stabilized during the maintenance phase of anaesthesia. At ten minutes after intubation, heart rate and blood pressure values approached baseline levels, indicating adequate attenuation of sympathetic stimulation with maintenance anaesthetic agents. Comparable findings were documented by Amini et al., who reported better preservation of haemodynamic stability after the initial post-intubation period in patients undergoing elective surgeries under general anaesthesia.[18]

Advances in anaesthetic pharmacology and airway management have significantly improved perioperative cardiovascular stability. Various pharmacological agents including opioids, beta blockers, calcium channel blockers, lignocaine, dexmedetomidine, and vasodilators have been evaluated to reduce haemodynamic stress responses during intubation. Studies evaluating fentanyl administration during induction have shown that optimal timing and dosage can effectively blunt sympathetic stimulation associated with laryngoscopy.[17]

The findings of the present study are clinically important because perioperative haemodynamic instability may contribute to myocardial ischemia, arrhythmias, cerebrovascular events, and postoperative complications, especially in vulnerable populations. Continuous monitoring and prompt management of cardiovascular fluctuations during general anaesthesia therefore remain essential components of perioperative care. Careful selection of induction agents, adequate depth of anaesthesia, appropriate opioid administration, and gentle airway manipulation may help minimize adverse cardiovascular responses.

CONCLUSION

The present study demonstrated significant physiological variations in cardiovascular parameters during different phases of general anaesthesia. Induction of anaesthesia produced transient reductions in heart rate and arterial blood pressure, whereas laryngoscopy and endotracheal intubation resulted in significant sympathetic stimulation with elevations in heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure. These haemodynamic alterations gradually returned toward baseline during maintenance and recovery phases. Although most changes were transient and clinically manageable in ASA I and II patients, vigilant perioperative

monitoring and appropriate anaesthetic management remain essential to minimize cardiovascular instability and prevent potential perioperative complications.

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