Original Article

The Effect Of Passive Leg-Raising Maneuver On Hemodynamic Stability During Anesthesia Induction For Adult Cardiac Surgery

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Abstract

Background: Anesthesia-induced hypotension is a common complication among patients who undergo cardiac surgery. This study investigates/aims to investigate The present study investigated the efficacy of passive leg raising maneuver (PLMR) to prevent or modify the severity of post-anesthesia-induced hypotension during adult cardiac surgery.

Method and sample: A total of 146 subjects were equally randomized into to two groups. Group 1 (n=73): PLRM group [where PLRM was performed] and Group 2 (n=73): Control group [where PLRM was not performed]. Heart rate, invasive mean arterial blood pressure (MAP), and central venous pressure (CVP) was were recorded before PLRM, before anesthetic induction, before laryngoscopy, and at 5, 10, and 20 minutes after tracheal intubation. The hypotension episode rate (MAP <70 mmHg) and CVP changes were compared between the 2 groups.

Results: Out of total sample size of 146 patients, CAD was found in majority in PLRM group (52.1%) and control group (57.5%). The mean LVEF was found to be 49.72±5.73 in PLRM group while 48.17±5.83 in control group, (p>0.05). The mean hemodynamic parameters (HR, SBP, DBP and MAP) and CVP of patients from PLRM group was more stable as compared to that of the control group at different time intervals after laryngoscopy with statistically significant difference in SBP, DBP and MAP (P<0.05). Patients in the control group (51) showed significantly increased requirement of IVD (Inj Noradrenaline) compared to PRLM group (31).

Conclusion: This study concludes that PLRM is a simple, rapid, safe, and effective method of preventing anesthesia-induced hypotension and helps induce anesthesia in a more stable hemodynamic state during cardiac operations with simple monitoring of MAP and CVP.

Keywords: Passive leg raising maneuver; Anesthesia; Cardiac surgery; Hypotension; Hemodynamic parameters

Introduction

Intraoperative hemodynamic perturbations are common due to the effects of anesthetic agents and techniques, surgical manipulations, and the patient's medical comorbidities. Hypotension is a challenging complication for of anesthesia induction, and severe hypotension during induction is a serious situation requiring rapid and timely diagnosis and treatment [1]. To prevent hypotension, anesthesiologists routinely administer a bolus of fluid (3-5 mL/kg) intravenously before initiating anesthesia [2, 3]. While patients undergoing cardiac surgery have limited cardiac reserves and are sometimes volume depleted by preoperative diuretic consumption, which can cause anesthesia-induced hypotension. In patients with limited cardiac reserves, intravascular volume expansion may expose patients to some postoperative risks such as edema [4].

Theoretically, raising the lower extremities affects arterial blood flow by facilitating venous blood drainage from these extremities. In recent research, the hemodynamic response to PLRM (passive leg raising maneuver) which is considered as an auto-transfusion, has attracted widespread attention. This auto-transfusion or translocation increases cardiac preload by 10%-15%, and also CO by in the same value, through Frank-Starling mechanism. PLRM has have been reported to transport 150-300 mL of blood from the legs to the central blood department through a process that is rapid, reversible, and applicable to clinical cases that require rapid volume expansion, like the emergency departments or intensive care units [5].

In acute circulatory failure, passive leg raising (PLR) is a test that predicts whether cardiac output will increase with volume expansion [6]. By transferring a volume of around 300 mL of venous blood from the lower body toward the right heart, PLR mimics a fluid challenge. However, no fluid is infused and the hemodynamic effects are rapidly reversible, thereby avoiding the risks of fluid overload. This test has the advantage of remaining reliable in conditions in which indices of fluid responsiveness that are based on the respiratory variations of stroke volume cannot be used [1], like spontaneous breathing, arrhythmias, low tidal volume ventilation, and low lung compliance [7].

Most patients who undergo cardiac surgery have limited cardiac reserves and consume drugs which with target organs in the cardiovascular system. They are highly sensitive to anesthesia induction or intravascular volume expansion, both of which can expose patients to intra- and postoperative risks. PLRM may function as a buffer that temporarily and rapidly delivers adequate blood volume from the periphery of the patient’s body to the central circulation system. PLRM also increase CVP, though some studies have shown that this increase is a temporary phenomenon [8].

Thus, the present study was conducted to study effect of passive leg-raising maneuver on hemodynarnic stability during anesthesia induction for adult cardiac surgeries.

Materials and Methods

The study design was prospective randomised single-blinded study conducted in the department of Anesthesiology at tertiary care hospital during a period of 2.5 years from July 2020 to December2022 after approval of college ethics committee. A total of 146 patients between the ages of of age between 18 to 70 years, ASA class II, undergoing elective cardiac surgery were enrolled and equally randomized into two groups. **Group 1** (n=73) : PLRM group [where passive leg raising maneuver was performed] and **Group 2** (n=73) : Control group [where passive leg raising maneuver was NOT performed]. Patients with ASA class III or IV, who were undergoing redo and emergency surgery, left ventricular ejection fraction (LVEF) <0.40, recent acute myocardial infarction or onset of unstable angina, a recent unstable hemodynamic history (e.g., hypotension episodes or arrhythmia requiring inotropic drugs), initial arterial systolic blood pressure >160 mmHg, patients with history of previous hip surgery and pregnant and lactating mothers were excluded from the study.

A detailed pre-anesthetic evaluation was done on the night before surgery. Patients were evaluated regarding their present complaints and past medical history. General examination, systemic examination and airway assessment was carried out. Routine preoperative investigations included the following: CBC, PT INR, blood grouping, fasting and post prandial blood sugar, KFT and serum electrolyte, liver function tests, HIV, HBsAg, HCV tests, chest radiography, electrocardiography, echocardiography, coronary angiography.

Methodology

Informed consent was obtained from each patient. Patient were advised to stay at NBM from midnight before the day of the surgery. Tablet Diazepam 5 mg and Tablet Pantoprazole 40mg was administered to the patients on the night before surgery. All cardiac drugs which the patients were previously taking were continued till morning of surgery.

Review of PAC was done in the at waiting room of OT and Nil by Mouth (NBM) status (8hrs) was checked. Inside the operation theatre Phillips Multichannel monitor (**Philips IntelliVue MP70 multi-para monitor)** was used to monitor and record parameters like HR, Rhythm, ECG, Arterial BP, NIBP, SPO2, Temperature and CVP. Baseline vitals were recorded. A peripheral line, IV line was established with 16G IV cannula. The right internal jugular vein was cannulated with triple lumen central venous catheter, left radial arterial/right femoral arterial line was established under local anaesthesia and invasive blood pressure as well as CVP was monitored. Premedication was done with Inj Pantoprazole 40 mg IV + Inj Dexamethasone 8 mg IV and Inj Cefotaxim 20 mg/kg IV was administered to all the patients as a part of the institutional protocol.

Then in the PLRM group, PLRM was performed 2 minutes before anesthesia induction by passive leg-raising at 45° from supine position. In the control group, PLRM was not performed. Direct arterial BP, Heart Rate, CVP and Electrocardiography was monitored. Preoxygenation was done with 100% Fi02 on mask ventilation. Sedation was administered with IV Fentanyl 1 microgram/kg and Midazolam 0.05 mg/kg. Induction was done with Inj Fentanyl 2-4 microgram/kg and neuromuscular block was achieved and maintained with Inj Vecuronium 0.1 mg/kg. Intubation was done with appropriately sized cuffed endotracheal tube. After inflating cuff and securing the tube, controlled mechanical ventilation was started and anaesthesia was maintained on a mixture of O2, AIR, with inhalational anaesthetic agent 1% ISOFLURANE according to vital parameter on closed circle system with CO2 absorber and flow rate of 2 lit/min (**Drager Primus Anaesthesia Machine).** Then, a blinded coworker recorded the hemodynamic data from the anesthesia monitoring system at marked event times. This data was of the direct arterial blood pressure, CVP, and heart rate at 2 minutes prior to performance of PLRM to form a baseline (2 minutes prior to anesthetic injection in control group); immediately before anesthetic injection; immediately before laryngoscopy; and at 5, 10, and 20 minutes after tracheal intubation. Hypotension (systolic blood pressure <20% from baseline) if observed was recorded and treated using Inj Noradrenaline 0.1mcg/kg/min IV infusion and titrated accordingly.

Infusion of Fentanyl, Midazolam, Vecuronium was administered as a mixture of Vecuronium 20 mg, Midazolam 10 mg, Fentanyl 500 mg diluted to 50 cc started as infusion. Heparin was given at a dose of 300-500 U/kg before cannulation and supplemented as necessary to maintain ACT> 480 sec while on Cardio Pulmonary Bypass.

Statistical Analysis

Descriptive Statistics

Descriptive statistics included summary measures like Mean, Standard Deviation for quantitative variables while frequency and percentages were used to summarize qualitative (Categorical) variables.

Analytical Statistics

Inferential statistics included P-values from hypothesis testing procedures. Between-the groups-comparison of mean difference across 2 groups was evaluated with two-independent samples (unpaired) t-test. Chi-square test and Z test was performed for comparing difference in proportions in two independent groups for qualitative parameters. Within-the-group comparison of means in each treatment group was separately performed by paired t-test for assessing change at each time interval. A P-value less than 0.05 was considered as statistically significant for all the comparisons. Data was coded and analyzed with the statistical software, STATA, version 10.1, 2011.

Results

A total of 146 patients were enrolled during the study period and were randomly divided into two groups. Group 1 (n=73) : PRLM group [where passive leg raising maneuver was performed] and Group 2 (n=73) : Control group [where passive leg raising maneuver was NOT performed]. Both the groups were comparable and found no significant difference with respect to demographic profile of the patients with p value >0.05 as shown in table 1.

Table 1: Demographic profile

Demographic data		Group 1	Group 2	P value
Mean age (years)		53.84 ± 12.24	49.02 ± 12.44	>0.05
Weight (kgs)		62.52 ±7.13	64.36 ±6.54	>0.05
Height (cm)		168.32±11.12	166.38±10.36	>0.05
BMI		21.73±5.18	22.84±5.43	>0.05
Gender	Male	40 (54.8%)	44 (60.3%)	>0.05
	Female	33 (45.2%)	29 (39.7%)	

Out of the total 146 patients, CAD was found in majority in PLRM Group (52.1%) and Control Group (57.5%). There was no significant statistical difference in the type of heart disease distribution amongst two groups, (Table 2). The mean LVEF was found to be 49.72 ±5.73 in PLRM group while 48.17 ±5.83 % in Control group. The difference in mean LVEF was statistically not significant, (P >0.05).

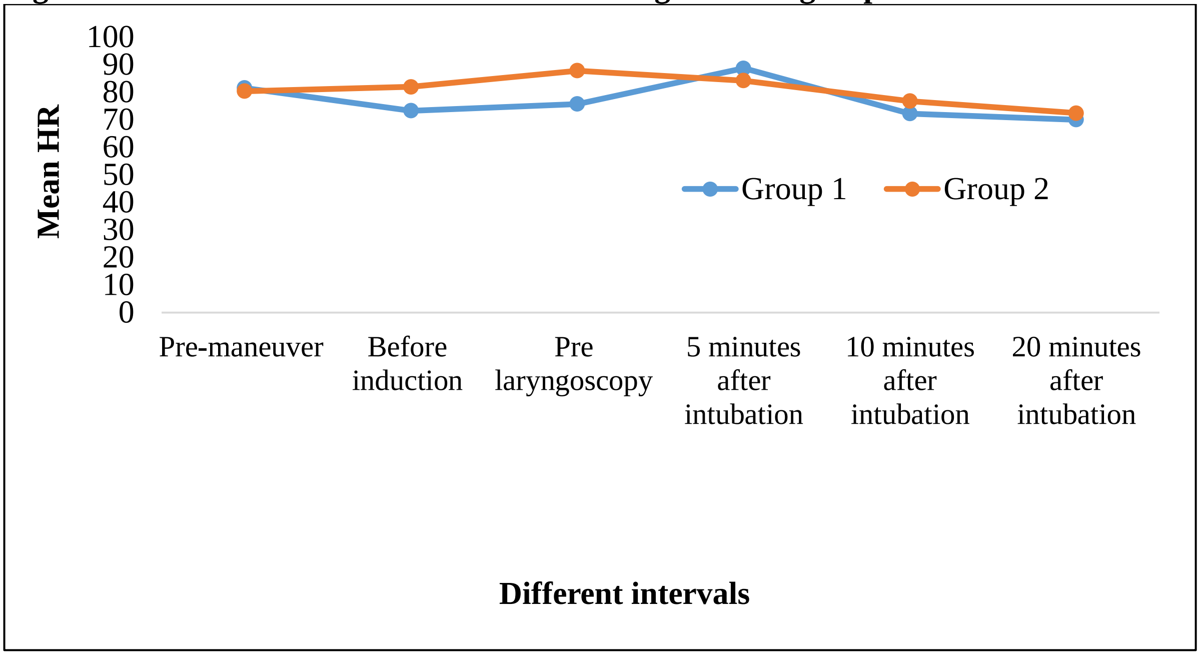
Table 2: Distribution according to type of heart disease

Type of heart disease	Group 1	Group 2	P value
CAD	38	42	X2= 2.14 P>0.05
Valvular	23	20	
CAD/Valvular	09	07	
Other	03	04	
Total	73 (100)	73 (100)	

There was no statistically significant difference amongst the baseline characteristics of mean heart rate, systolic and diastolic blood pressure and CVP in two study groups (P>0.05).

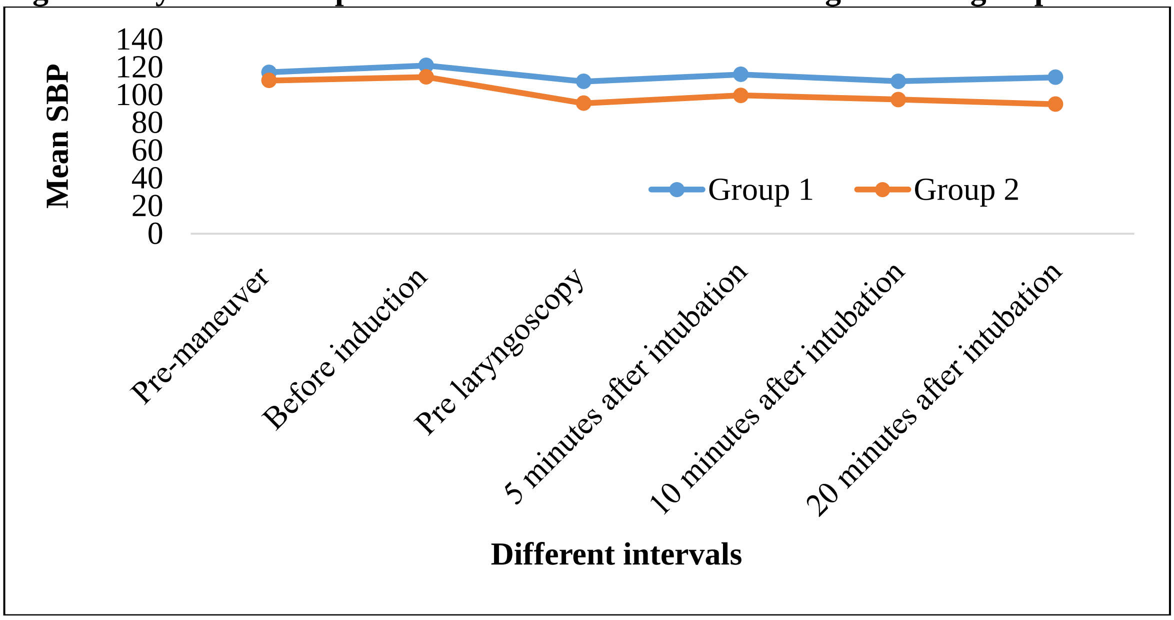
Compared to baseline values, a gradual reduction in the heart rate was observed in both groups before induction and pre laryngoscopy with clinical significance, (P<0.05). The mean intraoperative heart rates of patients from PLRM Group were more stable as compared to Control Group at different time intervals after laryngoscopy with no statistical significance. (P>0.05), (Figure 1).

Figure 1: Heart rate at different intervals among both the groups



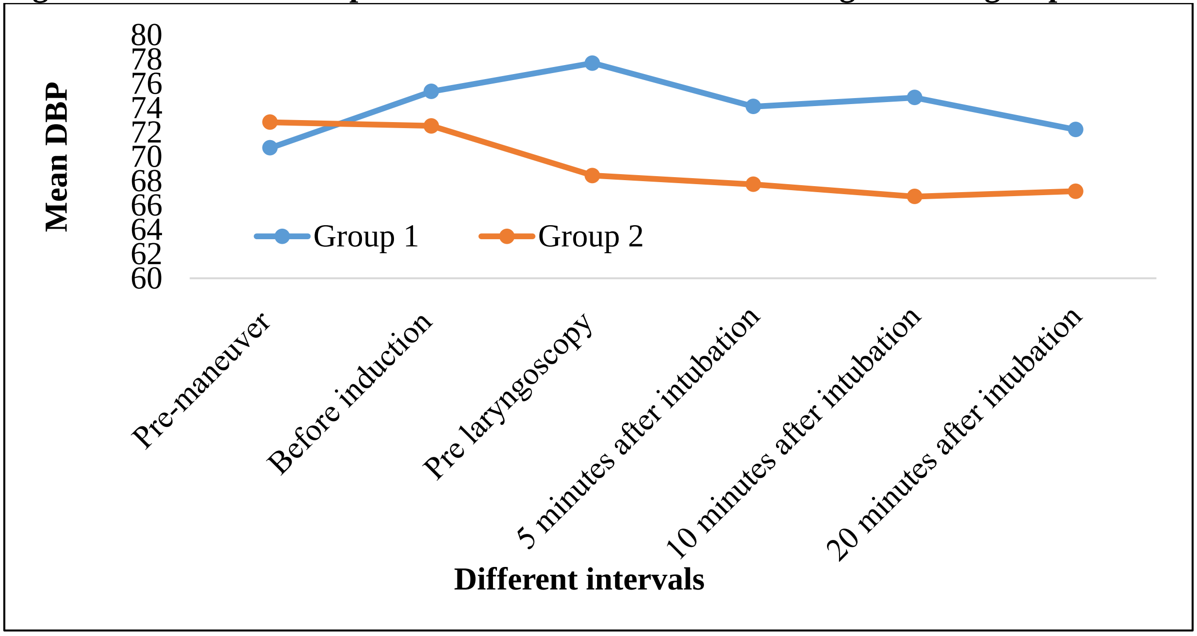
The mean intraoperative systolic blood pressure of patients from PLRM group were more stable as compared to control group at different time intervals after laryngoscopy with statistical significance, (P<0.05), (Figure 2).

Figure 2: Systolic blood pressure at different intervals among both the groups



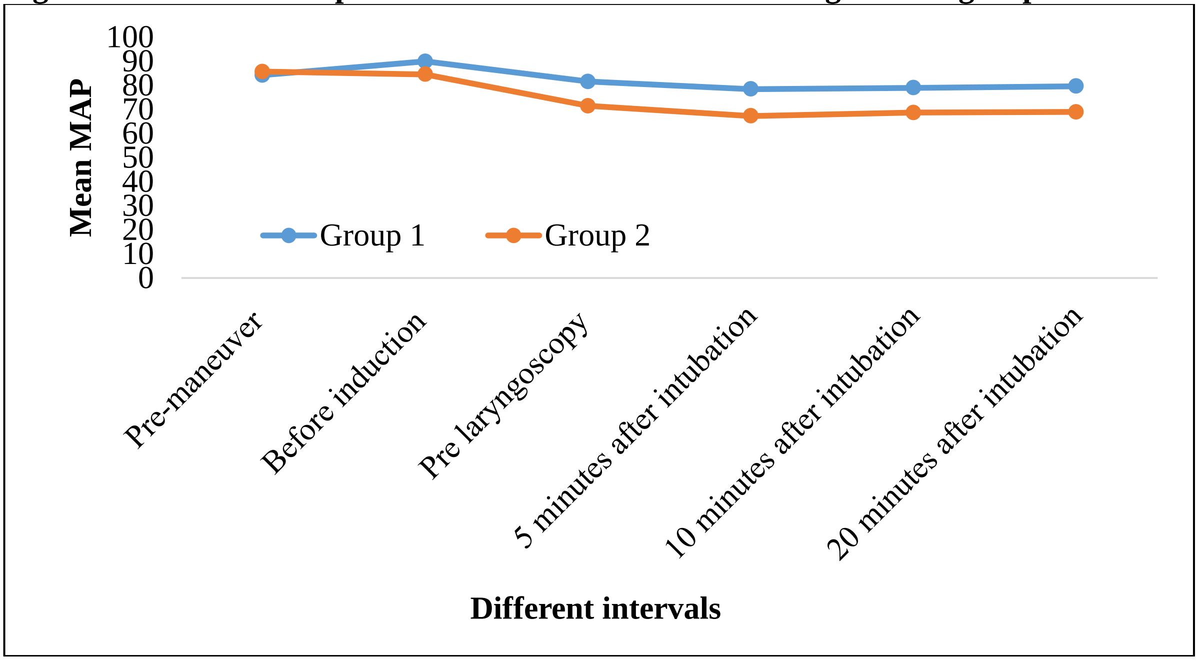
Compared to baseline values, a gradual increase in the diastolic blood pressure was observed in PRLM group before induction with clinically significant difference. (P<0.05). The mean intraoperative diastolic blood pressure of patients from PLRM Group were more stable as compared to Control Group at different time intervals after laryngoscopy with statistical significance. (P<0.05), (Figure 3).

Figure 3: Diastolic blood pressure at different intervals among both the groups



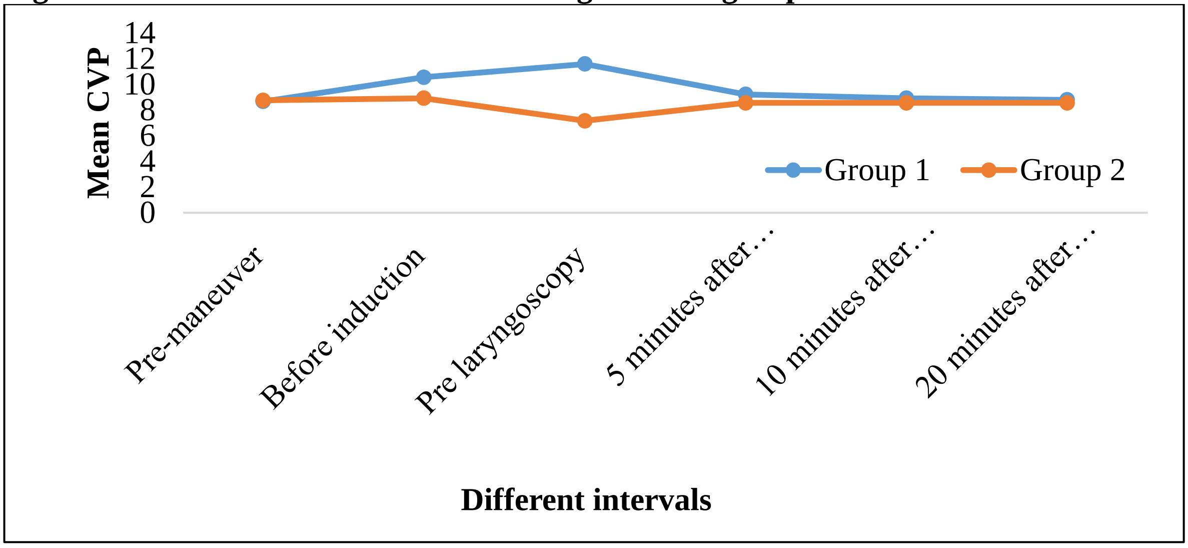
Compared to baseline values, a gradual increase in the MAP was observed in PLRM group before induction with clinically significant difference. ($P<0.05$). The mean intraoperative arterial blood pressure of patients from PLRM Group were more stable as compared to Control Group at different time intervals after laryngoscopy with statistical significance. ($P<0.05$), (Figure 4).

Figure 4: Mean arterial pressure at different intervals among various group



Compared to baseline values, a gradual increase in the CVP was observed in PLRM group before induction. The mean CVP of patients from PLRM Group were more stable as compared to Control Group at different time intervals after laryngoscopy till 5 minutes after intubation but were comparable among both the groups 10 and 20 minutes after intubation with no statistical significance. ($P>0.05$).

Figure 5: CVP at different intervals among both the groups



There was a significant statistical difference in IV Drug (Inj Noradrenaline) distribution amongst two groups after induction showing control group required more IVD compared to PLRM group, (Table 3).

Patients in PLRM group showed decreased episodes of hypotension compared to control group, (P<0.05).

Table 3: Monitoring of IVD (Inj Norad) at different intervals among both the groups

Respiratory rate	Group I	Group II	P value
Pre-maneuver	00	00	>0.05
Before induction	00	00	>0.05
Pre laryngoscopy	05	10	<0.05
5 minutes after intubation	06	11	<0.05
10 minutes after intubation	08	13	<0.05 (S)
20 minutes after intubation	12	17	<0.05 (S)

Discussion

In the present study, both the groups were comparable and found no significant difference with respect to demographic profile of the patients with p value > 0.05 which is comparable with the study conducted by Fakhari S et al [9] and Jabot et al [10]. Out of total 146 patients, CAD was found in majority in PLRM group (52.1%) and control group (57.5%), (p>0.05). The mean LVEF was found to be 49.72 ±5.73 in PLRM group while 48.17 ±5.83 in control group. This finding is in accordance with Fakhari S. et al [9] and Jabot J et al [10]. In the present study, the baseline characteristics were noted before giving induction doses of both the drugs. There was no statistically significant difference amongst the baseline characteristics of mean heart rate, systolic and diastolic blood pressure and CVP in two study groups which is comparable with the study done by Fakhari S. et al [9].

The mean heart rate in PLRM group and control group at baseline were 81.52±7.13 and 80.36±6.54 respectively. Compared to baseline values, a gradual reduction in the heart rate was observed in both groups before induction and pre laryngoscopy with clinical significance (P value <0.05). The mean intraoperative heart rates of patients from PLRM group were more stable as compared to control group at different time intervals after laryngoscopy with no statistical significance. (P>0.05). Similar findings are reported in Fakhari S. et al study [9].

Compared to baseline values, a gradual increase in the SBP, DBP, MAP was observed in PRLM group before induction with clinically significant difference, ($P<0.05$). The mean intraoperative SBP, DBP and MAP of patients from PLRM Group were more stable as compared to Control Group at different time intervals after laryngoscopy with statistical significance, ($P<0.05$). However, the mean CVP in PLRM group and control group at baseline 8.68±2.28 and 8.76±2.32 respectively. Compared to baseline values, a gradual increase in the CVP was observed in PLRM group before induction. The mean CVP of patients from PLRM group were more stable as compared to control group at different time intervals after laryngoscopy till 5 minutes after intubation but were comparable among both the groups 10 and 20 minutes after intubation with no statistical significance, ($P>0.05$). All the above findings are comparable with the study conducted by Fakhari S. et al [9] and correlated with the previous studies [6, 10, 11].

Out of total 146 patients, IVD (Inj. Nord) requirement was found that episodes of hypotension in 31 patients in PLRM Group (42.46%) and 51 patients in Control Group (69.8%). There was significant statistical difference showing that patients in PLRM group showed decreased episodes of hypotension compared to control group, ($P<0.05$). These findings are correlated with the study done by Fakhari S. et al [9], Cherpanath et al [12] and Bentzer et al [13].

In the current study, the peak increase in CVP was more than 4 mmHg, which agreed with Lakhal et al [14] findings that CVP changes after PLRM were at least ≥2 mmHg, which is required to affect patients' hemodynamic parameters. PLRM are regularly prescribed to treat hypotension or to predict patient responses to volume expansion, although few studies have used PLRM for prophylactic purposes. Administration of PLRM to prevent anesthesia-induced hypotension differs from volume responsibility assessment in that all aspects of PLRM (eg, increased preload, afterload, and CO) contribute to such prevention [5, 6].

The current study proved that PLRM help maintain hemodynamic stability, similar to the findings of Yu et al [15]. Here, PLRM reduced heart rates for short periods, similar to Monnet et al [6] and Kyriakides et al [16], who reported increased CO and arterial blood pressure in response to PLRM as positive responses to fluid therapy.

Measuring CO using echocardiography is an operator-dependent skill that may cause study bias; therefore, the current study did not measure CO. The head-down tilt or Trendelenburg position uses a similar mechanism to transport blood from the lower extremities to the upper body and has been employed successfully to treat or prevent hypotension during the application of some anesthetic techniques [8, 17].

Frost studied this position and concluded that it can help identify patients who need IV fluid after surgery;24 however, Reuter et al reported that this position does not improve cardiac performance [18]. Thus, despite such controversies regarding the potential of PLRM for predicting patient volume status, the present study proved such maneuvers to be useful for reducing the prevalence or severity of hypotension during anesthesia induction.

The physiological effects of PLR consist of an increase in venous return and cardiac preload. The PLR thus acts as a self-volume challenge which is easy to-perform and completely reversible. It has gained an increasing interest in the field of functional hemodynamic monitoring since it can help to detect fluid responsiveness in critically ill patients even in cases of ventilator spontaneous triggering or cardiac arrhythmias. Its optimal use requires a real-time cardiovascular assessment device able to quantify accurately the short-term hemodynamic response.

Limitations:

- Limited sample size
- Limited duration of study
- Cardiac output monitoring could not be done due to nonavailability of advanced hemodynamic monitors.
- Whether PLRM is helpful in preventing post anesthesia induced hypotension in patients belonging to ASA class III and IV could not be evaluated.Hence further studies are needed in ASA class III And IV patients.

Conclusion

The present study concludes that PLRM is a simple, rapid, safe, and effective method for preventing anesthesia-induced hypotension and helps induce anesthesia in a more stable hemodynamic state during cardiac operations with simple monitoring of MAP and CVP.

The PLRM thus acts as a self-volume challenge which is easy to-perform even in the absence of initial pre-loading prior to induction of anesthesia in patients with poor cardiac reserve. It has gained an increasing interest in the field of functional hemodynamic monitoring since it can help to detect fluid responsiveness in critically ill patients even in cases of spontaneous breathing or cardiac arrhythmias.

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