# Effect of Magnesium Sulfate on Hemodynamic Changes During Sternotomy and Laryngoscopy in Coronary Artery Bypass Graft Surgery: A Randomized Clinical Trial

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**Abstract**

**Background:** This study was designed to evaluate the effectiveness of low and high dose magnesium sulfate in reducing pressure responses to laryngoscopy and sternotomy.

**Methods:** A total of 90 patients were assigned into three groups. The patients in Group L received a 20 mg/kg bolus dose of magnesium sulfate 3 minutes before intubation followed by an infusion of magnesium sulfate (10 mg/kg/h) in contrast to 40 mg/kg of magnesium sulfate followed by an infusion of 20 mg/kg/h magnesium sulfate administered to Group H. Patients in Group P received saline as placebo. Heart rate and mean arterial pressure (MAP) recorded at the baseline were noted down again before intubation and 30 seconds, 2 and 4 minutes after intubation and 1 minute before, and 30 seconds, 2 and 4 minutes after sternotomy.

**Results:** MAP in Groups L and H compared to Group P was significantly lower, after intubation (P = 0.0040). The difference between MAP in Groups L and H was only statistically significant 30 seconds after intubation. MAP 30 seconds and 2 minutes after sternotomy was statistically different between Groups L and H compared to Group P. The difference between Groups H and P was only statistically significant before sternotomy and 4 minutes after sternotomy (P = 0.0001).

**Conclusions:** A low dose magnesium sulfate attenuates the hemodynamic response to laryngoscopy and sternotomy in coronary artery bypass graft surgery.



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**Keywords:** Magnesium sulfate; Laryngoscopy; Sternotomy; Hemodynamic response; Coronary artery bypass graft

## Introduction

Hemodynamic stability during anesthesia and surgery is one of the basic goals that every anesthesiologist wishes to achieve. Laryngoscopy and sternotomy are two major stresses to the human body that could alter heart rate (HR) and blood pressure significantly and are of great threat in achieving this goal. Although these changes may be very well tolerated by healthy individuals but can be highly hazardous in patients with ischemic heart disease.

Many pharmacological techniques have been previously proposed to attenuate the responses elicited by the mentioned stresses during anesthesia such as using adrenoreceptor blockers, calcium channel blockers, opioids, and vasodilators (1,2).

Magnesium sulfate inhibits catecholamine release from adrenergic nerve terminals and the adrenal gland and also by a direct mechanism causes coronary artery dilatation (3,4). Considering the mentioned effects of magnesium sulfate, it can be a good candidate to attenuate stress responses during laryngoscopy and sternotomy.

The primary outcome of this study was to evaluate the effect of low and high doses of magnesium sulfate on mean arterial pressure (MAP) of patients undergoing coronary artery bypass graft (CABG) during laryngoscopy and sternotomy and compare it with the placebo group. Changes in HR were considered as secondary outcomes.

## Materials and Methods

The study protocol was approved by the Institutional Ethics Committee; the nature of the study was thoroughly explained to the patients and a written informed consent was obtained from the patients. In

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this randomized, double-blinded, placebo-controlled clinical trial, 90 patients of both sexes aged between 40 and 80 years of the American Society of Anesthesiologists physical status Classes II to III who were scheduled for elective CABG surgery were selected.

The patients with left ventricular ejection fraction < 40%, left ventricular aneurysm, valvular heart disease, previously documented hypertension, and diabetes mellitus were not enrolled in the study. Patients with renal disease (Cr > 2 mg/dl) or unstable hemodynamics or any electrolyte abnormalities were also not included in the study. Moreover, if the intubation attempt took longer than 15 seconds, the patients were excluded from the study.

Using a computer-generated randomization list, the patients were randomly assigned into three groups consisting of a control group (Group P, n = 30) and two interventional. Required drugs were prepared and administered by an anesthetist who was not involved in the administration of the drugs. All of the drugs were prepared into the 20 ml volumes.

On arrival to the operating room, all patients were monitored with an electrocardiogram, non-invasive blood pressure and pulse oximetry. Baseline HR and MAP were recorded. An 18-gauge cannula was inserted and lactated ringer solution 7 ml/kg was administered. The radial artery of the non-dominant hand of all patients was cannulated using a 20 gauge cannula. The patients in Group L (low dose group) received a 20 mg/kg bolus dose of magnesium sulfate over a period of 3 minutes followed by an infusion of magnesium sulfate (10 mg/kg/h) in contrast to 40 mg/kg of magnesium sulfate followed by an infusion of 20 mg/kg/h magnesium sulfate administered to Group H (high dose group). Patients in Group P received saline as placebo. All the bolus doses of placebo and magnesium sulfate were administered 3 minutes before induction of anesthesia, and the infusions were discontinued 3 minutes after sternotomy. Anesthesia was induced with 5 mg/kg sodium thiopental, 0.1 mg/kg midazolam, and 4 μg/kg fentanyl; endotracheal intubation was facilitated with 0.1 mg/kg pancuronium. After tracheal intubation which was done by a single anesthesiologist, anesthesia was maintained by isoflurane and $N_2O$ (50%); 0.2 mg/kg pancuronium and 1 μg/kg fentanyl were administered half hourly. Ventilation was adjusted to maintain normocapnia (end-tidal carbon dioxide partial pressure 4.7-5.3 kPa). A central venous catheter was inserted after induction of anesthesia. MAP was maintained between 50 and 90 mmHg. If plasma hematocrit was below, 20% a unit of red blood pack cell was administered.

The variables recorded at the baseline were noted down again before intubation and 30 seconds, 2 and 4 minutes after intubation and 1 minute before (baseline), during and 30 seconds, 2 and 4 minutes after sternotomy. The variables were noted down by an anesthesiologist who was not aware of patients grouping.

Considering the power of 80% and $\alpha = 0.05$ 30 samples in each group was sufficient to show at least 10 mmHg change in MAP. The distribution of data was tested by the Kolmogorov–Smirnov test. They followed a normal distribution. For statistical analysis of demographic data and comparison of different groups, one-way ANOVA was used. Fischer's exact or chi-square tests were appropriate for the analysis of categorical data. HR and MAP were analyzed by repeated measurement analysis. Two-tailed $P < 0.0500$ were considered statistically significant. A statistical analysis of the data was performed using SPSS for windows, release 19 (SPSS Inc., Chicago, Illinois, USA).

## Results

### *Patients characteristics*

A total of 90 patients were randomized; there were no protocol violations and all the patients were enrolled in data analysis. Patients' basic characteristics consisting of the patients age, weight, sex, left ventricular ejection fracture, and duration of intubation were similar and are presented in table 1.

### *Hemodynamic changes following tracheal intubation*

After 30 seconds (Group L: 106.3 ± 11.9 mmHg, H: 95.5 ± 6.8 mmHg, P: 122.1 ± 11.9 mmHg), 2 minutes (Group L: 94.2 ± 13.1 mmHg, H: 87.2 ± 8.3 mmHg, P: 108.4 ± 16.9 mmHg) and 4 minutes (Group L: 79.5 ± 10.9 mmHg, H: 77.7 ± 8.8 mmHg, P: 91.3 ± 19.0 mmHg) MAP in Group P was significantly higher compared to Groups L and H ($P = 0.0040$). In addition, MAP recorded before intubation was significantly lower in Group H (83.7 ± 10.6 mmHg) compared to Group P (94.3 ± 14.3 mmHg) (Figure 1).

**Table 1.** Basic characteristics of the patients

| Characteristics | Control group | Low dose group | High dose group | P value |
|---|---|---|---|---|
| Age | 57.2 ± 7.6 | 58.1 ± 12.3 | 57.1 ± 9.0 | 0.9200 |
| Weight | 73.2 ± 8.7 | 73.1 ± 8.8 | 72.8 ± 8.2 | 0.9840 |
| Left ventricular ejection fraction | 52.1 ± 3.3 | 51.6 ± 4.2 | 53.3 ± 4.9 | 0.3030 |
| Sex (F/M) | 15/15 | 16/14 | 14/16 | 0.8850 |
| Intubation time | 9.6 ± 2.1 | 9.7 ± 1.5 | 10.2 ± 1.3 | 0.3310 |

Data presented as mean ± SD. SD: Standard deviation

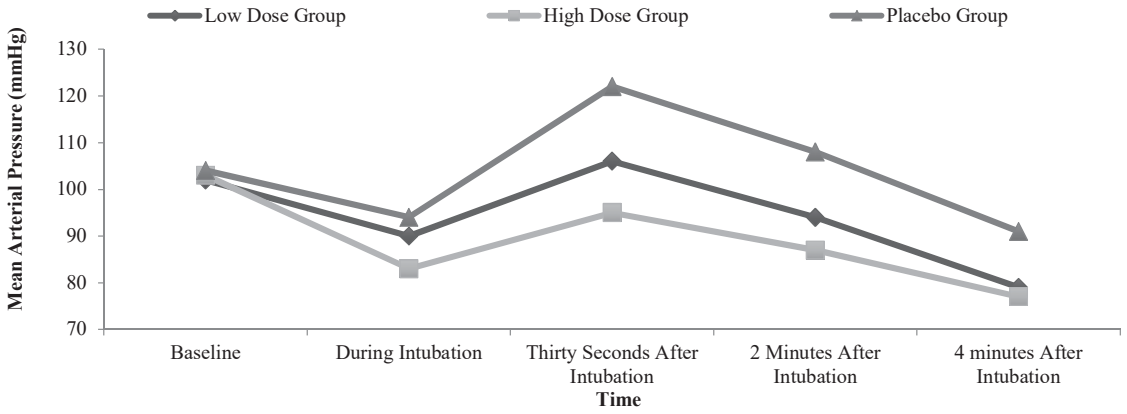


**Figure 1.** Changes in mean arterial pressure during intubation in the two interventional groups and the placebo group

The MAP during intubation was significantly different at different measured times in groups (repeated measure analysis of variance, between subjects effect), and at different measured times in each group (repeated measure analysis of variance, within subjects effect).

HR before intubation and 30 seconds after intubation was significantly lower in Group L (83.0 ± 25 bpm, 84.7 ± 23.2 bpm) and H (82.3 ± 16.6 bpm, 94.0 ± 16.0 bpm) compared to Group P (85.2 ± 11.5 bpm, 106.0 ± 7.6 bpm) (P = 0.0010). Two minutes after intubation HR was significantly lower in Group L (78.5 ± 21.4 bpm) compared to Group P (92.0 ± 17.0 bpm). HR was not statistically significant between Groups L and H at any time (Figure 2).

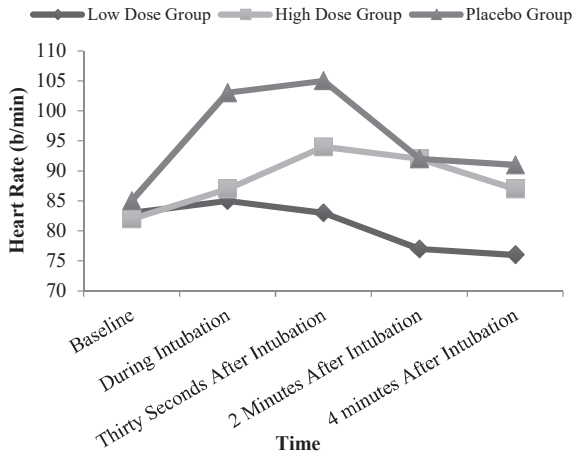


**Figure 2.** Changes in heart rate during intubation in the two interventional groups and the placebo group

The HR during intubation was not significantly different in groups (repeated measure analysis of variance, between subjects effect), yet there was statistically meaningful in HRs measured at different times in each group (repeated measure analysis of variance, within subjects effect.

**Hemodynamic changes following sternotomy**

MAP 30 seconds and 2 minutes after sternotomy was statistically different between Groups L (98.2 ± 7.1, 94.0 ± 11.1 mmHg) and H (94.9 ± 1.7 mmHg, 92.5 ± 6.7 mmHg) compared to Group P (106.9 ± 15.7, 102.3 ± 11.5 mmHg). The difference between Groups H and P was only statistically significant before sternotomy and 4 minutes after sternotomy (P = 0.0010) (Figure 3).

The MAP during sternotomy was significantly different at different measured times in groups (repeated measure analysis of variance, between subjects effect), yet at different measured times in each group and it was not statistically significant (repeated measure analysis of variance, within subjects effect).

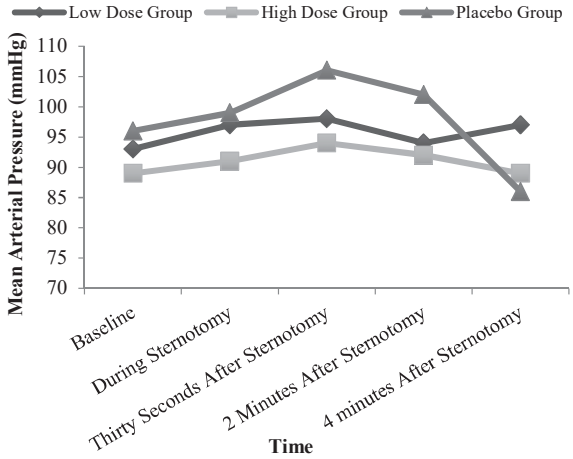


**Figure 3.** Changes in mean arterial pressure during sternotomy in the two interventional groups and the placebo group

The difference in HR was significant at all times between Groups L and H compared to Group P and but it was not statistically different in between Groups L and H.

The HR during sternotomy was significantly

different at different measured times in groups (repeated measure analysis of variance, between subjects effect), and at different measured times in each group (repeated measure analysis of variance, within subjects effect) (Figure 4).

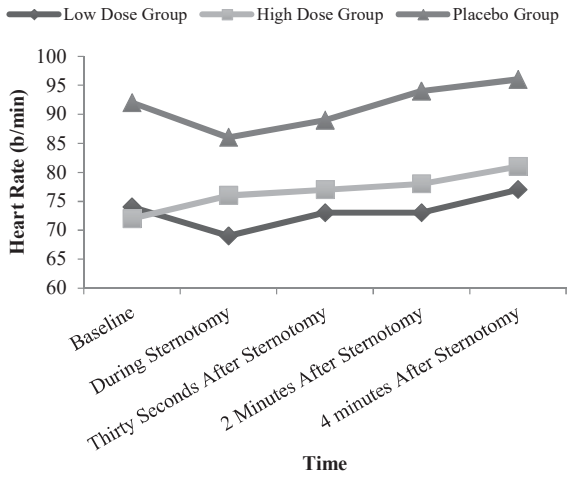


**Figure 4.** Changes in heart rate during sternotomy in the two interventional groups and the placebo group

## Discussion

In this study, the effect of low dose and high dose magnesium sulfate, on hemodynamic profiles after tracheal intubation and sternotomy of patients undergoing CABG was studied.

This study illustrated that pretreatment with both high and low doses of magnesium sulfate lead to better hemodynamic profile following tracheal intubation and sternotomy in patients who undergo CABG surgery. There were no differences in hemodynamic profiles of patients who received high or low doses of magnesium sulfate. The high dose of magnesium sulfate dropped MAP more than the low dose.

The drop in MAP observed after intubation and sternotomy in patients receiving high dose magnesium sulfate was significant. This drop in MAP is unfavorable and also the fact that no considerable difference was observed between patients receiving a high dose and low dose magnesium sulfate supports using low dose magnesium sulfate. It is reasonable to suggest that low dose magnesium sulfate may be more relevant in preventing changes in hemodynamics in patients undergoing CABG compared to high dose magnesium sulfate. Previously, Trivedi and Patel (5) compared the effect of low dose magnesium sulfate and buprenorphine and concluded that low dose magnesium sulfate attenuated the response to laryngoscopy better than buprenorphine.

In a prospective study, Puri et al. (3) compared hemodynamic changes following induction of anesthesia and intubation with pretreatment of magnesium sulfate or lidocaine. The group treated with magnesium sulfate 50 mg/kg showed a slight increase in MAP and systemic vascular resistance and no decrease in cardiac output, as compared to the lidocaine group, with equally good control of increased HR.

Magnesium sulfate has been previously used to induce anesthesia with conflicting results (6,7). Magnesium has also been suggested for reducing anesthetic requirements, attenuating cardiovascular effects from laryngoscopy and intubation, and exerting muscle relaxing effects (3-8). Magnesium was found to induce coronary and systemic vasodilation, to improve metabolism of cardiomyocytes, and to attenuate ischemia–reperfusion injury of myocardial tissue (9-12). Except for a brief decrease in platelet function, there is no other major complication to 50 mg/kg of magnesium sulfate (13).

Magnesium sulfate is one of the most commonly drugs used in obstetric practice to prevent eclamptic seizures during pregnancy. Magnesium decreases the amount of acetylcholine liberated at the end plate by the motor nerves and controls convulsions by blocking neuromuscular transmission (14). Altering calcium metabolism in the body is one of the many proposed mechanisms of action. Magnesium acts peripherally to produce vasodilation which may be antagonized partially by parenteral calcium administration. With low doses only flushing and sweating occur, but larger doses can cause lowering of blood pressure (15). Although many pathway has been proposed for magnesium sulfate in the human body, the exact mechanism of action of magnesium sulfate is mostly hypothetical.

The main shortcoming of this study was that serum levels of magnesium were not measured before induction of anesthesia between the studied groups.

We suggest that in future studies in addition to dose titration of magnesium sulfate on hemodynamic profiles following sternotomy and tracheal intubation, the effect of magnesium sulfate on oxygen delivery be studied.

## Conclusion

Both 20 mg/kg sulfate magnesium followed by an infusion of 10 mg/kg/h until after sternotomy may be reasonable in attenuate the hemodynamic response to laryngoscopy and sternotomy in patients undergoing CABG surgery.

## Conflict of Interests

Authors have no conflict of interests.

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