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Dexmedetomidine vs Magnesium Sulphate for Optimizing Hemodynamic Stability in Laparoscopic Surgery: A Prospective Randomized Double-Blind Controlled Study

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Abstract: ***Background: Laparoscopic surgery has become the preferred surgical approach due to its benefits, including reduced morbidity, mortality, and hospital stay. However, the hemodynamic changes associated with CO2 pneumoperitoneum, including increased mean arterial pressure, systemic vascular resistance, and myocardial oxygen demand, pose challenges for anaesthesiologists. Various pharmacological agents were used to mitigate these responses. This study compared the efficacy of Dexmedetomidine and Magnesium Sulphate in attenuating hemodynamic fluctuations during laparoscopic surgery under general anaesthesia. Aims: To evaluate and compare the efficacy of intravenous Dexmedetomidine and Magnesium Sulphate infusion in maintaining hemodynamic stability during laparoscopic surgery and to assess any adverse effects of these drugs. Study Design: A prospective randomized double-blind controlled study. Material and Methods: The study was conducted at Hi-Tech Medical College & Hospital, Bhubaneswar, from March 2023 to February 2025. The study included 135 ASA I and II patients aged 18-60 years, scheduled for elective laparoscopic surgery. Patients were randomly divided into three groups: Group C: Received 0.9% Normal Saline (control group). Group D: Received Dexmedetomidine 1 mcg/kg over 10 minutes, followed by an infusion of 0.5 mcg/kg/hour. Group M: Received Magnesium Sulphate 30 mg/kg over 10 minutes, followed by an infusion of 10 mg/kg/hour. Hemodynamic parameters, including heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP), were recorded at baseline, before and after intubation, and at 5, 10, 20, 30, and 40 minutes of pneumoperitoneum. Adverse drug reactions, such as hypotension, bradycardia, and hypoxia were also monitored. Results and Discussion: This study statistically confirmed that Dexmedetomidine was more effective than Magnesium Sulphate in controlling hemodynamic responses during laparoscopic surgery under general anaesthesia. Patients in the Dexmedetomidine group exhibited significantly lower HR, SBP, DBP, and MAP at all measured intervals ($p < 0.05$), ensuring greater cardiovascular stability. Although mild bradycardia and hypotension were observed, they were manageable and did not compromise patient safety. Given these findings, Dexmedetomidine emerges as a superior agent for attenuating the cardiovascular effects of pneumoperitoneum, supporting its preferential use in laparoscopic procedures. Conclusion: This study provides insights into the relative efficacy of Dexmedetomidine and Magnesium Sulphate in managing hemodynamic responses during laparoscopic surgery. The findings will aid anaesthesiologists in optimizing patient safety and perioperative management during laparoscopic procedures.***

Keywords: Dexmedetomidine, Magnesium Sulphate, Laparoscopic Surgery, Hemodynamic Stability, General Anaesthesia, Pneumoperitoneum

1. Introduction

To reduce patient trauma, morbidity, mortality, and hospital stay, with consequent reductions in health care costs, laparoscopic procedures are the preferred choice of surgical approach in both developing and developed countries. Hemodynamic changes in laparoscopic surgery are a major concern for anaesthesiologists. The hemodynamic consequences of pneumoperitoneum include an increase in mean arterial pressure, a rise in systemic vascular resistance, and increased myocardial oxygen demand, leading to myocardial ischemia and cerebral haemorrhage.

Since the advent of laparoscopy in the early 1970s, anaesthesia for laparoscopy has been continuously evolving, with ongoing efforts to identify an ideal anaesthetic drug to attenuate hemodynamic responses due to carbon dioxide (CO_2) pneumoperitoneum. Both mechanical and neuroendocrine factors contribute to the hemodynamic changes induced by CO_2 pneumoperitoneum. An increase in intra-abdominal pressure above 10 mmHg and patient positioning significantly impact hemodynamics, including decreased thoraco-pulmonary compliance (30% to 50%), increased systemic and pulmonary vascular resistance (SVR), severely increased arterial pressure, and inferior vena cava (IVC) compression, leading to decreased venous return and consequently reduced cardiac output (10% to 30%). These factors can precipitate adverse cardiac events in patients with pre-existing cardiovascular and cerebrovascular diseases.

Maintaining hemodynamic parameters during laparoscopic procedures is of paramount importance because intraoperative hemodynamic variations may lead to catastrophic adverse reactions, particularly in patients with pre-existing cardiovascular and cerebrovascular comorbidities.

The two main factors responsible for hemodynamic variations are elevated $PaCO_2$ and increased intra-abdominal pressure. Many clinical trials on healthy individuals have demonstrated that α2-adrenergic receptor agonists are highly effective in controlling hemodynamic variations. Studies continue to

explore and compare the efficacy of different α2-adrenergic receptor agonists. Magnesium Sulphate has also shown efficacy in maintaining hemodynamic stability. In this study, we aim to compare the effects of Dexmedetomidine and Magnesium Sulphate on heart rate, blood pressure, and mean arterial pressure when administered intravenously as premedication during laparoscopic surgery under general anaesthesia.

2. Methods and Methodology

This study was conducted in the Department of Anaesthesiology at Hi-Tech Medical College & Hospital, Bhubaneswar, from March 2023 to February 2025. It included patients aged 18-60 years, weighing 50-70 kg, classified as ASA I and II, undergoing elective laparoscopic surgery under general anaesthesia. A prospective randomized double-blind controlled design was used. A sample size of 135 patients was taken and divided into three equal groups containing 45 patients in each group.

Patients were randomly assigned to one of three groups: Group C (control) received 0.9% Normal Saline, Group D received Dexmedetomidine, and Group M received Magnesium Sulphate. Study drugs were prepared in identical syringes by an anaesthesiologist not involved in data collection to maintain blinding. Patients were premedicated and induced as per protocol, with hemodynamic parameters monitored at predefined intervals. Data collection included SBP, DBP, MAP, HR, SpO_2, and $EtCO_2$ at baseline, pre- and post-intubation, and at 5, 10, 20, 30, and 40 minutes of pneumoperitoneum. The primary outcome was hemodynamic stability, while secondary outcomes included adverse drug reactions.

3. Results

A total of 135 patients were included in the study. They were randomly assigned to one of three equal groups: Group-C (NS), Group-M (Magnesium Sulphate) and Group-D (Dexmedetomidine)- with 45 patients in each group. The allocation process was conducted using computer-generated randomization to ensure an unbiased distribution.

Following completion of the study, an intergroup analysis was performed using the student's t-test to compare the two groups, yielding the following results. The data was presented as range, mean, and standard deviation (SD). A p-value < 0.05 was considered statistically significant.

Table 1: Sex distribution in group D, M and C.

Gender	Dexmed (n, %)	MgSo4 (n, %)	NS (n, %)
Female	34 (75.55%)	39 (86.67%)	34 (75.55%)
Male	11 (24.45%)	6 (13.33%)	11 (24.45%)
Total	45 (100%)	45 (100%)	45 (100%)

Table 2: Distribution of age in years

Drug	Age (years) (Mean ± SD)	p- Value (ANOVA)
Dexmeditomidine (D)	33.20 ± 10.18	0.481
Magnesium Sulphate (M)	33.22 ± 10.10	
N.S (C)	35.39 ± 9.63	

Table 3: Distribution of height in cms

Drug	Height (cm) (Mean ± SD)	p- Value (ANOVA)
Dexmeditomidine (D)	155.02 ± 10.52	0.124
Magnesium Sulphate (M)	152.73 ± 7.12	
N.S (C)	156.63 ± 9.35	

Table 4: Distribution of mean weights in kg.

Drug	Weight (Kg) (Mean ± SD)	p- Value (ANOVA)
Dexmeditomidine (D)	57.20 ± 6.89	0.929
Magnesium Sulphate (M)	57.71 ± 7.25	
N.S (C)	57.58 ± 6.78	

Table 5: Comparison of mean heart rate among the groups

Time (min)	Dexmed Mean ± SD	MgSo4Mean ± SD	NS Mean ± SD	P Value	Significance
HR_B	81.13 ± 11.15	85.43 ± 6.50	78.20 ± 8.25	0.001	**Significant**
HR_0	81.37 ± 11.46	90.67 ± 7.07	82.63 ± 8.34	0.000	**Significant**
HR_5	83.72 ± 11.44	92.11 ± 9.56	88.59 ± 7.83	0.000	**Significant**
HR_10	78.74 ± 14.04	94.15 ± 12.51	93.26 ± 6.84	0.000	**Significant**
HR_20	69.98 ± 19.35	98.46 ± 11.96	96.70 ± 7.41	0.000	**Significant**
HR_30	69.46 ± 14.55	104.39 ± 13.58	93.36 ± 21.21	0.000	**Significant**
HR_40	63.61 ± 24.66	117.65 ± 25.31	96.93. ± 23.89	0.098	**Significant**

Table 6: Comparison of systolic blood pressure among the groups

Time (min)	Dexmed Mean ± SD	MgSo4Mean ± SD	NS Mean ± SD	P Value	Significance
SBP_B	129.37 ± 13.90	124.74 ± 12.18	125.26 ± 8.01	0.116	Not Significant
SBP_0	126.57 ± 14.64	135.54 ± 8.95	137.35 ± 9.87	0.000	**Significant**
SBP_5	125.72 ± 13.25	141.48 ± 4.18	138.65 ± 6.45	0.000	**Significant**
SBP_10	129.26 ± 11.34	144.41 ± 5.33	141.67 ± 6.45	0.000	**Significant**
SBP_20	117.60 ± 28.16	147.13 ± 5.04	146.34 ± 6.42	0.000	**Significant**
SBP_30	119.05 ± 21.46	139.53 ± 22.22	140.48 ± 31.45	0.000	**Significant**
SBP_40	118.93 ± 36.07	128.92 ± 42.60	138.97 ± 33.10	0.098	Not Significant

Table 7: Comparison of diastolic blood pressure among the groups

Time (min)	Dexmed Mean ± SD	MgSo4Mean ± SD	NS Mean ± SD	P Value	Significance
DBP_B	85.98 ± 12.02	85.83 ± 8.67	88.89 ± 8.90	0.256	Not Significant
DBP_0	90.17 ± 12.86	97.15 ± 6.78	98.11 ± 6.88	0.000	**Significant**
DBP_5	90.09 ± 9.91	102.63 ± 6.54	99.98 ± 6.48	0.000	**Significant**
DBP_10	83.72 ± 9.89	104.98 ± 3.32	102.30 ± 7.16	0.000	**Significant**
DBP_20	79.88 ± 20.02	101.78 ± 8.90	105.26 ± 7.56	0.000	**Significant**
DBP_30	81.21 ± 16.94	100.45 ± 10.29	104.02 ± 23.90	0.000	**Significant**
DBP_40	80.93 ± 24.49	99.21 ± 32.62	101.45 ± 25.42	0.008	**Significant**

Table 14: MAP variation among the groups

Time	Dexmed Mean ± SD	MgSo4Mean ± SD	NS Mean ± SD	P Value	Significance
MAP_B	95.76 ± 12.84	93.04 ± 10.07	97.63 ± 10.88	0.152	Not Significant
MAP_0	100.07 ± 10.60	106.09 ± 7.34	105.70 ± 7.29	0.001	**Significant**
MAP_5	96.70 ± 10.06	109.26 ± 6.01	111.80 ± 8.55	0.000	**Significant**
MAP_10	99.93 ± 10.07	115.02 ± 3.67	114.93 ± 9.10	0.000	**Significant**
MAP_20	86.74 ± 21.40	112.33 ± 8.26	137.24 ± 148.36	0.028	**Significant**
MAP_30	89.92 ± 17.65	110.67 ± 19.82	113.35 ± 30.98	0.000	**Significant**
MAP_40	87.18 ± 25.99	104.76 ± 34.74	114.05 ± 27.89	0.002	**Significant**

4. Discussion

This study evaluated the efficacy of intravenous dexmedetomidine versus magnesium sulphate in attenuating the cardiovascular effects of pneumoperitoneum during laparoscopic surgery under general anaesthesia. Hemodynamic parameters such as heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) were assessed.

Baseline HR, SBP, DBP, and MAP were comparable across the groups. However, dexmedetomidine significantly attenuated the hemodynamic stress response, maintaining lower HR and blood pressure levels compared to magnesium sulphate and the control group. The superior efficacy of dexmedetomidine may be attributed to its central sympatholytic action, leading to reduced catecholamine release. These findings are consistent with studies by Kalra et al. (2019) [13] and Rajabi et al. (2023) [17], which also demonstrated better HR stability with dexmedetomidine compared to magnesium sulphate.

While magnesium sulphate also demonstrated some attenuation of the hemodynamic response, it was not as effective as dexmedetomidine. The study observed that dexmedetomidine was more consistent in preventing surges in blood pressure and heart rate, supporting its role as a superior agent for hemodynamic stability. Similar results were reported by Manne et al. (2014) [14] and Waindeskar et al. (2015) [15], who highlighted dexmedetomidine's role in maintaining perioperative hemodynamic stability.

No significant adverse effects were noted in either group, except for mild bradycardia in the dexmedetomidine group, which was manageable. Jee et al. (2016) [9] reported similar findings regarding magnesium sulphate's effects on hemodynamics, though it was less effective than dexmedetomidine.

Thus, dexmedetomidine proves to be a more effective choice for hemodynamic stability during laparoscopic surgeries compared to magnesium sulphate.

5. Limitations of the Study

1) **Lack of plasma drug concentration measurement**
The study didn't measure plasma concentrations of dexmedetomidine and magnesium sulphate, which might have yielded more precise pharmacokinetic correlations with hemodynamic effects, which could have affected the accuracy of interpretations of clinical parameter.
2) **Absence of stress hormone analysis**
The study did not assess plasma catecholamine or stress hormone levels in response to pneumoperitoneum. Measuring these biomarkers could have offered additional insights into the sympathetic activation and the efficacy of drug interventions.
3) **Study Population and Generalizability**
Present study involved ASA physical status Class I and II patients only. Therefore, the results from this study cannot be emphasized on ASA physical status Class II, III and IV patients, e.g. patients with uncontrolled hypertension and/or uncontrolled diabetes mellitus.
4) **Limited sample size**
The study was conducted on a relatively small sample size of 135, which may limit the generalizability of the findings. A larger study population could provide more robust statistical validation and improve the reliability of the conclusions.

6. Conclusion

The present study strengthens the expanding evidence supporting the superiority of Dexmedetomidine over Magnesium sulphate in attenuating the hemodynamic responses to pneumoperitoneum during laparoscopic surgery. Consistent with previous research, present findings demonstrate that Dexmedetomidine significantly reduces heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure at all measured intervals compared to Magnesium sulphate ($p < 0.05$). Its selective alpha-2 agonist action provides better cardiovascular stability, minimizing the fluctuations associated with pneumoperitoneum. Given the alignment of our results with earlier studies, Dexmedetomidine emerges as a more reliable agent for hemodynamic control in laparoscopic procedures,

further substantiating its clinical utility in anaesthetic practice.

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Conflicts of Interest
There are no conflicts of interest.

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