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# Dexmedetomidine versus magnesium sulfate as adjunct to general anesthesia in patients undergoing video-assisted thoracoscopy

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## Abstract

**Background:** This study was designed to evaluate the effects of infusion of magnesium sulfate compared to dexmedetomidine on the postoperative analgesic consumption and pain control in patients scheduled for video-assisted thoracoscopic surgeries (VATS). The intraoperative hemodynamics, anesthesia requirements, and recovery profile were also evaluated.

**Results:** The mean arterial pressure (MAP) and heart rate (HR) recordings were significantly lower in group D than in groups C and M. The MAP recordings were significantly lower in group M than in group C with no significant difference as regards the HR recordings between both groups. Intraoperative sevoflurane and fentanyl requirements were significantly lower in groups D and M than in group C and in group D than in group M. The atracurium consumption was significantly lower in group M than in groups C and D. The time to reach modified Aldrete score  $\geq 9$  was significantly longer in groups D and M than in group C and in group D than in group M. Postoperative Ramsay sedation scores were significantly higher in groups D and M than in group C throughout the PACU stay and in group D than in group M in the 1st h postoperatively. The VAS score recordings were significantly lower in groups D and M than in group C and in group D than in group M except at 24-h postoperative recordings. The postoperative nalbuphine and ketorolac requirements were significantly lower in groups D and M than in group C and in group D than in group M.

**Conclusions:** During VATS, patients who received dexmedetomidine had better hemodynamic stability, less intraoperative anesthetic consumption with better quality of postoperative analgesia, and less postoperative analgesic consumption but longer postoperative anesthesia recovery and higher postoperative sedation scores compared with magnesium sulfate.

**Keywords:** Video-assisted thoracoscopy, Dexmedetomidine, Magnesium sulfate

## Background

The indications for applying VATS have been expanded by advances in technology and needs of patients (Jheon et al., 2012) with the benefits of being a minimally invasive technique, smaller incisions, less pain, less blood

loss, faster postoperative recovery, and shortened hospital stay with similar or superior survival rates (Lacin & Scott, 2013). However, the incidence of postoperative moderate-to-severe pain is still experienced in some patients. Effective and early management of acute pain following thoracoscopy is of critical importance for early mobilization as well as to improve postoperative pulmonary functions and to decrease global stress response (Raveglia et al., 2014).

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Dexmedetomidine is a highly selective  $\alpha_2$  adrenergic receptor agonist (selectivity ratio of  $\alpha_2:\alpha_1$  is 1600:1) (Carollo et al., 2008). Sympatholysis of dexmedetomidine causes reduction of heart rate and blood pressure and results in antistress effects. In addition, opioid-sparing and analgesic effects are promoted by the perioperative administration of dexmedetomidine (Ren et al., 2015).

Magnesium acts as an *N*-methyl-D-aspartate (NMDA) receptor antagonist; therefore, it reduces perioperative analgesic and anesthetic requirements (Srebro et al., 2017). Also, it was employed as the hypotensive agent in diverse surgical procedures for several years (Elsharnouby & Elsharnouby, 2006).

This study aimed to compare the effects of magnesium sulfate compared to dexmedetomidine infusion on the post-operative analgesic consumption and pain control in patients who underwent VATS. The intraoperative hemodynamics, anesthesia requirements, and recovery profile were also evaluated.

## Methods

Following ethics committee approval, written informed consents were obtained from ninety patients enrolled in this randomized, double-blind study that was conducted at the duration between January 2020 and January 2021. Patients were of ASA I–II, of both sexes, and in the age group of 21 to 60 years.

Exclusion criteria are patients' refusal; pregnancy; BMI > 30 kg/m<sup>2</sup>; preoperative bradycardia or heart block; significant cardiac, renal, and hepatic dysfunction; myopathy; and neuromuscular diseases. Patients who were known to have hypersensitivity to the study drugs and those on treatment with B blockers,  $\alpha_2$  adrenergic agonists, and opioid abuse were also excluded. Randomization was performed using a computerized program, and patients were divided into group C (control group), group M (magnesium group), and group D (dexmedetomidine group) (each group is 30 patients).

When the patients arrived in the operating room, the standard anesthesia monitoring was started. A peripheral intravenous cannula was inserted, and granisetron 1 mg was received before anesthesia induction. After local anesthetic infiltration, radial artery catheterization was done and invasive arterial blood pressure monitoring was started. Bispectral index (BIS) electrodes were connected to all patients to assess the anesthesia depth. The adequacy of muscle relaxation was measured via Datex-Ohmeda M-NMT Module.

In group M, patients received an initial intravenous bolus dose of 40 mg/kg of magnesium sulfate (in 50 ml normal saline) followed by a continuous infusion of 15 mg/kg/h. In group D, patients received an initial bolus dose of 1  $\mu$ g/kg of dexmedetomidine sulfate (in 50 ml normal saline) followed by a continuous infusion of 0.5  $\mu$ g/

kg/h. Group C patients received an initial bolus of normal saline 50 ml followed by a continuous infusion of normal saline. The bolus dose of the study medications was infused in 10 min before anesthesia induction, and the infusion was continued throughout surgery which was stopped 10 min before the operation end. The anesthesiologist responsible for anesthesia management and study data collection was blinded to study medications infused that was prepared by a different anesthesiologist.

Anesthesia induction was started with intravenous 2  $\mu$ g/kg fentanyl and propofol (1.5–2) mg/kg. Muscle relaxation was provided by intravenous atracurium 0.5 mg/kg and when train of four (TOF) reached to 0; the patients were intubated using a double-lumen endobronchial tube of appropriate size and one-lung ventilation was initiated. Intraoperative, intermittent arterial blood gases were done to assure patients' oxygenation and ventilation status. Titration of sevoflurane concentration for anesthesia maintenance was performed in order to maintain intraoperative BIS reading between 40 and 60 during operation while muscle relaxation was maintained by intermittent atracurium boluses (0.1 mg/kg) which were administered if more than one twitch were detected with TOF stimulation.

If intraoperative HR and MAP increased to be higher than the baseline recordings by 20% or more in spite of maintained desired BIS reading (40–60), fentanyl 0.5  $\mu$ g/kg intravenous increments were received. Hypotension (MAP less than 60 mmHg) while BIS was within the desired range was treated by increasing the rate of intravenous fluids and intravenous 5-mg ephedrine increments if needed. If hypotension persisted, the infusion of the study medication was stopped and the patient was excluded from the study. Bradycardia (HR below 50 bpm) was treated by intravenous 0.5 mg atropine that was repeated if required. If bradycardia persisted, the infusion of the study medication was stopped, and the patient was excluded from the study.

After the conclusion of surgery, the inhalational agent was turned off and patients were extubated after reversal of the residual neuromuscular blockade and return of protective airway reflexes then intravenous PCA system (Accufuser) infusion was started, after which they were transferred to the postanesthesia care unit [PACU] and monitored for 2 h then transferred to the surgical intensive care. The PCA infusion consisted of 100 mL normal saline loaded with 60 mg of nalbuphine. The PCA settings were 1 mL bolus dose per demand, a lockout of 15 min, and 2 ml/h continuous infusion. Patients were instructed to press the PCA analgesic-demand button when they need further analgesia or their visual analogue scale (VAS) (Breivik et al., 2008) scores were  $\geq 4$  and to repeat that till pain control was achieved. Additional

rescue boluses of ketorolac (30 mg) I.V. infusion were given if the pain scores persisted to be  $\geq 4$  and this dose could be repeated after 6 h (not to exceed 120 mg/day).

Our primary outcome in this study was the assessment of total postoperative analgesic consumption while the secondary outcome measures were:

- Hemodynamics were recorded at baseline ( $T_0$ ), following the initial bolus of study medications ( $T_1$ ), after patients were intubated ( $T_2$ ), every 20 min throughout the operation ( $T_{3,4,5,6,7}$ ), and after patient extubation ( $T_8$ ).
- Intraoperative anesthesia agent requirements.
- The anesthesia recovery time is defined as the time needed to reach modified Aldrete score (Aldrete, 1995)  $\geq 9$  after PACU arrival (Table 1).
- Postoperative pain was evaluated by VAS scores and postoperative sedation assessment was carried out using the Ramsay sedation score (Table 2) (Ramsay et al., 1974) and the scores for both of them were documented after patients arrived to PACU then after 15 and 30 min and 1, 2, 4, 8, 12, and 24 h postoperative.
- The incidence of perioperative complications.

**Table 1** Modified Aldrete score (Aldrete, 1995)

Criteria	Point value
<b>Oxygenation</b>	
SpO <sub>2</sub> > 92% on room air	2
SpO <sub>2</sub> > 92% on oxygen	1
SpO <sub>2</sub> < 90% on room air	0
<b>Respiration</b>	
Breathes deeply and coughs freely	2
Dyspneic, shallow breathing	1
Apnea	0
<b>Circulation</b>	
Blood pressure $\pm$ 20 mmHg of the baseline value	2
Blood pressure $\pm$ 20–50 mmHg of the baseline value	1
Blood pressure $\pm$ 50 mmHg of the baseline value	0
<b>Consciousness</b>	
Fully awake	2
Arousable on calling	1
Not responsive	0
<b>Activity</b>	
Moving all extremities	2
Moving two extremities	1
No movement	0

**Table 2** Ramsay sedation score (Ramsay et al., 1974)

1. Patient is anxious, agitated, or restless.
2. Patient is co-operative, oriented, and calm.
3. Patient is responsive to verbal command only.
4. Patient exhibiting brisk response to light glabellar tap or to an auditory stimulus.
5. Patient exhibiting a sluggish response to light glabellar tap or to an auditory stimulus.
6. No response to any of these stimulations

### Statistical analysis

Based on previously published data (Kweon et al., 2018), the sample size was calculated using G\*power 3.1.9 (Franz Faul, Kiel University, Germany) to be 25 patients per group which was needed to detect an expected difference of 25% in PCA nalbuphine consumption (primary outcome) with a study power of 80% ( $\alpha = 0.05$ ,  $\beta = 0.2$ ). With the assumption of a possible dropout rate of 20%, the final sample size was determined to be 30 patients per group. Patients' data analysis was done using SPSS 16.0 computer software (Chicago, IL, USA). Quantitative parametric data were described as mean  $\pm$  standard deviation while quantitative nonparametric data as median (interquartile range). Intergroup quantitative parametric data comparison was done using a one-way analysis of variance (ANOVA) and within the same group using repeated measure ANOVA and Tukey's test was used for post hoc analysis. A Kruskal–Wallis test was used for quantitative nonparametric data comparison. Categorical data were expressed as number (percentage) and analyzed by  $\chi^2$  tests or Fisher exact tests when appropriate. *P* value less than 0.05 was taken to indicate a significant difference.

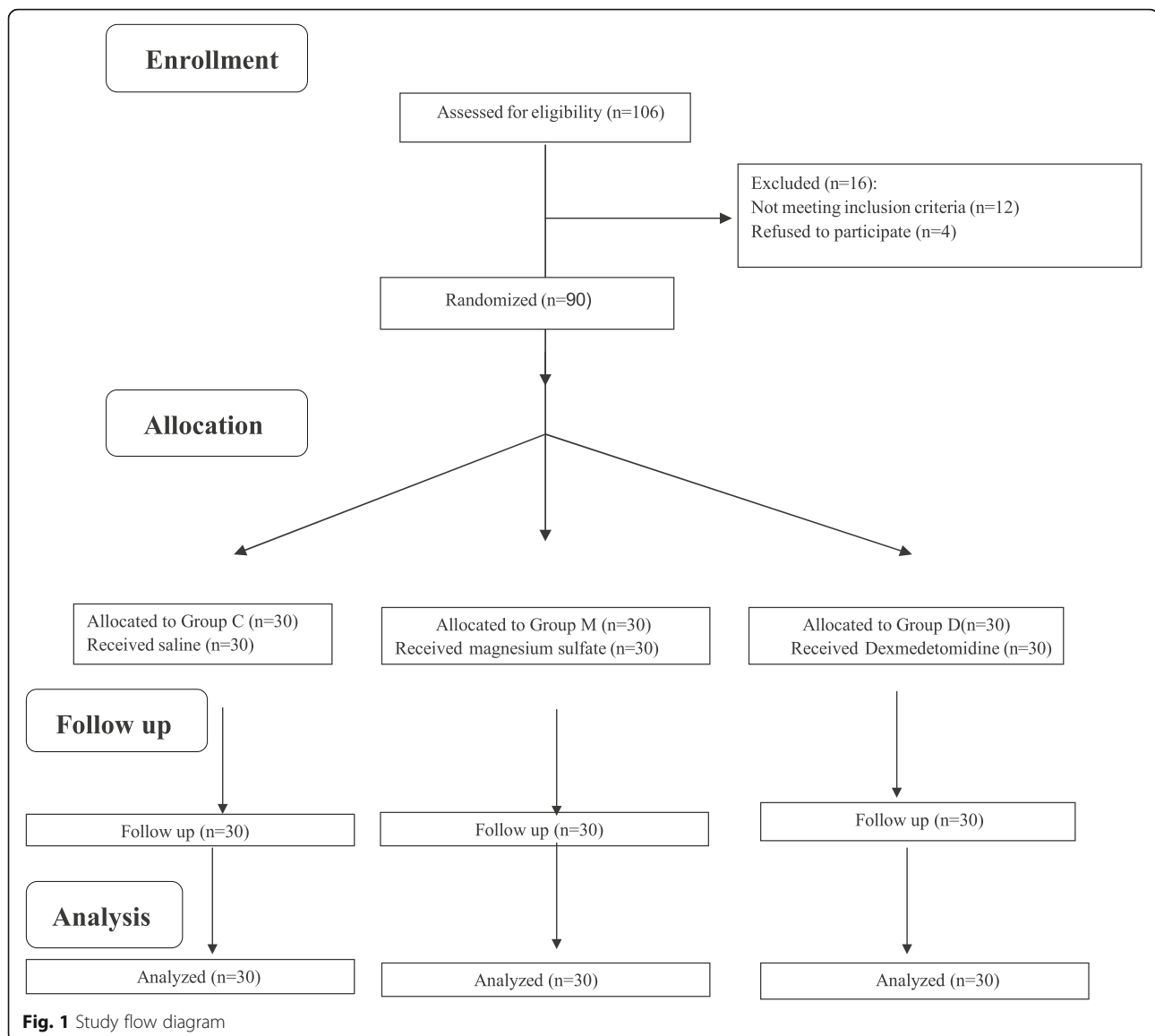
### Results

Among 106 patients that were scheduled to undergo VATS and screened to be eligible for this study, sixteen patients were excluded as four patients refused to participate and twelve patients did not meet this study's inclusion criteria; thus, 90 patients were included in this study and randomized to either the magnesium group (group M), dexmedetomidine group (group D), or control group (group C) (30 patients per group) (Fig. 1).

Demographic data of the study groups were comparable with no intergroup statistically significant differences ( $P > 0.05$ ) (Table 3).

There was no statistically significant difference between the study groups as regards the types and duration of surgical procedures ( $P > 0.05$ ) (Table 4).

Figure 2 shows changes in MAP values recorded throughout the surgery. After the bolus dose of the study medications and at all the following recordings, the MAP was significantly lower in groups D and M



than in group C ( $P < 0.05$ ) and in group D than in group M ( $P < 0.05$ ). In group C, there was a significant increase in MAP at  $T_2$  recordings compared to  $T_0$  ( $P < 0.05$ ) with no significant difference at all other recordings compared to  $T_0$  ( $P > 0.05$ ). In group M, there was a significant decrease in MAP at  $T_1$  and  $T_4$ – $T_7$  compared to  $T_0$  ( $P < 0.05$ ) with no significant change at  $T_2$ ,  $T_3$ , and  $T_8$  recordings compared to  $T_0$  ( $P > 0.05$ ). In group D, there

was a significant decrease in MAP at  $T_1$  and  $T_3$ – $T_7$  compared to  $T_0$  ( $P < 0.05$ ) with no significant change in MAP at  $T_2$  and  $T_8$  recordings compared to  $T_0$  ( $P > 0.05$ ). Figure 3 shows changes in HR values recorded throughout the surgery. After the bolus dose of the study medications and at all the following recordings, the HR was significantly lower in group D than in group C and group M ( $P < 0.05$ ) with no significant difference

**Table 3** Demographic profile of the study groups expressed as mean  $\pm$  SD or number of patients

	Group C (n = 30)	Group M (n = 30)	Group D (n = 30)	P value
Age (years)	48.96 $\pm$ 7.30	49.37 $\pm$ 8.11	47.65 $\pm$ 6.84	0.646
Gender (male/female)	20/10	19/11	18/12	0.866
Weight (kg)	77.86 $\pm$ 11.40	75.53 $\pm$ 9.41	73.83 $\pm$ 13.08	0.392

**Table 4** Procedure-related variables of the study groups expressed as mean ± SD or number of patients

	Group C (n = 30)	Group M (n = 30)	Group D (n = 30)	P value
Types of operation				
Lobectomy	15	13	12	0.891
Bullectomy	8	11	10	
Decortication	7	6	8	
Operation time (min)	153.16 ± 25.55	147.16 ± 29.14	144.83 ± 27.38	0.481

between group M and group C ( $P > 0.05$ ). In groups C and M, there was a significant increase in HR at  $T_2$  and  $T_8$  recordings compared with  $T_0$  ( $P < 0.05$ ) with no significant difference at all other HR recordings compared to  $T_0$  ( $P > 0.05$ ) but in group D there was a significant decrease at all HR recordings compared to  $T_0$  ( $P < 0.05$ ) with no significant change in HR at  $T_2$  recordings compared to  $T_0$  ( $P > 0.05$ ).

Both intraoperative sevoflurane and fentanyl requirements were significantly lower in group D and group M than in group C ( $P$  value  $< 0.05$ ). They were also significantly lower in group D than in group M ( $P$  value  $< 0.05$ ). The total intraoperative atracurium consumption was significantly lower in group M than in group C and group D ( $P$  value  $< 0.05$ ) (Table 5).

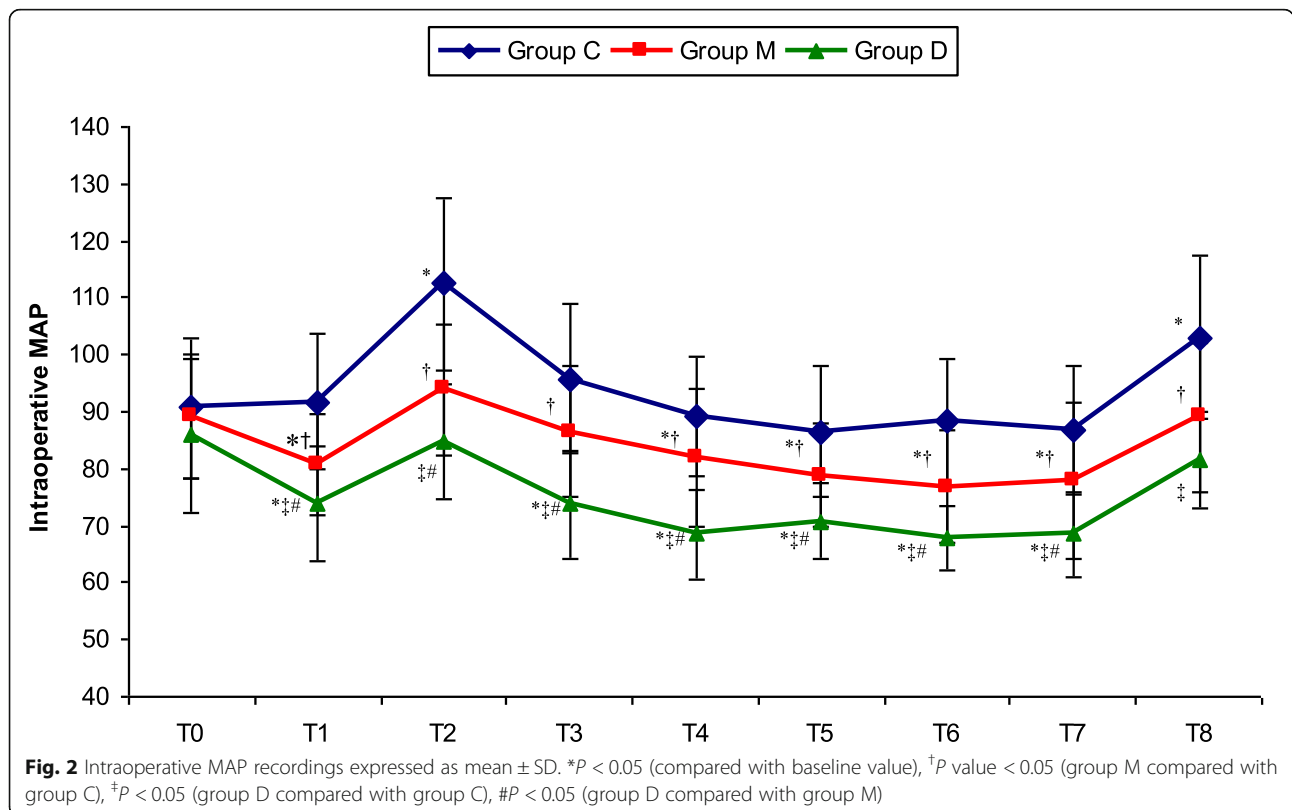
The anesthesia recovery time was significantly longer in group D and group M than in group C ( $P < 0.05$ ). It

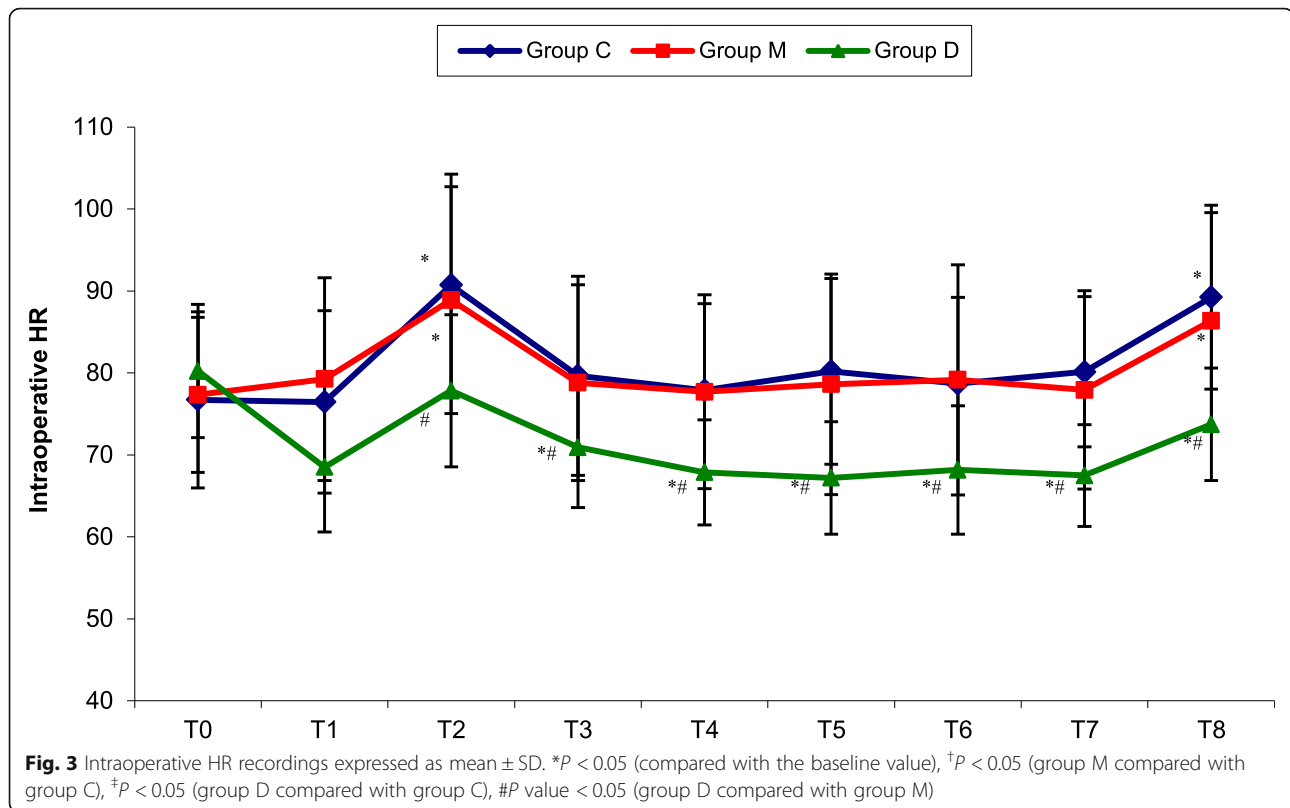
was also significantly longer in group D than in group M ( $P$  value  $< 0.05$ ) (Table 6).

Postoperative Ramsay sedation scores were significantly higher in groups D and M than in group C throughout the PACU stay ( $P < 0.05$ ) and in group D than in group M in the 1st h postoperatively ( $P < 0.05$ ) with no significant difference between the three study groups at all the following recordings ( $P > 0.05$ ) (Table 7). The VAS score recordings were significantly lower in groups D and M than in group C ( $P < 0.05$ ); they were also significantly lower in group D than in group M ( $P < 0.05$ ) except at 24-h postoperative recordings ( $P > 0.05$ ) (Table 8).

**The postoperative nalbuphine consumption**

The total dose of postoperative PCA nalbuphine consumption was significantly lower in group D and group





M than in group C ( $P < 0.05$ ). It was also significantly lower in group D than in group M ( $P$  value  $< 0.05$ ). The number of patients who received postoperative rescue ketorolac (1st dose and 2nd dose) was significantly lower in group D and group M than in group C ( $P < 0.05$ ). It was also significantly lower in group D than in group M ( $P$  value  $< 0.05$ ) but the number of patients who received postoperative rescue ketorolac (3rd dose) was significantly lower in group D and group M than in group C ( $P < 0.05$ ) with no significant difference between groups M and D (Table 9).

There is no significant difference between the study groups as regards the incidence of perioperative adverse events ( $P > 0.05$ ). Intraoperative hypotension occurred in 6 patients (3 patients in group C, 1 patient in group M, and 2 patients in group D) ( $P > 0.05$ ) which was managed by increasing the rate of intravenous fluids and ephedrine boluses. Intraoperative bradycardia was encountered in 3 patients in group D

but no patient had bradycardia in group C and group M ( $P > 0.05$ ) which was managed in all cases by intravenous atropine (0.5 mg) increments. Two patients in each study group developed postoperative hypoxia ( $\text{SpO}_2$  dropped to be  $< 92\%$ ) ( $P > 0.05$ ) which responded to  $\text{O}_2$  supplementation via nasal cannula. Four patients suffered postoperative shivering (2 patients in group C, 1 patient in group M, and 1 patient in group D) which was controlled by intravenous pethidine (25 mg) ( $P > 0.05$ ). The incidence of nausea and vomiting was 4 patients in group C, 3 patients in group M, and 1 patient in group D ( $P > 0.05$ ) which was controlled using ondansetron 4 mg by intravenous route.

## Discussion

This study was designed to evaluate the effects of infusion of magnesium sulfate compared to dexmedetomidine on the intraoperative hemodynamics, anesthesia requirements, recovery

**Table 5** Intraoperative anesthetic agent requirements expressed as mean  $\pm$  SD

	Group C (n = 30)	Group M (n = 30)	Group D (n = 30)	P value
End-tidal sevoflurane concentration (vol.%)	2.37 $\pm$ 0.25	1.97 $\pm$ 0.15 <sup>†</sup>	1.68 $\pm$ 0.18 <sup>‡, #</sup>	$< 0.001$
Total intraoperative fentanyl ( $\mu\text{g}$ )	202.07 $\pm$ 37.70	171.96 $\pm$ 31.23 <sup>†</sup>	146.33 $\pm$ 26.98 <sup>‡, #</sup>	0.001
Total intraoperative atracurium (mg)	97.56 $\pm$ 17.37	73.5 $\pm$ 14.06 <sup>†, #</sup>	88.67 $\pm$ 20.07	$< 0.001$

<sup>†</sup> $P < 0.05$  (group M compared with group C), <sup>‡</sup> $P < 0.05$  (group D compared with group C), <sup>#</sup> $P < 0.05$  (group D compared with group M)

**Table 6** Anesthesia recovery time expressed as mean  $\pm$  SD

	Group C (n = 30)	Group M (n = 30)	Group D (n = 30)	P value
Recovery time (minutes)	13.66 $\pm$ 5.46	20.84 $\pm$ 6.09 <sup>†</sup>	26.17 $\pm$ 7.25 <sup>‡,#</sup>	< 0.001

<sup>†</sup>P < 0.05 (group M compared with group C), <sup>‡</sup>P < 0.05 (group D versus group C), <sup>#</sup>P < 0.05 (group D versus group M)

profile, and postoperative pain management in patients scheduled for video-assisted thoracoscopic surgeries (VATS).

Demographic patients' data and procedure-related variables were comparable between the three study groups. The MAP and HR recordings were significantly lower in group D compared with groups C and M. In group M, the MAP recordings were significantly lower than in group C with no significant difference between both groups as regards the HR recordings. The reduction of both HR and MAP encountered with dexmedetomidine is attributed to stimulation of presynaptic  $\alpha_2$  receptors causing inhibition of noradrenaline release from the peripheral nerve endings (Nguyen et al., 2017) and the central sympatholytic properties caused by stimulation of the  $\alpha_2$  receptor in locus ceruleus of the brainstem (Farag et al., 2012) while magnesium administration reduces the arterial blood pressure via inhibiting the release of norepinephrine by blocking the N-type Ca<sup>++</sup> channels at the nerve endings and thus decreases the blood pressure (Shimosawa et al., 2004). Moreover, it produces vasodilator by acting directly on blood vessels, and high-dose magnesium attenuates vasopressin-stimulated vasoconstriction (Do, 2013).

Our results agreed with those reported by Soliman et al. (Soliman & Fouad, 2017) who studied the effects of dexmedetomidine versus magnesium sulfate infusion in patients undergoing transnasal transsphenoidal hypophysectomy. In their study, both dexmedetomidine and magnesium provided adequate control of perioperative hemodynamics with better attenuation of hemodynamic responses and less blood loss with dexmedetomidine compared to magnesium. The efficacy of both magnesium sulfate and dexmedetomidine in the suppression of hemodynamic responses to various surgical noxious

stimuli and maintenance of the hemodynamic stability was also reported by Kamal et al. (2018), Modir et al. (2018) in functional endoscopic sinus surgery, and Srivastava et al. (2016) in spine surgeries, giving superiority for dexmedetomidine when compared with magnesium sulfate.

Both dexmedetomidine and magnesium sulfate are well known for their anesthetic sparing effects. In this study, the sevoflurane requirement was significantly lower in groups D and M when compared with group C and in group D when compared with group M. The results of this study coincide with those obtained by several previous studies (Ryu et al., 2009; Saadawy et al., 2010; Mahmoud et al., 2016; Moharram et al., 2016) which reported a significant reduction of sevoflurane consumption with intraoperative magnesium infusion. Magalhães et al. (2004) observed a significant reduction in end-tidal sevoflurane concentration with perioperative dexmedetomidine infusion which was also reported in several previous studies (Patel et al., 2013; Harsoor et al., 2014; Sharma et al., 2017). Moreover, the study by Soliman & Fouad (2017) showed that sevoflurane consumption in the dexmedetomidine group was less than that in the magnesium sulfate group. A previous meta-analysis by Huang et al. (2017) reported that intraoperative dexmedetomidine infusion used as an anesthesia adjuvant during thoracoscopy improved the arterial oxygenation via decreased intraoperative inhalational anesthetic requirement which limits their effects on hypoxic pulmonary vasoconstriction during one-lung ventilation.

In this study, we observed that intraoperative fentanyl consumption was significantly lower in patients of groups D and M when compared with group C and in group D when compared with group M. The perioperative

**Table 7** Postoperative Ramsay sedation scores expressed as median (interquartile range)

	Group C (n = 30)	Group M (n = 30)	Group D (n = 30)	P value
At PACU arrival	2.5 (1-3)	3 (2-3) <sup>†</sup>	4 (3-4) <sup>‡,#</sup>	< 0.001
After 15 min	2 (1-3)	3 (2-3) <sup>†</sup>	3.5 (3-4) <sup>‡,#</sup>	< 0.001
After 30 min	2(1-2)	2.5 (2-3) <sup>†</sup>	3 (3-4) <sup>‡,#</sup>	< 0.001
After 1 h	2 (1-2)	2 (2-3) <sup>†</sup>	3 (2-3) <sup>‡,#</sup>	< 0.001
After 2 h	2 (1-2)	2(2-2) <sup>†</sup>	2 (2-2) <sup>‡</sup>	0.005
After 4 h	2 (2-2)	2(2-2)	2 (2-2)	0.440
After 8 h	2 (1-2)	2 (1-2)	2 (22)	0.360
After 12 h	2 (1-2)	2 (2-2)	2 (2-2)	0.073
After 24 h	2 (1-2)	2 (2-2)	2 (2-2)	0.180

<sup>†</sup>P < 0.05 (group M compared with group C), <sup>‡</sup>P < 0.05 (group D compared with group C), <sup>#</sup>P < 0.05 (group D versus group M). P value derived using the Kruskal-Wallis test

**Table 8** Postoperative VAS recordings expressed as median (interquartile range)

	Group C (n = 30)	Group M (n = 30)	Group D (n = 30)	P value
At PACU arrival	3 (2-4)	2 (2-3) <sup>†</sup>	1 (0-1) <sup>†,#</sup>	< 0.001
After 15 min	4 (3-4)	2 (2-3) <sup>†</sup>	1 (0-2) <sup>†,#</sup>	< 0.001
After 30 min	4 (4-5)	2.5 (2-4) <sup>†</sup>	2 (1-2) <sup>†,#</sup>	< 0.001
After 1 h	5 (4-6)	3.5 (3-4) <sup>†</sup>	2 (1-3) <sup>†,#</sup>	< 0.001
After 2 h	5 (4-5)	3 (3-4) <sup>†</sup>	2 (2-3) <sup>†,#</sup>	< 0.001
After 4 h	4 (4-5)	3.5 (2-4) <sup>†</sup>	2 (1-3) <sup>†,#</sup>	< 0.001
After 8 h	4(3-5)	3.5 (3-4) <sup>†</sup>	2 (1-3) <sup>†,#</sup>	< 0.001
After 12 h	4(3-5)	3 (2-4) <sup>†</sup>	2 (1-2) <sup>†,#</sup>	< 0.001
After 24 h	3 (2-4)	2.5 (2-3)	2 (1-3)	0.067

<sup>†</sup>P < 0.05 (group M compared with group C), <sup>‡</sup>P < 0.05 (group D compared with group C), <sup>#</sup>P < 0.05 (group D compared with group M). P value derived using the Kruskal-Wallis test

analgesic activity of  $\alpha 2$  agonists is mediated via  $\alpha 2$  receptors in the locus coeruleus and spinal cord (Guo et al., 1996; De Kock et al., 1993) while magnesium is a well-known NMDA receptor antagonist (Srebro et al., 2017; Clarke et al., 2013). The results of this study run in accordance with those of Gupta et al. (2013) and Alzeftawy and Elsheikh (2015) who reported a significant reduction of intraoperative analgesic requirement with intraoperative dexmedetomidine infusion. Manaa and Alhabib (2012) and Silva Filho et al. (2021) demonstrated significant reductions of intraoperative analgesic requirement with the use of magnesium infusion. The better intraoperative analgesic sparing effect of dexmedetomidine compared with magnesium observed in this study was also noted by Saleh and Hassan (2017) in patients who underwent cochlear implantation surgery and coincides with the results of previous studies (Soliman & Fouad, 2017; Rokhtabnak et al., 2017).

Magnesium sulfate is known to augment the action of non-depolarizing neuromuscular blocking drugs and reduce their intraoperative requirements via acting as a calcium channel blocker at presynaptic nerve terminals; thus, it causes a decrease in presynaptic acetylcholine release at the motor endplate (Do, 2013). This could explain the significantly lower atracurium requirement in group M when compared with other study groups in this study which was also consistent with those of previous

studies (Alzeftawy & Elsheikh, 2015; Manaa & Alhabib, 2012; Wang et al., 2011; Sohn et al., 2021).

Postoperative Ramsay sedation scores were significantly higher in groups D and M than in group C throughout the PACU stay ( $P < 0.05$ ) and in group D than in group M in the 1st h postoperatively which was associated with significantly longer anesthesia recovery time in group D and group M compared with group C and in group D compared with group M; the same findings were also observed by multiple previous studies (Karthik Kamal et al., 2018; Hassan & Saleh, 2017; Aboushanab et al., 2011; Khalifa & Awad, 2015) which reported a significantly longer time of recovery and PACU discharge with dexmedetomidine when compared with magnesium. In spite of the more extended sedation reported with dexmedetomidine, it produces physiological sleep-like phenomenon in the EEG and a characteristic arousable sedation by acting on the  $\alpha 2$  adrenoceptors in the locus coeruleus in the brainstem where it decreases sympathetic outflow and increases parasympathetic outflow (Nelson et al., 2003) without affecting the ventilatory drive (Hsu et al., 2004) or causing respiratory depression (Buck, 2010).

In this study, patients in group D and group M had significantly lower postoperative VAS score recordings when compared with group C. They were also significantly lower in group D when compared with group M.

**Table 9** Postoperative analgesia requirements expressed as mean  $\pm$  SD or number of patients (percentage)

	Group C (n = 30)	Group M (n = 30)	Group D (n = 30)	P value
Total postoperative nalbuphine requirements (mg)	49.06 $\pm$ 7.05	40.32 $\pm$ 5.13 <sup>†</sup>	33.58 $\pm$ 3.10 <sup>†,#</sup>	< 0.001
Postoperative ketorolac requirements (1st dose), no. of patients	30 (100%)	19 (63.33%) <sup>†</sup>	8 (26.66%) <sup>†,#</sup>	< 0.001
Postoperative ketorolac requirements (2nd dose), no. of patients	20 (66.66%)	6 (20%) <sup>†</sup>	0 (0%) <sup>†,#</sup>	< 0.001
Postoperative ketorolac requirements (3rd dose), no. of patients	11 (36.66%)	0 (0%) <sup>†</sup>	0 (0%) <sup>†</sup>	< 0.001

<sup>†</sup>P < 0.05 (group M compared with group C), <sup>‡</sup>P < 0.05 (group D compared with group C), <sup>#</sup>P < 0.05 (group D compared with group M)



Moreover, the cumulative postoperative nalbuphine consumption was significantly lower in group D and group M when compared with group C. It was also significantly lower in group D when compared with group M. The results of this study were consistent with those obtained by Ren et al. (2015) and Ge et al. (2015) who observed a significant reduction of postoperative pain scores and postoperative analgesic consumption in the dexmedetomidine group compared with the control group in patients who underwent hysterectomy and colectomy, respectively. A similar efficacy of intraoperative dexmedetomidine on postoperative pain control and analgesic consumption was also reported by Jannu and Dhorigol (2020) after VATS. Moharam et al. (2016) and Sohn et al. (2017) also reported a better postoperative analgesia and less postoperative morphine consumption after VATS in patients who received intraoperative magnesium sulfate infusion which was also confirmed in multiple previous studies (De Oliveira et al., 2013; Albrecht et al., 2013; Altiparmak et al., 2018; El Mourad & Arafa, 2019; Rafik & Fotedar, 2018).

### Study limitations

This study had some limitations; the serum magnesium concentration was not measured. Goral et al. (2011) noted that toxic level of serum magnesium was not reached even after using magnesium sulfate in the bolus dose of 50 mg/kg and continuous infusion 20 mg/kg/h which is higher than the dose used in this study for both bolus and maintenance infusion. Moreover, the safety of the dose of magnesium used for bolus and infusion in this study was proved in several studies (Moharram et al., 2016; De Oliveira et al., 2013; Albrecht et al., 2013). Also, the cost implications for the studied drugs should be considered.

### Conclusions

In conclusion, during VATS, patients who received dexmedetomidine had better hemodynamic stability, less intraoperative anesthetic consumption with better quality of postoperative analgesia, and less postoperative analgesic consumption but longer postoperative anesthesia recovery and higher postoperative sedation scores compared with magnesium sulfate.

### Abbreviations

ASA: American Society of Anesthesiologist; BIS: Bispectral index; HR: Heart rate; MAP: Mean arterial pressure; NMDA: N-Methyl-D-aspartate; PACU: Postanesthesia care unit; PCA: Patient-controlled analgesia; VAS: Visual analogue scale; VATS: Video-assisted thoracoscopic surgeries

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### Authors' contributions

Corresponding author: MA who contributed to the study conception and design, acquisition of the data, analysis, and interpretation of the data. The other author: HM: drafting of the manuscript and its critical revision. All authors have read and approved the final manuscript.

### Funding

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### Availability of data and materials

The data sets generated during and/or analyzed during the current study are not publicly available due to restrictions based on privacy regulations and informed consent of the participants, but are available from the corresponding author on reasonable request.

### Declarations

#### Ethics approval and consent to participate

The current prospective randomized double-blinded study was conducted on 90 adult patients scheduled to undergo VATS in cardiovascular and thoracic surgery academy at Ain Shams university hospitals through the period from January 2020 to January 2021 after obtaining approval of research ethical committee (REC) of the Faculty of Medicine-Ain Shams University (FMASU) at January 2020 with a reference number of FMASU R 65/2020 and patients' written informed consents for acceptance of participation in the study.

#### Consent for publication

Not applicable.

#### Competing interests

The authors declare that they have no competing interests.

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