Original Article

The effects of dexmedetomidine and magnesium sulphate in adult patients undergoing endoscopic transnasal transsphenoidal resection of pituitary adenoma: A double-blind randomised study

Address for correspondence:
Dr. Rabie Soliman,
Department of Anaesthesia,
Cairo University, Cairo, Egypt.
E-mail: rabiesoliman@hotmail.com

Rabie Soliman, Eman Fouad
Department of Anaesthesia, Faculty of Medicine, Cairo University, Cairo, Egypt

Access this article online

Website: www.ijaweb.org

DOI: 10.4103/ija.IJA_581_16

Quick response code

ABSTRACT

Background and Aim: Transnasal transsphenoidal resection of pituitary tumours is associated with blood loss and wide fluctuations in haemodynamic parameters. The aim of the present study was to compare the effect of dexmedetomidine and magnesium sulphate during the transsphenoidal resection of pituitary tumours. **Methods:** The study was a double-blind, randomised study and included 152 patients classified randomly into two groups: Group D: Dexmedetomidine was given as a loading dose 1 μg/kg over 10 min before induction followed by an infusion at 0.5 μg/kg/h during the surgery. Group M: Magnesium sulphate was given as loading dose of 50 mg/kg over 10 min followed by an infusion at 15 mg/kg/h during the surgery. The systolic, diastolic and mean arterial blood pressures, in addition to the amount of blood loss were measured at specific timepoints. Data were described in terms of mean ± standard deviation, median, frequencies, 95% confidence of interval of mean and percentages. **Results:** Mean bleeding score was lower in Group D than Group M (1.36 ± 0.48 vs. 3.05 ± 0.65, respectively; $P = 0.002$). Mean blood loss was lower in Group D (157.43 ± 48.79 ml vs.299.47 ± 77.28 ml in Group M; $P < 0.001$)Heart rate, mean arterial pressure, fentanyl requirements, end-tidal sevoflurane concentration, and extubation and emergence times were lower, while incidence of bradycardia and hypotension were higher in Group D. **Conclusions:** During transsphenoidal pituitary resection, dexmedetomidine, compared to magnesium, is associated with lower blood loss and better operating conditions but with more hypotension and bradycardia

Key words: Dexmedetomidine, magnesium sulphate, pituitary adenoma, transsphenoidal resection

INTRODUCTION

Tumours of the pituitary gland represent approximately 10% of brain tumours and transsphenoidal resection of pituitary tumours represents 20% of all intracranial operations performed for primary brain tumours.[1]

Transnasal transsphenoidal resection of pituitary tumours is associated with wide fluctuations in haemodynamic parameters such as hypertension and tachycardia because of intense noxious stimulation during submucosal adrenaline injection in the nose, nasal speculum insertion, or during sphenoid and sellar dissection.[2]

The challenges for the anaesthetist during transsphenoidal resection include the surgical approach, the effects of hormone secretion by pituitary tumours, maintenance of a clear field by hypotensive

How to cite this article: Soliman R, Fouad E. The effects of dexmedetomidine and magnesium sulphate in adult patients undergoing endoscopic transnasal transsphenoidal resection of pituitary adenoma: A double-blind randomised study. Indian J Anaesth 2017;61:410-7.

anaesthesia to facilitate the transsphenoidal resection and to facilitate early recovery after the surgery.[3]

Various agents such as β-blockers, nitroglycerine and sodium nitroprusside, high doses of potent inhaled anaesthetics, α-2 agonist and magnesium sulphate have been used to achieve controlled hypotension.[4-6]

Dexmedetomidine is a highly selective α2 agonist that provides sedation, analgesia, respiratory and haemodynamic stability. It reduces narcotic and volatile agent requirements.[7]

Magnesium is an N-methyl-d-aspartate receptor antagonist that reduces the need for analgesic and sedative drugs, and it is a good agent for a controlled hypotension.[8] Magnesium inhibits the release of norepinephrine by blocking the N-type Ca^{++} channels at nerve endings and thus decreases the blood pressure.[9]

The aim of the present study was to compare the effects of dexmedetomidine and magnesium sulphate on the adequacy of hypotensive anaesthesia to produce bloodless field (Boezaart bleeding scale of 0 or 1),[10] and decreasing the blood loss in adult patients undergoing transsphenoidal resection of pituitary tumours. It is expected that dexmedetomidine would induce better hypotension than magnesium that is used routinely during transsphenoidal resection of pituitary tumours in our hospital.

METHODS

After obtaining Local Ethics and Research Committee approval and written informed consent from patients, a double-blind, randomised study was performed. One hundred and fifty-two patients with computed tomography and magnetic resonance imaging scanning proof of pituitary gland adenoma scheduled for endoscopic transsphenoidal resection under general anaesthesia were included between November 12, 2014 and October 9, 2016. The inclusion criteria were patients undergoing elective surgery of pituitary adenoma, Mallampati score of airway I, II and American Society of Anesthesiologists physical status classification system score I or II. The exclusion criteria were presence of morbid obesity, liver or kidney diseases, a pre-operative heart rate <45 beats/min, second or third degree heart block, ejection fraction <30%, coagulopathies, psychiatric diseases, neuromuscular diseases, diabetic neuropathy, known allergy history to study medications or patients receiving calcium channel blockers, beta-blockers or anticoagulants. The pre-operative assessment was focussed on the endocrine manifestations of pituitary tumours (hypo- or hyper-secretion of hormones), neurological complications (such as increased intracranial tension or compression on the adjacent structures, airway assessment and cardiovascular system assessment in addition to the pre-operative investigations). Chest X-ray, lateral view of X-ray neck, electrocardiogram (ECG), echocardiogram and hormonal assays were done for all patients. Pulmonary function tests were done in cases associated with sleep apnoea.

The patients were allocated randomly (by simple randomisation through a process of coin-tossing: The coin tossing test was carried out every two patients by the staff-nurse and according to the results, the study medication was prepared) into two groups (each = 76) and the study medications were prepared in 50 ml syringe and the infusion started by the staff-nurse according to the study protocol and the anaesthetist was blinded to the contents of the syringe and the name of the medication infused by the syringe pump. Group D: Dexmedetomidine (Abbott, Chicago, IL, USA) was given as loading dose 1 μg/kg IV over 10 min before induction and maintained as an intravenous infusion at 0.5 μg/kg/h to the end of surgery. Group M: Magnesium sulphate (magnesium sulphate injection, USP 50% American Regent Laboratories, Inc.), was given as a loading dose of 50 mg/kg IV over 10 min before induction and maintained as an intravenous infusion at 15 mg/kg/h to the end of surgery.

On arrival in the operating room and under local anaesthesia, left radial arterial line and two venous lines were inserted before starting the study medications. A pre-operative arterial blood gas analysis was performed in cases of sleep apnoea syndrome (due to enlargement of the oral tissues and tongue as in gigantism and acromegaly) or pulmonary function tests showing abnormal results. After attaching the monitors (ECG, pulse oximeter, invasive arterial blood pressure) and starting the study medication according to the study protocol, induction of anaesthesia was done for all patients by pre-oxygenation, intravenous propofol (1–2 mg/kg) followed by fentanyl (1–2 μg/kg) IV and atracurium 0.5 mg/kg IV as a bolus dose over 30 s. After tracheal intubation, anaesthesia was maintained with 50% oxygen in air, sevoflurane (1%–3%), IV fentanyl infusion (1–5 μg/kg/h) and IV atracurium (0.5 mg/kg/h IV to provide train-of-four count zero using

peripheral nerve stimulator). The end-tidal CO_2 was maintained between 30 and 35 mmHg. Nitroglycerine was added if needed to induce intraoperative hypotension. Propranolol or esmolol was added if there was intraoperative tachycardia. Patients with a heart rate below 50 bpm, were managed with a single dose of atropine 0.02 mg/kg IV. If mean arterial blood pressure decreased below 60 mmHg, it was managed with IV fluids (250–500 over 5–10 min according to the response) and a bolus dose of IV ephedrine (5–10 mg) if needed. After successful resection of the tumour, a valsalva manoeuvre (by applying positive end-expiratory pressure 30 cm H_2O and maintained for about 15 s) was done to test for a cerebrospinal fluid leak. After finishing the surgery, the study medications were stopped. After extubation, all patients were transferred to post-anaesthesia care unit (PACU) for 4 h and monitored using the same monitors used intraoperatively. Nausea and vomiting were treated by intravenous metoclopramide. Pain was assessed using verbal rating scale (no pain = 0, mild = 1, moderate = 2 and severe = 3),[11] and managed with a bolus dose of intravenous fentanyl (50–100 μg). The patients were transferred to the ward according to the modified Aldrete score.[12]

The monitors used during anaesthesia included ECG, pulse oximetry, invasive blood pressure from the left radial artery cannula (systolic arterial pressure [SAP], diastolic and mean arterial pressure), temperature from oropharyngeal probe and end-tidal carbon dioxide (CO_2) every 5 min. The end-tidal concentration of sevoflurane, total dose of fentanyl and atracurium, emergence time, extubation time, duration of surgery and anaesthesia, and urine output were recorded. The arterial blood gases were done every 30 min to follow up the arterial partial pressure ($PaCO_2$) of patients with sleep apnoea syndrome and to check the haemoglobin level. The degree of bleeding was assessed by Boezaart scale (to assess the extent of bleeding in the surgical field) [Table 1],[10] and the total amount of blood loss was assessed (by measuring the amount of blood in the in the suction bottle). Neurological assessment was performed for all patients by Glasgow coma scale[13] before induction of anaesthesia and 30 min after tracheal extubation.

The primary outcome was the adequacy of hypotensive anaesthesia on the Boezaart scale and the intraoperative blood loss. The secondary outcome was the safety of the study medications. The safety was assessed by the occurrence of any adverse events to the patients.

Table 1: Boezaart scale for intraoperative surgical field evaluation scale

Boezaart Score	Description
0	No bleeding, virtually bloodless field
1	Slight bleeding, blood suctioning is not required
2	Mild bleeding, occasional suctioning without interference of surgical field
3	Moderate bleeding, suctioning is usually used; bleeding threatens surgical field but improves after suctioning
4	Heavy bleeding, suctioning is frequently used; bleeding threatens surgical field directly after suction is removed
5	Severe bleeding, bleeding appears faster than suctioning and is uncontrollable

The haemodynamic data of patients were collected at the following time points: T0: At baseline; T1: Before anaesthesia induction; T2: 15 min after induction; T3: 30 min after induction; T4: 1 h after induction; T5: 2 h after induction; T6: At the end of surgery; T7: Directly before extubation; T8: 5 min after extubation; T9: On admission to the PACU; T10: 1 h after PACU admission; T11: before transferring to the ward.

Power analysis was performed based on the Chi-square test for independent samples on the adequacy of hypotensive anaesthesia to produce bloodless field (Boezaart bleeding scale of 0 or 1) and decreasing the blood loss. A pilot study was carried out before starting this study to assess the hypotensive effect and the incidence of bloodless field during the use of dexmedetomidine and magnesium sulphate in adult patients undergoing sulphate transsphenoidal resection of pituitary tumours. The results of the pilot study showed (18 cases in each group) that the incidence of the bloodless field was 45.5% in dexmedetomidine group and 24% in magnesium sulphate group. Taking power 0.8 and alpha error 0.05, a minimum sample size of 76 patients was calculated for each group.

Data were statistically described in terms of mean ± standard deviation, or frequencies (number of cases), 95% confidence of interval of mean, median and percentages when appropriate. Comparison of numerical variables between the study groups was done using Student's *t*-test for independent samples. For comparing categorical data, Chi-square test was performed. The exact test was used instead when the expected frequency is <5 such as bradycardia and hypotension. The values of $P < 0.05$ were considered statistically significant. All statistical calculations were done using computer program SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA) version 15 for Microsoft Windows.

RESULTS

Figure 1 shows the CONSORT diagram for the flow of participants through each stage of the present study. All patients completed the study and all patients were analysed for the study.

There were no significant differences regarding the demographic data ($P > 0.05$) [Table 2].

The SAP, diastolic and mean arterial blood pressure decreased after administration of the study medications (from T1 to T11), and the decrease was significantly lower in Group D than in Group M patients ($P < 0.001$). In comparison to the baseline, the decrease in SAP, diastolic and mean arterial blood pressures was comparable in Group D and not in Group M [Figure 2a-c].

The bleeding score was significantly lower in patients of Group D than Group M patients and the average was 1.36 ± 0.48 in Group D and 3.05 ± 0.65 in Group M ($P = 0.002$). The blood loss decreased significantly in Group D than Group M patients and the average was 157.43 ± 48.79 in Group D and 299.47 ± 77.28 in Group M ($P < 0.001$) [Table 3].

Table 2: Demographic data of patients (mean±standard deviation, *n*)

Item	Group D (*n*=76)	Group M (*n*=76)	*P*
Age (year)	43.20±10.93	44.02±10.14	0.632
Weight (kg)	90.09±9.98	92.26±10.24	0.227
Gender			
Male	40	36	0.472
Female	35	41	0.459

Group D – Dexmedetomidine group; Group M – Magnesium sulphate group

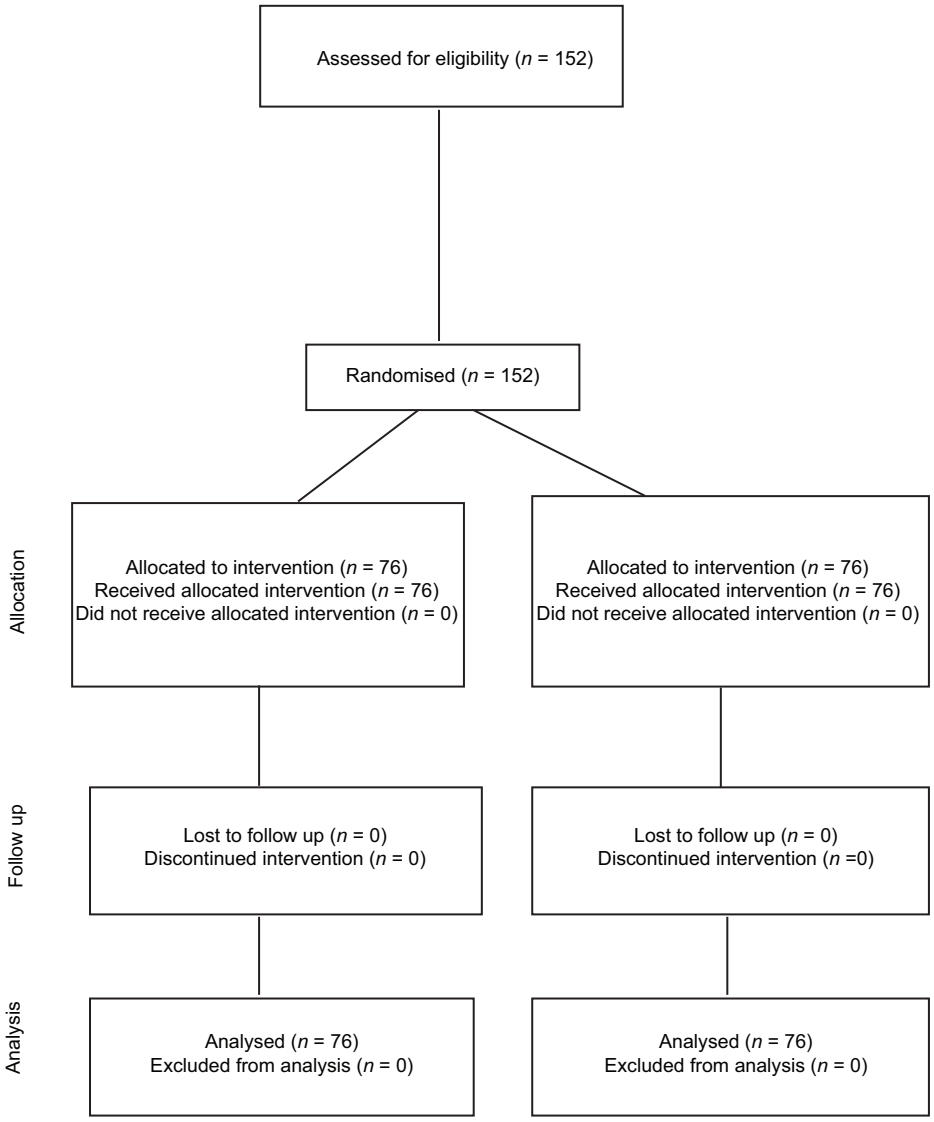

Figure 1: CONSORT diagram for the flow of participants through each stage of the present study

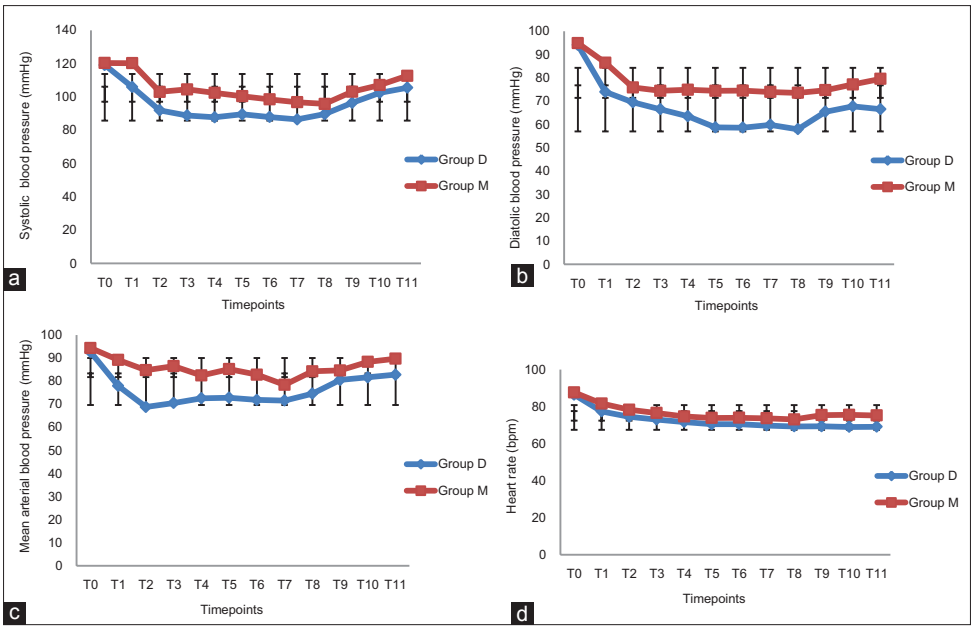

Figure 2: (a) Systolic arterial blood pressure of patients. (b) Diastolic arterial blood pressure of patients. (c) Mean arterial blood pressure of patients. (d) Heart rate of patients. Group D: Dexmedetomidine group; Group M: Magnesium sulphate group. T0: Reading at base line; T1: Reading before induction of anaesthesia; T2: Reading 15 min after induction; T3: Reading 30 min after induction; T4: Reading 1 h after induction; T5: Reading 2 h after induction; T6: Reading at end of surgery; T7: Reading directly before extubation; T8: Reading 5 min after extubation; T9: Reading at post-anaesthesia care unit admission; T10: Reading 1 h after post-anaesthesia care unit admission; T11: Reading before transferring to ward

The heart rate decreased in both groups after administration of the study medications, but the decrease was much lower in Group D than Group M patients during the surgery and post-operatively in PACU (from T1 to T11), and the comparison between the two groups was significant ($P < 0.001$). In comparison to the baseline, the decrease in heart rate was comparable in Group D and not in Group M [Figure 2d].

Significantly more patients in Group D, compared to Group M, had bradycardia (decrease in heart rate below 60 bpm); ($p = 0.041$) and hypotension (decrease in mean arterial blood pressure below 60 mmHg); ($P = 0.025$), [Table 3]. There was no heart block or cardiac arrest. The required fentanyl dose was significantly lower in Group D than Group M patients and the average was 3.94 ± 0.72 in Group D and 5.13 ± 1.15 in Group M ($P = 0.024$). The end-tidal sevoflurane was greatly lowered in Group D than Group M patients and the average was 1.51 ± 0.41 in Group D and 2.22 ± 0.35 in Group M ($P = 0.021$). The emergence time (time from the end of anaesthesia to the time of opening the eyes spontaneously or the response to verbal commands) between the two groups was comparable ($P = 0.041$). The extubation time (duration from end of anaesthesia until the patients become fully awake and removal of endotracheal tube) between the two groups was comparable and the average was 9.28 ± 1.51 in Group D and 13.2 ± 1.75 in Group M ($P = 0.012$). There were no significant differences regarding the total dose of atracurium, end-tidal CO_2, temperature, durations of surgery and anaesthesia ($P > 0.05$). The urine output was higher in Group D than Group M patients and the average was 850.14 ± 140.34 in Group D and 570.54 ± 134.78 in Group M ($P < 0.001$). The comparison of the Glasgow coma scale was insignificant at the baseline between the two groups ($P = 1.000$), but it was comparable at 30 min after extubation and the average was 14.90 ± 0.33 in Group D and 13.21 ± 1.41 in Group M ($P = 0.042$). In the PACU, the comparison of verbal rating scale of pain was insignificant between the two groups ($P = 0.086$). The incidence of nausea and vomiting was six patients in Group D and 13 patients in Group M ($P = 0.012$), and the patients were managed with single intravenous metoclopramide dose 0.1 mg/kg. The comparison of the total dose of fentanyl in the PACU was insignificant between the two groups ($P = 0.073$) [Table 3].

DISCUSSION

This study showed that blood pressure and heart rate were lower in Group D than Group M after administration of the study medications, during

Table 3: Intra- and post-operative data of patients (mean±standard deviation, percentage, n, 95% confidence interval of mean, median)

Item	Group D (*n*=76)	Group M (*n*=76)	*P*
Bradycardia (HR <60 bpm)	12	4	0.041
Hypotension	13	3	0.025
Hypertension (SAP ≥20% above baseline)	7	16	0.014
Blood loss (ml)			
Mean	157.43±48.79	299.47±77.28	0.001
95% CI	146.28-168.58	281.81-317.13	
Boezaart bleeding score			
Mean	1.36±0.48	3.05±0.65	0.002
95% CI	1.25-1.47	2.9-3.2	
Median	1	3	
Glasgow Coma Scale			
Pre-operative (mean)	15.00±0.00	15.00±0.00	1.000
Pre-operative (median)	15	15	
Post-operative (mean)	14.90±0.33	13.21±1.41	0.042
Post-operative (median)	15	13	
$ETCO_2$ (mmHg)	36.45±1.56	36.16±2.14	0.373
SpO_2 (%)	99.06±0.75	98.98±0.90	0.251
Temperature (°C)	37.04±0.30	37.07±0.26	0.630
Duration of anaesthesia (min)	208.44±15.62	211.08±13.40	0.264
Duration of surgery (min)	192.74±30.55	195.45±27.66	0.518
Atracurium (mg)	157.10±14.63	160.53±12.55	0.127
Fentanyl dose (μg/kg)	3.94±0.72	5.13±1.15	0.024
End-tidal sevoflurane (%)	1.51±0.41	2.22±0.35	0.021
Emergence time	7.43±5.22	10.23±1.18	0.041
Extubation time (min)	9.28±1.51	13.2±1.75	0.012
Urine output (ml)	850.14±140.34	570.54±134.78	0.001
Pain score			
Mean	0.95±1.39	1.34±1.40	0.086
Median	1	1	
Total fentanyl dose (μg) in PACU	76.70±13.3	80.43±12.16	0.073
Nausea and vomiting	6	13	0.012
Number of post-operative hypoxic episodes	-	-	

Group D – Dexmedetomidine group; Group M – Magnesium sulphate group; SAP – Systolic arterial pressure; $ETCO_2$ – End-tidal carbon dioxide, SpO_2 – Arterial oxygen saturation; PACU – Post-anaesthesia care unit;; D – Standard deviation; CI – Confidence interval

the procedures and in the PACUs. The decreased blood pressure led to decreased blood loss and good exposure of the surgical field in patients who received dexmedetomidine compared with magnesium. Furthermore, the requirements for intraoperative antihypertensive, fentanyl and sevoflurane were less with dexmedetomidine. The emergence and extubation times were shorter with dexmedetomidine than magnesium. The complications such as hypotension and bradycardia were higher with dexmedetomidine than magnesium, but not severe enough to causes haemodynamic instability, heart block or cardiac arrest. The bradycardia was managed with a small dose of atropine 0.02 mg/kg IV. The hypotension was managed with fluids and a small dose of ephedrine (5–10 mg) if needed. The management of bradycardia and hypotension did not produce too much elevation in the heart rate, blood pressure or blood loss.

A study which included sixty patients undergoing transsphenoidal resection of pituitary adenoma found that there was better surgical exposure due to minimal blood loss with dexmedetomidine as compared with the control group. The mean arterial blood pressure and heart rate throughout surgery were significantly lower with dexmedetomidine. The total dose of propofol maintenance dose and fentanyl were significantly lower in the dexmedetomidine group than the control group.[14]

In a randomised study which included 46 patients to evaluate the effect of dexmedetomidine in elective transsphenoidal pituitary resection; it was found that heart rate and mean arterial pressure were significantly higher after intubation, during various stages of surgery and immediately after extubation in the control group compared with the

dexmedetomidine group. Dexmedetomidine provided excellent surgical conditions and lesser bleeding than the control group. Emergence time and extubation time were significantly shorter with dexmedetomidine compared with the control group. The total fentanyl consumption during the study was significantly lower with dexmedetomidine than the control group (4.7 and 7.7 μg/kg, respectively; $P < 0.01$). End-tidal isoflurane concentration requirement was found to be significantly reduced with dexmedetomidine compared with the control group ($P < 0.01$).[15]

One study evaluated the effects of dexmedetomidine on haemodynamic stability during intracranial tumour surgery in 54 patients. The study showed that dexmedetomidine decreased response to noxious stimuli, intubation and extubation, thus providing greater haemodynamic stability compared with placebo.[16]

Another study compared dexmedetomidine and magnesium in patients undergoing functional endoscopic sinus surgery and found dexmedetomidine to be safe and more effective in inducing controlled hypotension, in decreasing blood loss and providing a good exposure of the surgical field than magnesium. Mean arterial blood pressure decreased significantly with dexmedetomidine compared with magnesium and the requirement for nitroglycerine was significantly higher with magnesium compared with dexmedetomidine.[17]

In a study which included 88 patients undergoing middle ear surgery showed no difference in the mean arterial blood pressure, surgical field and analgesic requirement between magnesium and dexmedetomidine, but magnesium was associated with shorter recovery time and earlier discharge from the PACU compared to dexmedetomidine.[18]

One study reported that dexmedetomidine is a safe and effective agent in controlled hypotension, decreased bleeding at the surgical site, better exposure of the surgical field and decreased the need for intraoperative fentanyl compared to placebo;[19] and the same results were documented by other studies.[20,21]

There was no hypertension during the loading dose administration of dexmedetomidine in the present study, but another study reported hypertension in 17.9%, in patients undergoing intracranial surgery with dexmedetomidine.[22]

Another study evaluated the effect of magnesium in forty adult patients scheduled for transnasal transsphenoidal pituitary surgery. The mean heart rate, SAP, diastolic and mean arterial pressures decreased significantly with magnesium compared to control group during and after surgery.[23]

In the present study, during infusion of dexmedetomidine or magnesium during surgery, side effects such as hypertension, hypotension or bradycardia were not severe and lasted for short durations (2–3 min). These side effects were managed by adding medications and fluids.

There are some limitations of the present study. It was done in a single centre, with a limited number of patients, and limited researchers talking about the same topics as the present study to discuss these findings in details. Therefore, we recommend other studies be done to compare the haemodynamic parameters and side effects of dexmedetomidine and magnesium on patients undergoing transnasal transsphenoidal pituitary surgery.

CONCLUSIONS

Dexmedetomidine and magnesium are safe in patients undergoing transsphenoidal pituitary resection. Dexmedetomidine has advantages such as better control of blood pressure and heart rate, and provides better exposure of the surgical field with minimal blood loss compared to magnesium. The incidence of hypotension and bradycardia was higher with dexmedetomidine than magnesium.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. Jane JA Jr., Sulton LD, Laws ER Jr. Surgery for primary brain tumours at United States academic training centers: Results from the Residency Review Committee for neurological surgery. J Neurosurg 2005;103:789-93.
2. Abou-Madi MN, Trop D, Barnes J. Aetiology and control of cardiovascular reactions during trans-sphenoidal resection of pituitary microadenomas. Can Anaesth Soc J 1980;27:491-5.
3. Nemergut EC, Dumont AS, Barry UT, Laws ER. Perioperative management of patients undergoing transsphenoidal pituitary surgery. Anesth Analg 2005;101:1170-81.
4. Shams T, El Bahnasawe NS, Abu-Samra M, El-Masry R. Induced hypotension for functional endoscopic sinus surgery:

A comparative study of dexmedetomidine versus esmolol. Saudi J Anaesth 2013;7:175-80.
5. Srivastava U, Dupargude AB, Kumar D, Joshi K, Gupta A. Controlled hypotension for functional endoscopic sinus surgery: Comparison of esmolol and nitroglycerine. Indian J Otolaryngol Head Neck Surg 2013;65 Suppl 2:440-4.
6. Wei-Min Z, Xi-Ming C, Rui-Jiao H, Bo-Xiong S. Clinical study of controlled hypotension with magnesium sulphate during functional endoscopic sinus surgery. J Shanghai Jiaotong Univ 2009;29:150-2.
7. Gerlach AT, Dasta JF. Dexmedetomidine: An updated review. Ann Pharmacother 2007;41:245-52.
8. Elsharnouby NM, Elsharnouby MM. Magnesium sulphate as a technique of hypotensive anaesthesia. Br J Anaesth 2006;96:727-31.
9. Shimosawa T, Takano K, Ando K, Fujita T. Magnesium inhibits norepinephrine release by blocking N-type calcium channels at peripheral sympathetic nerve endings. Hypertension 2004;44:897-902.
10. Boezaart AP, van der Merwe J, Coetzee A. Comparison of sodium nitroprusside – And esmolol-induced controlled hypotension for functional endoscopic sinus surgery. Can J Anaesth 1995;42(5 Pt 1):373-6.
11. Jensen TS, Karoly P. Self-report scales and procedures for assessing pain in adults. In: Turk DC, Melzack R, editors. The Handbook of Pain Assessment. New York: The Guildford Press; 1992. p. 135-51.
12. Aldrete JA. The post-anaesthesia recovery score revisited. J Clin Anesth 1995;7:89-91.
13. Teasdale G, Jennett B. Assessment of coma and impaired consciousness. A practical scale. Lancet 1974;2:81-4.
14. Salimi A, Sharifi G, Bahrani H, Mohajerani SA, Jafari A, Safari F, *et al.* Dexmedetomidine could enhance surgical satisfaction in trans-sphenoidal resection of pituitary adenoma. J Neurosurg Sci 2017;61:46-52.
15. Gopalakrishna KN, Dash PK, Chatterjee N, Easwer HV, Ganesamoorthi A. Dexmedetomidine as an anesthetic adjuvant in patients undergoing transsphenoidal resection of pituitary tumor. J Neurosurg Anesthesiol 2015;27:209-15.
16. Tanskanen PE, Kytta JV, Randell TT, Aantaa RE. Dexmedetomidine as an anesthetic adjuvant in patients undergoing intracranial tumour surgery: A double blind, randomized and placebo controlled study. Br J Anaesth 2006;97:658-65.
17. Bayram A, Ulgey A, Günes I, Ketenci I, Capar A, Esmaoglu A, *et al.* Comparison between magnesium sulfate and dexmedetomidine in controlled hypotension during functional endoscopic sinus surgery. Rev Bras Anestesiol 2015;65:61-7.
18. Aboushanab OH, El-Shaarawy AM, Omar AO, Abdelwahab HH. A comparative study between magnesium sulphate and dexmedetomidine for deliberate hypotension during middle ear surgery. Egypt J Anaesth 2011;27:227-32.
19. Guven DG, Demiraran Y, Sezen G, Kepek O, Iskender A. Evaluation of outcomes in patients given dexmedetomidine in functional endoscopic sinus surgery. Ann Otol Rhinol Laryngol 2011;120:586-92.
20. Ayoglu H, Yapakci O, Ugur MB, Uzun L, Altunkaya H, Ozer Y, *et al.* Effectiveness of dexmedetomidine in reducing bleeding during septoplasty and tympanoplasty operations. J Clin Anesth 2008;20:437-41.
21. Vineela CH, Ganapathi P, Shankara Narayana P. Effect of controlled hypotension with dexmedetomidine versus nitroglycerin on intraoperative blood loss during FESS. J Dent Med Sci 2015;14:42-5.
22. Yasemin G, Mediha T, Tahsin E, Hayri O, Geylan I. Anesthesia for craniotomy comparison of sevoflurane, desflurane, or isoflurane anesthesia supplemented with an infusion of dexmedetomidine during supratentorial craniotomy. Neurosurg Q 2009;19:110-5.
23. Rajan S, Kavita M, Andrews S. The attenuating effect of magnesium on hemodynamic responses during transnasal transsphenoidal surgery. Amrita J Med 2012;8:31-5.