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Comparison of Different Maintenance Doses of Dexmedetomidine for Controlled Hypotensive Anesthesia in Functional Endoscopic Sinus Surgery: A Prospective Observational Study

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Abstract

Background: Controlled hypotensive anesthesia is preferred in functional endoscopic sinus surgery (FESS). The idea is to reduce intraoperative bleeding, which tends to improve surgical visibility for the procedure. Dexmedetomidine is commonly used because of its alpha antagonist activity and ability to induce controlled hypotension with sedation and analgesia. Evidence is regarding the optimal dose to be used for hemodynamic stability as well as surgical conditions. The current study aimed to determine the different doses of dexmedetomidine on hemodynamic parameters in cases undergoing FESS under general anesthesia. ***Methods:*** This study was done on patients undergoing FESS in our hospital. A standard induction protocol was followed for each patient. Administration of dexmedetomidine was done in various infusion rates (0.2, 0.4, and 0.6 µg/kg/h). Assessment of hemodynamic parameters, including MAP, heart rate, and other intraoperative and postoperative parameters, was recorded. The quality of the surgical field was graded based on a standard, validated scoring system. Other parameters recorded were blood loss, recovery parameters, time to extubation, and postoperative sedation scores. ***Results:*** A total of n=60 cases, divided into three groups of n=20 each, were included in the study with different dose concentrations. It was found that patients receiving dexmedetomidine at 0.4 and 0.6 µg/kg/h showed a reduction in mean arterial pressure. The assessment of surgical field visibility was also better as compared to the 0.2 µg/kg/h group ($p<0.05$). The higher dose of dexmedetomidine was associated with increased recovery time and increased postoperative sedation. It was found that the 0.4 µg/kg/h group exhibited an optimal balance between hemodynamic stability and acceptable recovery profile. ***Conclusion:*** The current study found that dexmedetomidine at a dose of 0.4 µg/kg/h provided optimal maintenance of controlled hypotension for FESS, providing improved surgical conditions with minimal adverse effects on recovery.

Keywords: Controlled Hypotension, Dexmedetomidine, Functional Endoscopic Sinus Surgery (FESS), Hemodynamic Stability.

INTRODUCTION

Functional endoscopic sinus surgery (FESS) is an extensively performed and minimally invasive surgery for the treatment of chronic rhinosinusitis and other sinonasal pathologies. Intraoperative bleeding is one of the main issues in FESS that may seriously impair the visibility of the operative field, which may increase the duration of surgery and increase the risk of complications (1). Anesthesiologists have tried to counter this by using controlled hypotensive anesthesia, which is a planned decrease in mean arterial pressure (MAP) in order to enhance the visibility of the surgical field, lessen blood loss during surgery, and enable a safer and effective surgical practice (2). Controlled hypotension has traditionally achieved with the help of a variety of pharmacologic agents such as vasodilators, beta-blockers, magnesium sulfate, and anesthetic infusion, but most of these agents are linked to the unfavorable cardiovascular or recovery profile (3,4). The use of selective alpha-2 adrenergic agonists such as dexmedetomidine has become popular in controlled hypotensive anesthesia with its unique ability to provide sedation, analgesia, and sympatholysis without significant respiratory depression (5). Its pharmacologic effects, such as central inhibition of sympathetic outflow and increased vagal activity, make it reliable to reduce the heart rate and blood pressure, which are effective in establishing an appropriate operating environment during FESS (6). In addition, sedative

effects of dexmedetomidine, which are mediated by action on the locus coeruleus, are claimed to be beneficial in the perioperative practice, especially in areas that entail maintenance of hemodynamics (5). There have been a number of clinical trials that assess the effectiveness of dexmedetomidine in controlled hypotension in FESS. According to Shams et al. [7], the dexmedetomidine infusions were reported to achieve target levels of MAP (55-65 mmHg) and a good-quality surgical field, as well as result in lower intraoperative opioid requirements than esmolol (7). Similarly, the other drugs, such as magnesium sulfate and propofol, in the comparison of dexmedetomidine showed that dexmedetomidine has a better hemodynamic profile with a reduction in intraoperative blood loss and an enhanced visibility of the surgical field (8,9). It is also observed that the dose of dexmedetomidine could affect the regularity and the period of maintained hypotension in association with other maintained anesthetics, and the various rates of dexmedetomidine maintenance infusion could affect clinical outcome (10). Although dexmedetomidine is now being increasingly used for FESS, there is a lack of optimal dosing schedules of dexmedetomidine to regulate hypertensive anesthesia during FESS. The majority of published research utilizes quite fixed loading and maintenance infusion levels, commonly ranging between 0.4 and 0.8 5g/kg/h, without strong prospective data based on patient variables or intraoperative reaction (7,11). Consequently, there is no unanimity in the clinical community regarding the best maintenance dosing regimen, which avoids hemodynamic instability, maintenance of the surgical field, adverse effects (bradycardia, excessive sedation), and recovery profiles. Therefore, the comparison of various doses of dexmedetomidine in maintenance is very important in order to optimize the controlled hypotensive anesthesia in FESS. Understanding whether anesthetic practices can be optimized by administering higher maintenance dose levels to offer better control of MAP, or whether maintaining low doses would lead to fewer adverse effects without affecting the conditions of the surgery. This can help to refine anesthetic protocols and improve patient outcomes. Thus, the proposed observational study will focus on comparing the clinical outcomes of the various maintenance dosing regimens of dexmedetomidine in controlled hypotensive anesthesia in adults undergoing FESS. The study aims to provide evidence to aid in tailored anesthetic management of this surgical population through systematic evaluation of hemodynamics, the quality of the surgical field, intraoperative blood loss, and perioperative complications, as the study will evaluate the dosing groups.

MATERIALS AND METHODS

This prospective randomized controlled study was conducted in the Department of Anesthesiology, Gandhi Medical College and Hospital, Secunderabad, Telangana. Institutional Ethical approval was obtained for the study after explaining the nature of the study in the vernacular language. Written informed consent was obtained from all the participants of the study.

Inclusion criteria

1. Patients undergoing Functional Endoscopic Sinus Surgery (FESS) under general anesthesia.
2. Aged 18 and above
3. ASA category I and II
4. Voluntary participation

Exclusion criteria

1. Uncontrolled hypertension or arrhythmias
2. Respiratory diseases affecting ventilation
3. Hepatic or renal diseases
4. History of hypersensitivity to dexmedetomidine
5. Pregnancy and lactation

A total of n=60 cases were included in the study based on the inclusion and exclusion criteria. Group allocation (n=20), each group for the patients was done by computer-generated random numbers the participants were allotted to one of the three groups. Group D1: Dexmedetomidine 0.2 µg/kg/h maintenance infusion. Group D2: Dexmedetomidine 0.4 µg/kg/h maintenance infusion. Group D3: Dexmedetomidine 0.6 µg/kg/h maintenance infusion. The study drugs of different doses were prepared in identical syringes by an anesthesiologist not involved in patient management, and records were maintained for allotment. Both the anesthesiologist administering anesthesia and the surgeon were blinded to group allocation.

All patients were premedicated with intravenous (IV) midazolam (0.03 mg/kg) along with fentanyl (2 µg/kg). Standard monitors, including electrocardiography (ECG), non-invasive blood pressure (NIBP), pulse oximetry, and capnography, were applied. Baseline hemodynamic parameters were recorded before induction. Anesthesia was induced with propofol (2 mg/kg) and atracurium (0.5 mg/kg), and the airway was secured with an endotracheal tube. Maintenance of anesthesia was achieved using sevoflurane (1.5–2%) in a 50% oxygen-nitrous oxide mixture.

The drug in question was started at a pre-assigned infusion rate. Hypotension (mean arterial pressure less than 55 mmHg) was treated with IV ephedrine (6 mg boluses), and bradycardia (heart rate less than 50bpm) was treated with IV atropine (0.6 mg).

Outcome Parameters and Measures: Hemodynamic Measures: Heart rate, diastolic blood pressure (DBP), systolic blood pressure (SBP), and mean arterial pressure (MAP) were measured at baseline, after induction, at 5 minutes intraoperative, and postoperative 30 minutes. Quality of the Surgical Field: This is

assessed with the Boezaart bleeding scale (0-5), whereby a low result represents a desirable surgical field. Intraoperative Blood Loss: Suction volume and gauze weighing method. Recovery Characteristics: Time to extubation, modified Aldrete score 10 and 30 minutes after extubation, and rate of postoperative nausea and vomiting (PONV).

Statistical Analysis: All the available data were refined, segregated, and uploaded to an MS Excel spreadsheet and analyzed by SPSS version 26 in Windows format. The continuous variables were represented as mean, standard deviation, frequency, and percentage. The categorical variables were calculated by analysis of variance (ANOVA), and group comparisons were done with a chi-square test, and values of P <0.05 were considered statistically significant.

RESULTS

The baseline characteristics of the cohort are presented in Table 1. Analysis of the table showed that the three groups, Group D1 (0.2 µg/kg/h), Group D2 (0.4 µg/kg/h), and Group D3 (0.6 µg/kg/h), were divided based on the dose of dexmedetomidine used. All the groups were found to be comparable based on the baseline demographic and clinical variables. There were no statistically significant differences in relation to age, sex, body weight, and ASA Physical status. This shows that the process of randomization was achieved in these groups. No confounding factors were likely to affect the outcomes based on baseline characteristics.

Table 1: Baseline Demographic and Clinical Characteristics

Characteristic	Group DI (0.2 µg/kg/h) (n=20)	Group D2 (0.4 µg /kg/h) (n=20)	Group D3 (0.6 µg /kg/h) (n=20)	p-value
Age (Years)	38.5 ± 12.4	40.2 ± 11.8	36.9 ± 13.1	0.712
Sex (Male: Female)	12:08	11:9	13: 7	0.847
Weight (kg)	68.3 ± 10.5	70.1 ± 9.8	67.8 ± 11.2	0.789
ASA Physical Status				
ASA I	14 (70%)	13 (65%)	15 (75%)	0.774
ASA II	6 (30%)	7 (35%)	5 (25%)	0.774
Duration of Surgery (min)	85.5 ± 20.3	88.2 ± 18.7	90.1 ± 22.5	0.801

The intraoperative hemodynamics of the cohort are compared and presented in Table 2. Overall analysis of the table showed that a dose-dependent reduction of Heart rate and mean arterial pressure was observed with increasing dexmedetomidine infusion rates from Group D1 to D3. The post-induction and intraoperative at 5 minutes, it was found that Group D3 had significantly higher HR and MAP compared with Groups D1 and D2. The reduction was most pronounced at the time interval of 5 minutes intraoperatively. Group D3 achieved the lowest HR and MAP, which indicated more pronounced but controlled hypotension. At the end of 30 minutes postoperatively, the heart rate and mean arterial pressure values were found to be comparable among the different groups, which indicated that recovery of hemodynamic parameters occurred after cessation of infusion.

Table 2: Intraoperative Hemodynamic Parameters

Parameter	Time Point	Group DI (0.2 µg /kg/h) (n=20)	Group D2 (0.4 µg /kg/h) (n=20)	Group D3 (0.6 µg /kg/h) (n=20)	P value
Heart Rate (bpm)	Baseline	78.4 ± 9.2	76.9 ± 8.7	77.8 ± 9.5	0.895
	Post-induction	72.1 ± 8.5	68.3 ± 7.9	65.5 ± 8.1	0.032*
	5 min Intraop	69.5 ± 7.8	64.2 ± 6.5	58.8 ± 6.1	<0.001*
	Postop 30 min	75.2 ± 8.1	73.8 ± 7.6	72.4 ± 7.9	0.571
Mean Arterial Pressure (MAP, mmHg)	Baseline	92.5 ± 10.2	91.8 ± 9.7	93.1 ± 10.5	0.924
	Post-induction	82.3 ± 9.5	78.6 ± 8.8	75.4 ± 9.1	0.045*
	5 min Intraop	79.8 ± 8.7	71.5 ± 7.9	64.2 ± 7.3	<0.001*
	Postop 30 min	86.4 ± 9.3	84.7 ± 8.9	83.1 ± 9.2	0.482

*<0.05 vs. Group DI; p <0.05 vs. Group D2 (post-hoc analysis) *Significant*

Assessment of the quality of the surgical field and blood loss is depicted in Table 3. The assessment was done by using the Boezaart bleeding scale. Analysis of the table showed Group D3 had the highest proportion of patients with no or minimal bleeding (scores 0–1), whereas Group D1 had a greater proportion of patients with moderate to severe bleeding (scores 3–4). The results showed that there is a tendency for the mean values of the Boezaart score to decrease from Group D1 to Group D3, with the differences found to be statistically significant. The intraoperative blood loss was

correspondingly lowest in Group D3 as compared to Groups D2 and D1 (P<0.001). This showed that there is a dose-dependent improvement of surgical field visibility and reduced blood loss following administration of dexmedetomidine.

Table 3: Quality of Surgical Field (Boezaart Bleeding Scale) and Blood Loss

Outcome	Group DI (0.2 µg/kg/h) (n=20)	Group D2 (0.4 µg /kg/h) (n=20)	Group D3 (0.6 µg /kg/h) (n=20)	P value
Boezaart Score, n (%)				<0.001
O (No Bleeding)	0 (0%)	1 (5%)	3 (15%)	
1 (Minimal)	4 (20%)	8 (40%)	10 (50%)	
2 (Mild)	9 (45%)	7 (3.5%)	6 (30%)	
3 (Moderate)	6 (30%)	4 (2.0%)	1 (5%)	
4 (Severe)	1 (5%)	0 (0%)	0 (0%)	
5 (Massive)	0 (0%)	0 (0%)	0 (0%)	
Mean Boezaart Score	2.2 ± 0.8	1.8 ± 0.7*	1.4 ± 0.6	<0.001*
Estimated Blood Loss (ml)	185.5 ± 45.2	142.3 ± 38.7	115.8 ± 32.4	<0.001*
*Boezaart Scale: 0=No bleeding, 5=Massive uncontrollable bleeding *Significant*				

The recovery profile of the cohort is presented in Table 4. Analysis of the table showed that the time to extubation was increased with a higher dose of dexmedetomidine. The shortest extubation time was in Group D1, and the longest was in Group D3; the differences were found to be statistically significant. Modified Alderete scores after 10 minutes of extubation were found to be lower in Group D3, indicating delayed recovery. At the end of 30 minutes, Aldrete scores were comparable across all the groups. The incidence of postoperative nausea and vomiting (PNOV) was similarly distributed in all groups.

Table 4: Recovery Characteristics

Parameter	Group DI (0.2 µg/kg/h) (n=20)	Group D2 (0.4 µg /kg/h) (n=20)	Group D3 (0.6 µg /kg/h) (n=20)	P value
Time to Extubation (min) Modified Aldrete Score	8.2 ± 2.5	9.8 ±3.1	12.5 ± 3.8	<0.001*
At 10 min	8.5 ± 1.2	8.1 ± 1.3	7.6 ± 1.5*	0.038*
At 30 min	9.8 ± 0.5	9.7 ± 0.6	9.5 ±0.7	0.254
PONV within 24h, n (%)	3(15%)	2 (10%)	4(2.0%)	0.661
<0.05 vs. Group DI; p <0.05 vs. Group D2 (post-hoc analysis).				
PONV: Postoperative Nausea and Vomiting.				

The incidence of intraoperative complications and need for rescue medications is depicted in Table 5. Analysis of the results showed that the incidence of bradycardia and hypotension had a dose-dependent increase, with Group D3 having a significantly higher incidence of bradycardia and hypotension; therefore, increased requirements of atropine and ephedrine were present in this group. The total requirement of rescue mediation in the cases was higher in Group D3 (60%), followed by Group D2 (30%) and Group D1 (15%), respectively, and the values were found to be statistically significant. While higher doses of dexmedetomidine provided superior hemodynamic control, improved surgical field quality, and reduced blood loss, they were also associated with delayed recovery and a higher incidence of dose-related adverse effects requiring intervention.

Table 5: Intraoperative Complications and Rescue Medication Requirements

Complication / Intervention	Group DI (0.2 µg/kg/h) (n=20)	Group D2 (0.4 µg /kg/h) (n=20)	Group D3 (0.6 µg /kg/h) (n=20)	P value
Bradycardia (HR < 50 bpm)	1 (5%)	3 (15%)	7 (35%)	0.037*
Required Atropine	1 (5%)	3 (15%)	7 (35%)	0.037*
Hypotension (MAP <55 mmHg)	2 (10%)	5 (25%)	9 (45%)	0.028*
Required Ephedrine	2 (10%)	5 (25%)	9 (45%)	0.028*
Total Patients Requiring Rescue Medication	3 (15%)	6 (30%)	12(60%)	0.008
*p<0.05 vs. Group DI; p <0.05 vs. Group D2 (post-hoc analysis). *Significant*				

DISCUSSION

FESS requires a bloodless surgical site to allow maximum visibility of delicate anatomic structures encountered in the procedure. One of the methods of achieving this is the application of controlled hypotensive anesthesia. Dexmedetomidine, a highly selective α2- adrenergic agonist, has gained widespread popularity for this purpose. Apart from its hypotensive actions, it has additional beneficial properties such as sedative action, sympatholytic action, and anesthetic sparing effects that are characterized by minimal respiratory depression (12). In the current study, the maintenance doses of dexmedetomidine (0.2, 0.4, and 0.6 µg/kg/h) produced a clear effect of dose-dependent change of heart rate and mean arterial pressure during the intraoperative period. Our results are in agreement with previous studies that found dexmedetomidine to suppress sympathetic activities by blocking the release of norepinephrine in presynaptic nerve endings (13,14). In this study, results showed that greater hypotensive and bradycardia responses were seen in Group D3 (0.6 µg/kg/h), which supports the hypothesis that the higher the rate of infusion, the more successful the control of hypotension. Improvement in the surgical field quality, as measured by the Boezaart bleeding scale, was found to be much better in patients who were given higher doses of dexmedetomidine (Group D3). The higher dose of dexmedetomidine was characterized by a low mean bleeding score and a much lower estimated blood loss than Groups D1 and D2. These findings correlate with previous studies by Durmuş et al. (15) and Cincikas et al. (16), who reported that dexmedetomidine provided optimal visibility of the surgical field when the dose was higher because of its ability to decrease mucosal blood flow and prevent venous oozing. The minimized loss of blood is not only beneficial to the precision of the operation, but could also aid in minimizing the time of operation and surgeon fatigue. Although these were the benefits, results showed that at higher doses, they were linked to delayed emergence and recovery. In this study, time to extubation was significantly increased in Group D3, and the Modified Aldrete scores at 10 minutes were also lower than those of the other groups (Table 4). Previous studies in this field have made similar observations as the central α2-agonist sedation effects of dexmedetomidine extended with increased doses of dexmedetomidine (17). Nevertheless, Aldrete scores were similar at 30 minutes, which signified that this delay was both temporary and acceptable clinically in the majority of patients. An important observation of this was a greater frequency of dose-related adverse effects. Bradycardia and hypotension were also more common in Group D3, and there was a higher need for rescue drugs like atropine and ephedrine in this group. This has been well reported in the literature where increased dexmedetomidine rates have been linked to exaggerated sympatholysis, especially in the case of volume-depleted or vagotonic patients (18,19). Though there were neither severe nor irreversible complications in our study, these findings underscore the importance of monitoring hemodynamic parameters when higher doses are used. Interestingly, the intermediate dose Group D2(0.4 µg/kg/h) was found to provide a good trade-off between efficacy and safety. Group D2 had superior conditions in the surgical field and less blood loss than the low-dose group, and had a lower incidence of adverse events than the high-dose group. Bajwa et al. and Guven et al. have also made similar conclusions and advised moderate dexmedetomidine infusion rates to achieve the best surgical conditions without jeopardizing the safety of patients (20,21). On the whole, the results of this research showed that the benefits of dexmedetomidine in controlled hypotensive anesthesia during FESS are dose-dependent, and the personalization of dosage based on patients' profiles and intraoperative hemodynamic dynamics is crucial for all cases.

CONCLUSION

Dexmedetomidine is a useful drug for the application of controlled hypotensive anesthesia in functional endoscopic sinus surgeries. Itprovides better hemodynamic stability and better surgical field conditions in a dose-effect relationship. Increased infusion rates have been shown to cause a significant reduction in the heart rate, mean arterial pressure, and blood loss during FESS. However, higher doses are linked with a higher incidence of bradycardia, hypotension, delayed extubation, and use of more rescue drugs. An intermediate range dose of 0.4 µg/kg/h seems to be the most effective level of maintenance that provides satisfactory hypotension and proper surgery conditions with minimum side effects.

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