

Assessment of Perioperative Hemodynamic Responses and Recovery Characteristics Following the Use of Dexmedetomidine Versus Esmolol for Controlled Hypotension During Functional Endoscopic Sinus Surgery

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<https://doi.org/10.5281/zenodo.21738006>

Received: 09 July 2026, Accepted: 28 July 2026, Online First: 02 August 2026

ABSTRACT

Background: Functional endoscopic sinus surgery (FESS) is associated with intraoperative bleeding that may impair surgical visualisation and increase operative difficulty. Controlled hypotension is commonly used to reduce blood loss and improve surgical conditions. Dexmedetomidine and esmolol are frequently used agents for achieving controlled hypotension; however, their effects on perioperative hemodynamic stability and recovery characteristics differ. **Aim:** To compare perioperative hemodynamic responses, surgical field quality, blood loss, recovery profile, and postoperative complications following the use of dexmedetomidine versus esmolol for controlled hypotension during FESS. **Materials and Methods:** This prospective randomized comparative study was conducted in the Department of Anaesthesiology at C.S.I. Redfern Memorial Hospital, Hassan, Karnataka, from January 2023 to December 2026. A total of 100 patients undergoing elective FESS under general anaesthesia were randomly allocated into two groups of 50 patients each. Group D received dexmedetomidine infusion, while Group E received esmolol infusion for controlled hypotension. Perioperative heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, oxygen saturation, surgical field quality, intraoperative blood loss, recovery parameters, and postoperative complications were assessed. **Results:** Both groups were comparable regarding demographic characteristics, baseline laboratory investigations, and preoperative hemodynamic parameters. Dexmedetomidine provided better attenuation of heart rate response during intubation, controlled hypotension, and extubation compared with esmolol ($p < 0.05$). Mean arterial pressure was more consistently maintained in the dexmedetomidine group with fewer perioperative fluctuations. The dexmedetomidine group demonstrated better surgical field visibility with a higher proportion of excellent Boezaart scores and significantly lower intraoperative blood loss compared with the esmolol group (94.6 ± 25.8 ml vs 120.8 ± 31.4 ml, $p < 0.05$). Recovery parameters including time to eye opening, extubation time, response to verbal commands, and PACU stay were significantly shorter in the dexmedetomidine group. Both groups showed comparable safety profiles without major adverse events. **Conclusion:** Dexmedetomidine provides superior perioperative hemodynamic stability, improved surgical field quality, reduced intraoperative blood loss, and faster postoperative recovery compared with esmolol when used for controlled hypotension during functional endoscopic sinus surgery. Dexmedetomidine may therefore be considered an effective agent for achieving controlled hypotension with favourable recovery characteristics.

keywords: Dexmedetomidine; Esmolol; Functional Endoscopic Sinus Surgery (FESS); Controlled Hypotension; Hemodynamic Stability; Mean Arterial Pressure; Intraoperative Blood Loss; Recovery Profile; Surgical Field Quality; General Anaesthesia.

INTRODUCTION

Functional endoscopic sinus surgery (FESS) is a commonly performed minimally invasive procedure for the management of chronic rhinosinusitis and other sinonasal disorders. Although FESS offers improved

visualization and reduced tissue trauma compared with conventional sinus surgery, intraoperative bleeding remains a major challenge that can significantly affect surgical field visibility and operative precision. Excessive bleeding may obscure the endoscopic view,

prolong operative time, and increase the risk of complications. Therefore, achieving an optimal surgical field through controlled reduction of blood pressure has become an important component of anaesthetic management during FESS.¹

Controlled hypotension is a deliberate reduction of arterial blood pressure during surgery to decrease intraoperative blood loss and improve surgical visualization. Various pharmacological agents including vasodilators, beta-adrenergic blockers, and α 2-adrenergic agonists have been used for this purpose. The ideal hypotensive agent should provide predictable blood pressure reduction, maintain adequate tissue perfusion, allow rapid recovery, and produce minimal adverse effects.²

Esmolol, an ultra-short acting selective β 1-adrenergic antagonist, reduces heart rate and myocardial contractility, thereby decreasing cardiac output and arterial pressure. Due to its rapid onset and short duration of action, esmolol has been widely used for attenuation of sympathetic responses during stressful perioperative events such as laryngoscopy and surgical stimulation. However, excessive reduction in heart rate and limited control of vascular resistance may restrict its effectiveness in achieving stable controlled hypotension.³

Dexmedetomidine is a highly selective α 2-adrenergic receptor agonist that produces sympatholysis by reducing norepinephrine release from presynaptic nerve terminals. It provides sedation, analgesia, and attenuation of sympathetic responses without significant respiratory depression. Its ability to decrease heart rate, maintain cardiovascular stability, and reduce anaesthetic requirements has increased its use in various surgical procedures requiring controlled hypotension.⁴

Several studies have demonstrated the beneficial role of dexmedetomidine in improving surgical field quality and reducing intraoperative blood loss during ENT procedures. However, comparison between dexmedetomidine and esmolol regarding perioperative hemodynamic stability and postoperative recovery characteristics during FESS remains clinically relevant.⁵

Maintenance of stable hemodynamic parameters during controlled hypotension is essential because excessive reduction in blood pressure may compromise cerebral, renal, and other vital organ perfusion. Therefore, selection of an appropriate hypotensive agent should balance effective blood pressure control with patient safety and rapid postoperative recovery.⁶

The present study was designed to compare dexmedetomidine and esmolol for controlled hypotension during functional endoscopic sinus surgery, with emphasis on perioperative hemodynamic responses, quality of surgical field, intraoperative blood loss, recovery profile, and postoperative complications. The study included 100 patients

randomly allocated into dexmedetomidine and esmolol groups for comparative evaluation.

MATERIALS AND METHODS

Study Design and Setting

This prospective, randomized, comparative clinical study was conducted in the Department of Anaesthesiology at C.S.I. Redfern Memorial Hospital, Hassan, Karnataka. The study was carried out over a period of three years from January 2023 to December 2026. The aim of the study was to compare the perioperative hemodynamic responses and recovery characteristics following the use of dexmedetomidine versus esmolol for controlled hypotension during functional endoscopic sinus surgery (FESS).

Study Population and Sample Size

A total of 100 patients scheduled for elective functional endoscopic sinus surgery under general anaesthesia were enrolled in the study. Patients were randomly allocated into two equal groups of 50 patients each:

- **Group D (Dexmedetomidine group):** Patients received dexmedetomidine infusion for achieving controlled hypotension.
- **Group E (Esmolol group):** Patients received esmolol infusion for achieving controlled hypotension.

Randomization was performed using a computer-generated random allocation sequence.

Inclusion Criteria

Patients fulfilling the following criteria were included:

- Patients aged 18–60 years.
- American Society of Anesthesiologists (ASA) physical status I and II.
- Patients undergoing elective functional endoscopic sinus surgery.
- Patients providing written informed consent for participation.

Exclusion Criteria

Patients were excluded if they had:

- Significant cardiovascular disease such as ischemic heart disease, arrhythmias, or heart failure.
- Uncontrolled hypertension or hypotension.
- Severe hepatic or renal dysfunction.
- Known allergy or contraindication to dexmedetomidine or esmolol.
- Pregnancy.
- Patients requiring conversion to another surgical procedure or prolonged postoperative ventilation.

Preoperative Assessment

All patients underwent detailed preoperative evaluation including history, physical examination, airway assessment, and routine investigations. Baseline investigations included complete blood count, blood glucose estimation, renal function tests, liver function tests, serum electrolytes, coagulation profile (when indicated), electrocardiogram, and chest radiography whenever clinically required.

Patients were kept fasting according to standard fasting guidelines. Baseline parameters including heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), oxygen saturation (SpO₂), and respiratory rate were recorded before induction of anaesthesia.

Anaesthetic Technique

All patients received standardized general anaesthesia. After establishing intravenous access and routine monitoring, patients were premedicated with appropriate doses of midazolam and glycopyrrolate. Anaesthesia was induced with intravenous propofol and neuromuscular blockade was achieved using an appropriate muscle relaxant. Endotracheal intubation was performed, and anaesthesia was maintained with oxygen, air, and inhalational anaesthetic agent along with controlled ventilation.

Standard intraoperative monitoring included:

- Continuous electrocardiography (ECG)
- Heart rate monitoring
- Non-invasive blood pressure monitoring
- Mean arterial pressure monitoring
- Pulse oximetry
- End-tidal carbon dioxide monitoring

Controlled Hypotension Protocol

Group D (Dexmedetomidine group): Patients received dexmedetomidine infusion after induction of anaesthesia. The infusion rate was adjusted according to the desired blood pressure target.

Group E (Esmolol group): Patients received esmolol infusion after induction of anaesthesia. The dose was titrated to achieve comparable controlled hypotension. Controlled hypotension was maintained with a target mean arterial pressure appropriate for surgical requirements while ensuring adequate organ perfusion.

Intraoperative Hemodynamic Monitoring

Hemodynamic variables were recorded at predefined intervals:

- Baseline (before induction)
- After induction of anaesthesia
- After intubation
- During maintenance of controlled hypotension
- At completion of surgery
- After reversal of neuromuscular blockade

- After extubation

The following parameters were compared between groups:

- Heart rate
- Systolic blood pressure
- Diastolic blood pressure
- Mean arterial pressure
- Oxygen saturation

Assessment of Surgical Field Quality

The quality of the surgical field was assessed by the operating surgeon using a standardized grading scale based on intraoperative bleeding and visibility during FESS. Intraoperative blood loss was estimated by measuring blood collected in suction containers and surgical gauze assessment.

Recovery Assessment

Postoperative recovery characteristics were evaluated using:

- Time to eye opening after discontinuation of anaesthesia
- Time to extubation
- Time to achieve adequate response to verbal commands
- Post-anaesthesia care unit (PACU) stay duration
- Postoperative sedation score
- Incidence of adverse effects such as bradycardia, hypotension, nausea, vomiting, and respiratory depression

Postoperative Monitoring

Patients were monitored in the recovery area for vital parameters, pain score, sedation level, and any complications. Rescue analgesia was provided whenever required according to institutional protocol.

Statistical Analysis

Data obtained from the study were compiled and analyzed statistically. Continuous variables were expressed as mean $\pm$ standard deviation, while categorical variables were presented as frequencies and percentages. Comparison between the two groups was performed using appropriate statistical tests. A p-value <0.05 was considered statistically significant.

Ethical Considerations

The study protocol was approved by the Institutional Ethics Committee of C.S.I. Redfern Memorial Hospital, Hassan. Written informed consent was obtained from all participants before enrollment. Patient confidentiality was maintained throughout the study period.

RESULTS AND OBSERVATIONS

The present prospective randomized comparative study was conducted on 100 patients undergoing elective Functional Endoscopic Sinus Surgery (FESS) at C.S.I. Redfern Memorial Hospital, Hassan. Patients were randomly allocated into two groups:

- Group D (Dexmedetomidine group): 50 patients
- Group E (Esmolol group): 50 patients

The two groups were compared regarding baseline characteristics, preoperative investigations, perioperative hemodynamic responses, quality of surgical field, intraoperative blood loss, recovery profile, and postoperative complications.

Table 1: Demographic Characteristics of Study Population

Parameters	Group D (n=50)	Group E (n=50)	p-value
Age (years) Mean $\pm$ SD	38.6 $\pm$ 9.2	39.4 $\pm$ 8.8	>0.05
Male, n (%)	32 (64%)	34 (68%)	>0.05
Female, n (%)	18 (36%)	16 (32%)	>0.05
Weight (kg) Mean $\pm$ SD	63.2 $\pm$ 7.6	64.1 $\pm$ 8.0	>0.05
ASA Grade I, n (%)	29 (58%)	31 (62%)	>0.05
ASA Grade II, n (%)	21 (42%)	19 (38%)	>0.05

Observation:

The demographic characteristics including age, sex distribution, weight, and ASA physical status were comparable between both groups.

Table 2: Comparison of Preoperative Laboratory Investigations

Investigations	Group D	Group E	p-value
Hemoglobin (g/dL)	13.4 $\pm$ 1.2	13.6 $\pm$ 1.3	>0.05
TLC (/mm ³)	7200 $\pm$ 850	7300 $\pm$ 900	>0.05
Platelet count (/mm ³)	2.62 $\pm$ 0.48 lakh	2.58 $\pm$ 0.52 lakh	>0.05
RBS (mg/dL)	104 $\pm$ 18	106 $\pm$ 20	>0.05
Serum Creatinine (mg/dL)	0.82 $\pm$ 0.16	0.84 $\pm$ 0.18	>0.05
Urea (mg/dL)	28.6 $\pm$ 5.4	29.1 $\pm$ 5.8	>0.05
AST (U/L)	26.4 $\pm$ 5.8	27.1 $\pm$ 6.2	>0.05
ALT (U/L)	28.2 $\pm$ 6.4	28.8 $\pm$ 6.6	>0.05
Sodium (mEq/L)	138.6 $\pm$ 2.8	138.9 $\pm$ 3.0	>0.05
Potassium (mEq/L)	4.1 $\pm$ 0.4	4.2 $\pm$ 0.3	>0.05

Observation:

Preoperative laboratory investigations were within acceptable limits and showed no statistically significant difference between both groups.

Table 3: Baseline Hemodynamic Parameters

Parameters	Group D	Group E	p-value
Heart Rate (beats/min)	82.4 $\pm$ 8.5	81.8 $\pm$ 8.9	>0.05
SBP (mmHg)	124.8 $\pm$ 10.4	125.5 $\pm$ 11.1	>0.05
DBP (mmHg)	78.4 $\pm$ 7.6	79.1 $\pm$ 7.9	>0.05
MAP (mmHg)	93.8 $\pm$ 7.5	94.4 $\pm$ 8.0	>0.05
SpO ₂ (%)	98.2 $\pm$ 0.7	98.1 $\pm$ 0.8	>0.05
Respiratory rate/min	16.8 $\pm$ 1.8	17.0 $\pm$ 1.6	>0.05

Observation:

Baseline hemodynamic parameters were comparable between both groups before administration of study drugs.

Table 4: Comparison of Heart Rate Changes During Perioperative Period

Time Interval	Group D	Group E	p-value
Baseline	82.4 $\pm$ 8.5	81.8 $\pm$ 8.9	>0.05
After Induction	76.5 $\pm$ 7.2	78.3 $\pm$ 7.6	>0.05
After Intubation	83.1 $\pm$ 8.2	92.4 $\pm$ 9.4	<0.05
During Controlled Hypotension	68.6 $\pm$ 6.5	74.6 $\pm$ 7.3	<0.05
End of Surgery	72.5 $\pm$ 7.0	78.7 $\pm$ 8.0	<0.05
After Extubation	84.4 $\pm$ 8.4	95.1 $\pm$ 10.2	<0.05

Observation:

Dexmedetomidine significantly attenuated heart rate response during intubation, controlled hypotension, and extubation compared with esmolol.

Table 5: Comparison of Mean Arterial Pressure (MAP)

Time Interval	Group D	Group E	p-value
Baseline	93.8 ± 7.5	94.4 ± 8.0	>0.05
After Induction	84.5 ± 6.8	85.6 ± 7.1	>0.05
After Intubation	88.4 ± 7.2	96.2 ± 8.5	<0.05
During Hypotension	66.8 ± 5.6	71.4 ± 6.2	<0.05
End of Surgery	83.6 ± 6.6	89.4 ± 7.3	<0.05
After Extubation	92.2 ± 7.6	99.0 ± 8.8	<0.05

Observation:

Dexmedetomidine maintained more stable MAP control with fewer perioperative fluctuations.

Table 6: Comparison of Surgical Duration and Anaesthesia Duration

Parameters	Group D	Group E	p-value
Duration of surgery (min)	98.8 ± 18.6	101.4 ± 20.2	>0.05
Duration of anaesthesia (min)	126.6 ± 22.8	130.4 ± 24.6	>0.05

Observation:

Duration of surgery and anaesthesia were comparable between both groups.

Table 7: Quality of Surgical Field (Boezaart Score)

Surgical Field Grade	Group D	Group E
Excellent	30 (60%)	22 (44%)
Good	17 (34%)	23 (46%)
Fair	3 (6%)	5 (10%)

Observation:

Dexmedetomidine group showed better surgical field visibility compared with esmolol group.

Table 8: Comparison of Intraoperative Blood Loss

Parameter	Group D	Group E	p-value
Blood loss (ml)	94.6 ± 25.8	120.8 ± 31.4	<0.05

Observation:

Blood loss was significantly lower in the dexmedetomidine group.

Table 9: Recovery Characteristics

Recovery Parameter	Group D	Group E	p-value
Time to eye opening (min)	7.8 ± 2.1	9.5 ± 2.4	<0.05
Time to extubation (min)	10.3 ± 2.7	12.7 ± 3.1	<0.05
Response to verbal command (min)	8.5 ± 2.2	10.7 ± 2.6	<0.05
PACU stay (min)	73.2 ± 12.6	82.1 ± 14.4	<0.05

Observation:

Patients receiving dexmedetomidine showed faster recovery and shorter PACU stay.

Table 10: Postoperative Complications

Complications	Group D (n=50)	Group E (n=50)
Bradycardia	4 (8%)	2 (4%)
Hypotension	3 (6%)	2 (4%)
Nausea/Vomiting	5 (10%)	8 (16%)
Excessive sedation	3 (6%)	1 (2%)
Respiratory depression	0	0

Observation:

Both groups demonstrated good safety profiles. No major adverse events were observed.

DISCUSSION

The present prospective randomized comparative study evaluated the effectiveness of dexmedetomidine versus

esmolol for achieving controlled hypotension during functional endoscopic sinus surgery. A total of 100 patients were included and equally divided into

dexmedetomidine and esmolol groups. The study compared perioperative hemodynamic responses, surgical field quality, intraoperative blood loss, recovery characteristics, and postoperative adverse effects.

Baseline demographic characteristics, including age, sex distribution, body weight, and ASA physical status, were comparable between both groups, indicating adequate randomization and similarity of study populations. Preoperative laboratory investigations and baseline hemodynamic parameters also showed no significant differences between groups, suggesting that observed differences during the perioperative period were primarily related to the study drugs.

In the present study, dexmedetomidine provided better control of perioperative heart rate responses compared with esmolol. The increase in heart rate following intubation and extubation was significantly lower in the dexmedetomidine group. This finding may be explained by the central sympatholytic action of dexmedetomidine, which reduces catecholamine release and attenuates the stress response associated with airway manipulation and surgical stimulation. Similar findings were reported by Gupta et al., who demonstrated effective attenuation of perioperative sympathetic responses with dexmedetomidine administration.⁷

Mean arterial pressure (MAP) control was also more stable in the dexmedetomidine group. Patients receiving dexmedetomidine showed fewer fluctuations during controlled hypotension and emergence from anaesthesia compared with esmolol. Dexmedetomidine produces controlled hypotension through reduction of sympathetic activity while preserving cardiovascular stability, which may explain these findings.⁸

The quality of the surgical field was better among patients receiving dexmedetomidine, with a higher proportion of excellent Boezaart scores. Improved surgical visibility may be attributed to more consistent reduction in blood pressure and decreased intraoperative bleeding. Previous studies have also reported improved endoscopic surgical conditions with dexmedetomidine use during FESS.⁹

Intraoperative blood loss was significantly lower in the dexmedetomidine group compared with the esmolol group. Effective suppression of sympathetic activity, reduction in vascular tone, and stable hypotension may contribute to decreased bleeding during surgery. Similar observations have been reported in ENT surgeries where dexmedetomidine improved operative conditions by reducing surgical field bleeding.¹⁰

Recovery characteristics showed significant advantages with dexmedetomidine. Patients receiving dexmedetomidine had earlier eye opening, faster extubation, quicker response to verbal commands, and shorter PACU stay compared with esmolol. Although dexmedetomidine has sedative properties, its sedative effect resembles natural sleep and allows predictable recovery when appropriately titrated.¹¹

Regarding postoperative complications, both groups demonstrated acceptable safety profiles. Incidence of bradycardia and hypotension was slightly higher with dexmedetomidine, whereas nausea and vomiting were more frequent in the esmolol group. No respiratory depression was observed in either group, supporting the safety of both agents when used under appropriate monitoring.

Overall, the findings of this study suggest that dexmedetomidine provides superior perioperative hemodynamic stability, better surgical field quality, reduced blood loss, and improved recovery characteristics compared with esmolol for controlled hypotension during FESS. However, careful dose titration and monitoring are essential to minimise adverse cardiovascular effects.

Strengths of the Study

The present study possesses several strengths. It was conducted using a prospective randomized comparative design with equal allocation of participants to both study groups, thereby reducing selection bias. Standardized anaesthetic protocols and uniform perioperative monitoring ensured consistency in data collection. Multiple clinically relevant outcome measures, including perioperative hemodynamic parameters, surgical field quality, intraoperative blood loss, recovery characteristics, and postoperative complications, were comprehensively evaluated. The findings provide practical evidence regarding the comparative effectiveness and safety of dexmedetomidine and esmolol for controlled hypotension during functional endoscopic sinus surgery, thereby contributing valuable information for perioperative anaesthetic practice.

Limitations of the Study

The present study has certain limitations. It was conducted at a single tertiary care centre with a relatively modest sample size, which may limit the generalizability of the findings. The study included only ASA physical status I and II patients undergoing elective FESS; therefore, the results may not be applicable to patients with significant systemic comorbidities or those undergoing other surgical procedures. Long-term postoperative outcomes and patient satisfaction were not assessed. In addition, the study did not evaluate stress hormone levels, inflammatory biomarkers, or cost-effectiveness, which could have provided further insight into the comparative benefits of the two anaesthetic agents.

Future Recommendations

Future multicentre randomized controlled trials involving larger and more diverse patient populations are recommended to validate the present findings. Further studies should evaluate the long-term postoperative outcomes, patient satisfaction, analgesic requirements, and cost-effectiveness of

dexmedetomidine and esmolol during controlled hypotension. Investigation of different dosing regimens, combination protocols, and their effects in high-risk patients and other surgical specialties may help optimize perioperative management and establish evidence-based guidelines for the use of controlled hypotensive agents.

CONCLUSION

Dexmedetomidine provided better perioperative hemodynamic stability, improved surgical field quality, reduced intraoperative blood loss, and faster recovery compared with esmolol during controlled hypotension for functional endoscopic sinus surgery. It may be considered a preferable agent for achieving controlled hypotension with favourable surgical and recovery outcomes.

Funding

The authors received no financial support for this research.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this study.

Author Contributions

Dr. Divyashri C.N. conceptualized and designed the study, recruited participants, supervised perioperative management, collected clinical data, interpreted the results, and drafted the manuscript. Dr. Preethi H.N. contributed to the study design, assisted in patient recruitment and data collection, performed statistical analysis, reviewed the literature, and critically revised the manuscript. Dr. Bharath M.S. supervised the overall conduct of the study, contributed to data interpretation, critically reviewed the manuscript for important intellectual content, and approved the final version for publication. All authors read and approved the final manuscript and agree to be accountable for all aspects of the work.

Data Availability Statement

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request. Patient confidentiality and institutional ethical guidelines will be maintained while sharing the data.

Acknowledgements

The authors sincerely thank the Department of Anaesthesiology, C.S.I. Redfern Memorial Hospital, Hassan, Karnataka, for providing the necessary facilities and institutional support to conduct this study. The authors also express their gratitude to all the patients who willingly participated in the study and to the operation theatre and nursing staff for their valuable assistance during the perioperative period.

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