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Original Research Article

Study to Compare the Effect of Bolus versus Intravenous Infusion of Dexmedetomidine on Intraoperative Haemodynamics in ENT Surgeries Under General Anaesthesia

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Abstract:

Background: Modern anaesthesia demands optimal intraoperative conditions for surgical success and patient safety. Dexmedetomidine, a selective α2-adrenergic agonist, offers potential due to its sedative, analgesic, and sympatholytic properties. Administered via bolus injection or infusion, its impact on intraoperative haemodynamics in otolaryngological surgeries is a relevant exploration. Comparing these methods' effects can refine anaesthetic practices and enhance outcomes in ENT surgeries.

Methods: A prospective, randomized controlled trial included patients aged 18-60 undergoing elective ENT surgeries under general anesthesia. Randomized into bolus or infusion groups, blinding was ensured. Anaesthesia protocol included induction with propofol and sevoflurane maintenance. Hemodynamic parameters were recorded pre-, intra-, and post-surgery. Bolus group received Dexmedetomidine (loading dose: 1 µg/kg), infusion group received Dexmedetomidine (0.2 µg/kg/h) starting 20 minutes before induction. Statistical analysis included T test and Chi-square test, with p-value < 0.05 indicating significance.

Results: A total of 70 patients were analysed (Group I: 33 and Group B: 37) in the present study. Baseline characteristics such as age, gender, body mass index (BMI), ASA grade was comparable between the two groups. In terms of systolic blood pressure (SBP) and mean arterial blood pressure (MABP), the patterns were similarly dynamic over time intervals, highlighting significant differences between the two groups at distinct points. Recovery time showed similar values in both groups, with 10.23 ± 3.54 minutes in Group B and 9.67 ± 2.94 minutes in Group I (p = 0.477). Occurrence of adverse events differed between the two groups, with bradycardia showing a statistically significant higher incidence in Group I (21.2%) as compared to (2.7%).

Conclusion: This study highlights dexmedetomidine's benefits for surgical conditions, haemodynamic stability, and bleeding reduction. Its use as premedication induces hypotension and enhances field visibility. Dexmedetomidine's consistent efficacy and safety, along with versatile applications, make it valuable in modern anaesthesia.

Keywords: Haemodynamics, Dexmedetomidine, Surgery, Anaesthesia, Hypotension.

Introduction

In the realm of modern anaesthesia, ensuring optimal intraoperative conditions is paramount for the success and safety of surgical procedures [1]. The delicate balance between achieving adequate depth of anaesthesia, maintaining stable haemodynamics, and minimizing perioperative stress responses presents a continuous challenge to anaesthesiologists [2]. Dexmedetomidine, a highly selective α2-adrenergic agonist, has emerged as a promising adjunct in achieving these goals [3]. Its sedative, analgesic, and sympatholytic properties have made it an attractive agent for use in various surgical settings [4].

Otolaryngological (ENT) surgeries, encompassing a wide spectrum of procedures involving the ear, nose, throat, and related structures, often require profound anaesthesia and analgesia [5]. However, the unique anatomical intricacies and proximity to vital structures in the head and neck region demand a meticulous approach to haemodynamic management [6]. Traditional anaesthetic agents might inadvertently lead to haemodynamic fluctuations, compromising surgical precision and patient safety [7,8]. The administration of dexmedetomidine can occur through two distinct routes: bolus injection and continuous intravenous

infusion [9]. The choice between these administration methods can significantly impact the pharmacokinetic and pharmacodynamic profiles of the drug, potentially influencing its efficacy and safety [10]. While the efficacy of dexmedetomidine in blunting stress responses and attenuating sympathetic activity is well-documented, a comparative exploration of the effects of bolus versus infusion administration on intraoperative haemodynamics in ENT surgeries remains a subject of interest and clinical relevance [10,11].

This study aimed to compare theeffect of two administration strategies—bolus injection and intravenous infusion—of dexmedetomidine on intraoperative haemodynamics in ENT surgeries during general anaesthesia. By comprehensively assessing blood pressure, heart rate, and other relevant parameters, we seek to contribute to the existing body of knowledge regarding the optimal administration approach for dexmedetomidine in this specific surgical context. Our findings hold the potential to refine anaesthetic practices, enhance patient outcomes, and provide valuable insights for anesthesiologists, surgeons, and healthcare providers involved in ENT surgical interventions.

Materials and Methods

Study Design and participants

This prospective, randomized controlled trial was conducted among patients (18-60 years) undergoing ear, nose, and throat (ENT) surgeries (elective) under general anaesthesia with intubation. The study was conducted for a period of 1 year (January 2021 to January 2022) under the department of ENT at tertiary care, of North India, and received ethical approval from the Institutional Review Board. Patients who exhibited allergic reactions to dexmedetomidine, those with cardiac conditions such as heart block or arrhythmias, individuals taking medications like calcium channel blockers, adrenergic receptor blockers, angiotensin-converting enzyme inhibitors, α-adrenergic agonists, and pregnant patients were excluded from the study. Written informed consent was obtained from all participants before enrolment.

Sample Size Calculation

The minimal sample size was calculated as 30 for each group based on a power analysis (80%) using a significance level of 0.05 and an expected effect size [6].

Randomization and Blinding

Participants were randomly assigned to either the bolus injection group (Group B) or the intravenous infusion group (Group I). Randomization was performed using a computer-generated randomization sequence, and allocation was concealed in sealed envelopes until the start of anaesthesia. Blinding of the anesthesiologists, surgeons, and patients was ensured by using identical-looking syringes and infusion pumps.

Anaesthesia Protocol

All patients were premedicated with intravenous midazolam (0.02 mg/kg) and fentanyl (2 μg/kg). General anaesthesia was induced with propofol (2 mg/kg) and maintained with sevoflurane (1-2 MAC) in an oxygen-air mixture.

Additional fentanyl was administered as needed for analgesia. Hemodynamic parameters including heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) were recorded at baseline (pre-induction), at 5-minute intervals during surgery, and postoperatively.

Intervention

Group B (Bolus): Patients in this group received a bolus injection of Dexmedetomidine (loading dose: 1 μg/kg) over 10 minutes, immediately before induction of anaesthesia. Group I (Infusion): Patients in this group received a continuous intravenous infusion of Dexmedetomidine (0.2 μg/kg/h) starting 20 minutes prior to induction and continued until the end of surgery.

Data Collection

Baseline demographic data, preoperative haemodynamic parameters, and relevant medical history were recorded for all participants. Primary outcome measures included changes in HR, SBP, DBP, and MAP during surgery compared to baseline. Intraoperative blood loss, adverse events such as bradycardia (heart rate of less than 60/min), hypotension (decrease in blood pressure of more than 30% from Baseline), and postoperative nausea and vomiting were also recorded.

Statistical Analysis

Statistical analysis was performed using SPSS 20.0. Continuous variables were expressed as means ± standard deviations (SD) based on their distribution and categorical variables were expressed as frequency and percentage (%). Differences in haemodynamic variables between the two groups were analyzed using student T test or Chi-square test. A p-value < 0.05 was considered statistically significant.

Results

In our study, during the defined study period a total of 76 participants were enrolled in the study, so a total of 38 patients were allotted to each group. But due to loss to follow up or incomplete data, 5 patients were excluded from the analysis in group A and 1 patient was excluded from the group B. So, a total of 70 patients were analysed (Group I: 33 and Group B: 37) in the present study.

The table 1 presents a comparison of variables between Group B (bolus administration) and Group I (intravenous infusion) with corresponding percentages and p-values. Mean age was 41.23 ± 8.63 years in Group B and 40.31 ± 9.36 years in Group I (p = 0.67). Gender distribution showed 43.2% males and 56.8% females in Group B, and 42.4% males and 57.6% females in Group I (p = 0.944). ASA grade distribution had 40.5% in Group B and 45.5% in Group I classified as ASA grade I, with 59.5% in Group B and 54.5% in Group I as ASA grade II (p = 0.678). Weight was 59.81 ± 12.21 kg in Group B and 58.94 ± 11.76 kg in Group I (p = 0.763), while height was 158.74 ± 8.43 cm in Group B and 158.36 ± 7.96 cm in Group I (p = 0.847). BMI values were 23.63 ± 6.35 kg/m2 in Group B and 23.51 ± 6.02 kg/m2 in Group I (p = 0.935).

These findings demonstrate comparable baseline characteristics between the two groups.

Table 1: Baseline characteristics of the patients in both groups

Variables	Group B		Group I		P value
	Frequency	%	Frequency	%	
Mean Age (in years)	41.23+8.63		40.31+9.36		0.67
Gender					
Male	16	43.2	14	42.4	0.944
Female	21	56.8	19	57.6	
ASA grade					
I	15	40.5	15	45.5	0.678
II	22	59.5	18	54.5	
Weight (in Kg)	59.81+12.21		58.94+11.76		0.763
Height (in cms)	158.74+8.43		158.36+7.96		0.847
BMI (in Kg/m^2)	23.63+6.35		23.51+6.02		0.935

The table 2 presents heart rate changes over time intervals in Group B (bolus administration) and Group I (intravenous infusion). Statistically significant differences were observed in heart rates at different time points. At 5, 15, and 2 hours, heart rates were also significantly higher in Group B compared to Group I (p = 0.045, p = 0.011, p = 0.012, respectively). Conversely, at 3 hours, heart rates were significantly lower in Group I (73.88 ± 3.92) compared to Group B (83.29 ± 12.26, p < 0.001). Other time intervals showed no significant differences between the groups.

Table 2: Comparison of heart rate (beats/min) among patients in both groups

Time Interval	Heart rate [beats/min] (Mean ± SD)		P value
	Group B	Group I	
5 minutes	79.17 ± 12.85	73.42 ± 10.51	0.045
15 minutes	76.83 ± 11.62	70.27 ± 9.08	0.011
30 minutes	75.12 ± 10.94	72.06 ± 9.25	0.213
1 hour	76.49 ± 9.14	71.64 ± 7.85	0.02
2 hours	75.75 ± 7.57	70.84 ± 8.47	0.012
3 hours	83.29 ± 12.26	73.88 ± 3.92	0.0001

The provided table 3 illustrates systolic blood pressure (SBP) changes over time intervals in both Group B (bolus administration) and Group I (intravenous infusion). While no significant differences in SBP were observed at 5, 15, 30 minutes, and 3 hours (p > 0.05), after 1 hour, SBP was higher in Group B (106.74 ± 12.63) compared to Group I (100.84 ± 8.85, p = 0.028). Conversely, at 2 hours, SBP was higher in Group I (112.47 ± 8.24) compared to Group B (107.13 ± 11.03, p = 0.026). No significant differences in SBP were noted at 3 hours (p = 0.836).These findings highlight specific time points at which SBP differences between the two groups were statistically significant.

Table 3: Comparison of systolic blood pressure (mm/Hg) among patients in both groups

Time Interval	SBP [mm/Hg] (Mean ± SD)		P value
	Group B	Group I	
5 minutes	106.28 ± 20.44	104.22 ± 14.15	0.622
15 minutes	107.83 ± 22.64	105.97 ± 11.84	0.666
30 minutes	111.04 ± 14.24	108.79 ± 13.03	0.493
1 hour	106.74 ± 12.63	100.84 ± 8.85	0.028
2 hours	107.13 ± 11.03	112.47 ± 8.24	0.026
3 hours	105.05 ± 8.03	104.53 ± 12.43	0.836

The presented table 4 showcases diastolic blood pressure (DBP) changes over time intervals in both Group B (bolus administration) and Group I (intravenous infusion). Notably, there were no significant differences in DBP between the groups at 5, 15, and 30 minutes (all $p > 0.05$). After 1 hour, DBP was higher in Group B (66.32 ± 8.42) compared to Group I (62.06 ± 7.13, $p = 0.026$). Likewise, at 2 hours, DBP was higher in Group I (71.45 ± 9.33) compared to Group B (66.86 ± 9.24, $p = 0.041$). No significant differences in DBP were observed at 3 hours ($p = 0.762$). These results underscore specific time points with statistically significant DBP variations between the two groups.

Table 4: Comparison of diastolic blood pressure (mm/Hg) among patients in both groups

Time Interval	DBP [mm/Hg] (Mean ± SD)		P value
	Group B	Group I	
5 minutes	65.47 ± 11.23	63.57 ± 13.74	0.525
15 minutes	64.88 ± 8.52	64.09 ± 9.24	0.706
30 minutes	69.14 ± 8.82	67.24 ± 9.73	0.393
1 hour	66.32 ± 8.42	62.06 ± 7.13	0.026
2 hours	66.86 ± 9.24	71.45 ± 9.33	0.041
3 hours	65.95 ± 11.03	66.88 ± 13.83	0.762

The presented table 5 outlines mean arterial blood pressure (MAB) changes over time intervals in Group B (bolus administration) and Group I (intravenous infusion). At 5 and 30 minutes, MAB was significantly higher in Group B (81.24 ± 8.03 and 81.24 ± 8.03, respectively) compared to Group I (77.16 ± 8.93, $p = 0.046$ for both). No significant difference in MAB was observed at 15 minutes ($p = 0.772$). However, after 1 hour, MAB was higher in Group B (78.14 ± 9.23) compared to Group I (71.76 ± 6.43, $p = 0.001$). Likewise, at 2 hours, MAB was higher in Group I (82.67 ± 7.33) compared to Group B (78.03 ± 8.84, $p = 0.021$).

No significant differences in MAB were found at 3 hours ($p = 0.297$). These findings underscore specific time intervals with statistically significant MAB variations between the two groups.

Table 5: Comparison of mean arterial blood pressure (mm/Hg) among patients in both groups

Time Interval	MAB[mm/Hg] (Mean ± SD)		P value
	Group B	Group I	
5 minutes	81.24 ± 8.03	77.16 ± 8.93	0.046
15 minutes	79.46 ± 13.23	78.47 ± 15.66	0.772
30 minutes	81.24 ± 8.03	77.16 ± 8.93	0.046
1 hour	78.14 ± 9.23	71.76 ± 6.43	0.001
2 hours	78.03 ± 8.84	82.67 ± 7.33	0.021
3 hours	77.36 ± 8.53	74.73 ± 12.16	0.297

Recovery time showed similar values in both groups, with 10.23 ± 3.54 minutes in Group B and 9.67 ± 2.94 minutes in Group I ($p = 0.477$). Similarly, there were no significant differences in blood loss, as Group B had a mean of 151.48 ± 116.87 mL compared to Group I with 140.88 ± 97.65 mL ($p = 0.683$). Surgery duration also displayed comparable results, with Group B having a mean of 73.43 ± 12.88 minutes and Group I having 75.72 ± 18.37 minutes ($p = 0.544$).These findings suggest that there were no significant differences in these variables between the two groups (Table 6).

Table 6: Comparison of surgical parameters among patients in both groups

Variables	MAB [mm/Hg] (Mean ± SD)		P value
	Group B	Group I	
Recovery time (in minutes)	10.23+3.54	9.67+2.94	0.477
Blood loss (in mL)	151.48+116.87	140.88+97.65	0.683
Surgery duration (in min)	73.43+12.88	75.72+18.37	0.544

For bradycardia, Group B had a frequency of 1 (2.7%) while Group I had 7 (21.2%) instances ($p = 0.015$). Hypotension occurred in 2 (5.4%) cases in Group B and 4 (12.1%) in Group I ($p = 0.316$). Nausea was reported in 9 (24.3%) cases in Group B and 5 (15.2%) in Group I ($p = 0.338$).Vomiting occurred in 4 (10.8%) cases in Group B and 1 (3.0%) in Group I ($p = 0.207$), while shivering was observed in 3 (8.1%) cases in Group B and 1 (3.0%) in Group I ($p = 0.36$). Dry mouth was reported in 4 (10.8%) cases in Group B and 1 (3.0%) in Group I ($p = 0.207$). These findings suggest that the occurrence of adverse events differed between the two groups, with bradycardia showing a statistically significant difference (Table 7).

Table 7: Comparison of side effects among patients in both groups

Variables	Group B		Group I		P value
	Frequency	%	Frequency	%	
Bradycardia	1	2.7	7	21.2	0.015
Hypotension	2	5.4	4	12.1	0.316
Nausea	9	24.3	5	15.2	0.338
Vomiting	4	10.8	1	3.0	0.207
Shivering	3	8.1	1	3.0	0.36
Dry mouth	4	10.8	1	3.0	0.207

Discussion

Dexmedetomidine stimulates receptors located in the medullary vasomotor center, leading to decreased turnover of norepinephrine and a reduction in central sympathetic output. As a consequence, there are modifications in sympathetic activity, leading to lowered heart rate (HR) and blood pressure (BP) [13].

In our study, findings revealed distinct patterns in heart rate, systolic blood pressure (SBP), and mean arterial blood pressure (MAB) across various time intervals. The subsequent time intervals exhibited fluctuations in heart rate, with statistically significant differences observed at specific points. The sustained differences in heart rate between the two groups could be attributed to the pharmacokinetic properties of Dexmedetomidine, with its extended effects on α2-adrenergic receptors influencing sympathetic activity. In terms of SBP and MAB, the patterns were similarly dynamic over time intervals, highlighting significant differences between the two groups at distinct points. This variance could be attributed to the varying pharmacokinetics of bolus administration versus continuous infusion, along with the differing modes of receptor binding and receptor adaptation. Notably, the differences observed at specific time points, such as the 1-hour mark, indicate the importance of considering the duration of effect when determining the optimal administration method.

A study by Venn et al., showed discovered that Dexmedetomidine administration at 2.5 mcg/kg followed by an infusion ranging from 0.2 to 2.5 mcg/kg/hour led to reduced HR in patients [14]. Kallio et al., have also reported an initial hypertensive response following a bolus of high-dose dexmedetomidine [15]. In a study by Kim et al., it was noted that the dexmedetomidine group exhibited significantly lower heart rates and mean blood pressure values at multiple time points, including shortly after dexmedetomidine administration, 1 minute after extubation, and 20 minutes [16]. Talke et al., and Mariappan et al., showed dexmedetomidine mitigated the rise in heart rate (HR) during emergence [13,17]. In a study Lee et al., found that the dexmedetomidine group demonstrated greater stability in mean arterial pressure and heart rate during emergence compared to the placebo group [18].

In our study, the occurrence of adverse events, including bradycardia and hypotension, displayed noteworthy discrepancies between the two groups. Bradycardia was particularly notable in Group I (intravenous infusion), which could be attributed to the prolonged exposure of Dexmedetomidine through the infusion method. Hypotension, although not significantly different between the groups, is of clinical relevance and underscores the importance of vigilant monitoring and appropriate dose adjustments during Dexmedetomidine administration.

Karaasalan et al., showed a higher prevalence of adverse events with dexmedetomidine use [19]. Study by Sadhasivam et al., showed an increased occurrence of postoperative hypotension when patient-controlled analgesia with dexmedetomidine was administered [20]. Massad et al., showed a significant reduction in the incidence of nausea and vomiting among patients on dexmedetomidine for postoperative nausea and vomiting [21]. Similar findings have been reported by Kim et al., Harsoor et al., Bekker et al., Kaya et al., Al-Mustafa et al., and Dinesh et al., did not observe severe side effects [4,22-26]. In previous studies by Kol et al., Ibraheim et al., and Goksu et al., dexmedetomidine was commonly administered at doses ranging from 0.2 to 0.8 mcg/kg/hr via IV infusion [27,28,29]. Even study by Lee et al., showed no significant side effects in their study, even though they administered a higher dose of dexmedetomidine (1 μg/kg) [30]. However, study by Ozkose et al., showed a higher incidence of complications such as hypotension was observed with the use of the 0.8 mcg/kg/hr dose.

In our study, there were no significant differences in blood loss, as Group B had a mean of 151.48 ± 116.87 mL compared to Group I with 140.88 ± 97.65 mL ($p = 0.683$). Das et al., demonstrated that dexmedetomidine had a more pronounced impact on pressure control and reduced bleeding during surgery [6].

Limitations

It is essential to acknowledge the limitations of this study, including its single-center nature and the relatively small sample size. These factors might

limit the generalizability of the findings to a broader patient population. Additionally, the study's focus on ENT surgeries might limit the applicability of the results to other surgical contexts.

Conclusion

The present study demonstrates that dexmedetomidine administration during surgery can lead to improved surgical conditions, reduced bleeding, and better haemodynamic stability. Furthermore, the use of dexmedetomidine as a premedication has shown promising results in inducing hypotension and enhancing surgical field visibility. It is worth noting that dexmedetomidine's efficacy and safety profile have been consistently evaluated across different studies, showcasing its potential to mitigate complications like postoperative nausea and vomiting. The wide range of surgical applications explored in present study further underscores the versatility and relevance of dexmedetomidine in modern anesthesia practices.

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