RESEARCH PAPER

Comparison Of The Sedative Effects Of Intravenous Dexmedetomidine Versus Midazolam Plus Fentanyl For Post Operative Elective Mechanical Ventilation - A Randomised Control Trial

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ABSTRACT

Background: Sedation plays a crucial role in the management of patients requiring postoperative mechanical ventilation in the intensive care unit. An ideal sedative agent should provide adequate sedation, analgesia, hemodynamic stability, and allow early recovery. Dexmedetomidine, a selective α_2-adrenergic agonist, has emerged as an alternative to conventional sedatives such as benzodiazepines and opioids.

Aim:To compare the sedative effects of intravenous dexmedetomidine with a combination of midazolam and fentanyl in patients undergoing elective postoperative mechanical ventilation.

Materials and Methods: This prospective, randomized, double-blinded controlled trial included 92 adult patients aged 18–60 years requiring elective postoperative mechanical ventilation. Participants were randomly allocated into two groups: Group D (dexmedetomidine infusion) and Group MF (midazolam with fentanyl infusion), with 46 patients in each group. Sedation levels were assessed using the Richmond Agitation–Sedation Scale (RASS). Secondary parameters included behavioural pain scale score, hemodynamic variables, time to extubation, and length of ICU stay. Continuous variables were analyzed using Student's t-test and categorical variables using the chi-square test, with $p < 0.05$ considered statistically significant.

Results: Dexmedetomidine produced significantly deeper sedation at 24 hours compared to the midazolam–fentanyl group (-3.54 ± 0.09 vs -3.15 ± 0.08, $p < 0.001$). Behavioural pain scale scores were significantly lower in Group D at 6 hours (2.91 ± 0.16 vs 3.91 ± 0.16, $p < 0.001$). Group D also demonstrated lower heart rates, shorter extubation time (33.02 ± 5.09 vs 56.98 ± 7.13 minutes), and reduced ICU stay (2.58 ± 0.25 vs 3.61 ± 0.37 days) compared with Group MF.

Conclusion: Dexmedetomidine provided better sedation quality, improved analgesia, and faster postoperative recovery compared with midazolam–fentanyl in mechanically ventilated patients..

Keywords Dexmedetomidine; Midazolam; Fentanyl; Mechanical ventilation; Richmond Agitation–Sedation Scale

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INTRODUCTION

Sedation is an essential component of postoperative intensive care management, particularly in patients requiring elective mechanical ventilation. Adequate sedation helps relieve anxiety, reduce pain, facilitate patient–ventilator synchrony, and prevent accidental

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removal of endotracheal tubes or other life-support devices. Inadequate sedation may result in agitation, hemodynamic instability, and increased oxygen consumption, whereas excessive sedation may prolong mechanical ventilation and delay recovery. Therefore, achieving an optimal level of sedation in mechanically ventilated patients remains a critical objective in modern intensive care practice [1].

Various pharmacological agents have been used for sedation in intensive care units (ICUs), including benzodiazepines, opioids, propofol, and α-2 adrenergic agonists. Traditionally, benzodiazepines such as midazolam have been widely used because of their rapid onset, amnestic properties, and relatively short duration of action. However, prolonged use of benzodiazepines has been associated with adverse effects such as respiratory depression, prolonged sedation, delirium, and delayed weaning from mechanical ventilation. In many clinical settings, midazolam is often combined with opioids such as fentanyl to provide both sedation and analgesia for mechanically ventilated patients [2]. Prolonged benzodiazepine exposure has also been associated with increased ICU delirium and delayed cognitive recovery in critically ill patients [3].

Dexmedetomidine is a highly selective α-2 adrenergic receptor agonist that has emerged as an effective sedative agent in critical care practice. It produces sedation resembling natural sleep and provides anxiolytic and analgesic effects without significant respiratory depression. Unlike benzodiazepines, dexmedetomidine allows patients to remain easily arousable and cooperative while maintaining adequate sedation, which can facilitate neurological assessment and early extubation. These properties have made dexmedetomidine an attractive alternative to conventional sedatives used in the ICU [4]. In addition, dexmedetomidine has demonstrated favorable outcomes in terms of reduced delirium incidence and improved communication with mechanically ventilated patients [5].

The Richmond Agitation–Sedation Scale (RASS) is widely used in clinical practice to monitor the depth of sedation in critically ill patients. This validated scale ranges from +4 (combative) to −5 (unarousable) and allows clinicians to titrate sedative medications to achieve the desired sedation level while avoiding oversedation or undersedation. Regular assessment using RASS helps optimize sedation protocols and improve patient outcomes in mechanically ventilated patients [6]. Current ICU sedation guidelines also recommend the routine use of validated sedation assessment tools such as RASS to improve sedation quality and reduce complications associated with inappropriate sedation practices [7].

Recent studies have suggested that dexmedetomidine may provide better sedation quality, improved hemodynamic stability, and shorter duration of mechanical ventilation compared with conventional sedatives such as benzodiazepines and opioid combinations [8]. Additionally, dexmedetomidine has been associated with reduced incidence of delirium and faster recovery in postoperative ICU patients [9]. Large randomized trials and systematic reviews have further supported the role of dexmedetomidine as an effective alternative to conventional ICU sedatives in mechanically ventilated adults [10].

Therefore, the present study was undertaken to compare the sedative effects of intravenous dexmedetomidine with a combination of midazolam and fentanyl in patients undergoing elective postoperative mechanical ventilation using the Richmond Agitation–Sedation Scale and other clinical outcome parameters.

MATERIALS AND METHODS

Study Design

This study was conducted as a prospective, randomized, double-blinded controlled trial designed to compare the sedative efficacy of intravenous dexmedetomidine with a combination of midazolam and fentanyl in patients undergoing elective postoperative mechanical ventilation.

Study Setting and Duration

The study was carried out in the Department of Anesthesiology, including the Post-Anesthesia Care Unit (PACU) and Intensive Care Unit (ICU), at SRM Medical College Hospital and Research Institute, a tertiary care teaching hospital. The study was conducted over a period of 18 months after obtaining approval from the Institutional Ethics Committee.

Study Population

Adult patients aged between 18 and 60 years who belonged to the American Society of Anesthesiologists (ASA) physical status I, II, or III and required elective postoperative mechanical ventilation for less than 24 hours were included in the study. Patients with decompensated cardiovascular, neurological, renal, or hepatic disease, known hypersensitivity to the study drugs, chronic opioid dependence, pregnancy, requirement of inotropic support, excessive intraoperative blood loss (>1.5 liters), or refusal to participate were excluded from the study.

Sample Size and Randomization

A total of 92 eligible patients were included in the study. Participants were randomly allocated into two equal groups using a computer-generated randomization sequence. Allocation concealment was maintained using sealed opaque envelopes.

Study Groups and Intervention

Group D received dexmedetomidine with a loading dose of 1 µg/kg administered over 15 minutes followed by a maintenance infusion of 0.2–0.7 µg/kg/h. Group MF received midazolam with a loading dose of 0.05 mg/kg followed by infusion of 0.05 mg/kg/h along with fentanyl administered as a loading dose of 1 µg/kg followed by continuous infusion of 1 µg/kg/h.

Data Collection and Outcome Measures

Sedation levels were assessed using the Richmond Agitation–Sedation Scale (RASS), and pain was evaluated using the Behavioural Pain Scale. Hemodynamic parameters, requirement of rescue analgesia, time to extubation, and occurrence of complications were recorded systematically.

Statistical Analysis

Data were analyzed using appropriate statistical software. Continuous variables were expressed as mean ± standard deviation and compared using Student's t-test, while categorical variables were analyzed using the chi-square test. A p-value <0.05 was considered statistically significant.

RESULTS

The age distribution showed that participants were fairly distributed across all age groups. The largest proportion belonged to the 31–40 years group (27.2%), followed by 51–60 years (26.1%), 18–30 years (25.0%), and 41–50 years (21.7%). Both groups had an equal number of participants (46 each), indicating comparable age distribution between the groups (Table 1).

Table 1: Age distribution of study participants

Age group (years)	Group D, n (%)	Group MF, n (%)	Total, n (%)
18–30	13 (56.5%)	10 (43.5%)	**23 (25.0%)**
31–40	17 (68.0%)	8 (32.0%)	**25 (27.2%)**
41–50	7 (35.0%)	13 (65.0%)	**20 (21.7%)**
51–60	9 (37.5%)	15 (62.5%)	**24 (26.1%)**
Total	**46 (50.0%)**	**46 (50.0%)**	**92 (100.0%)**

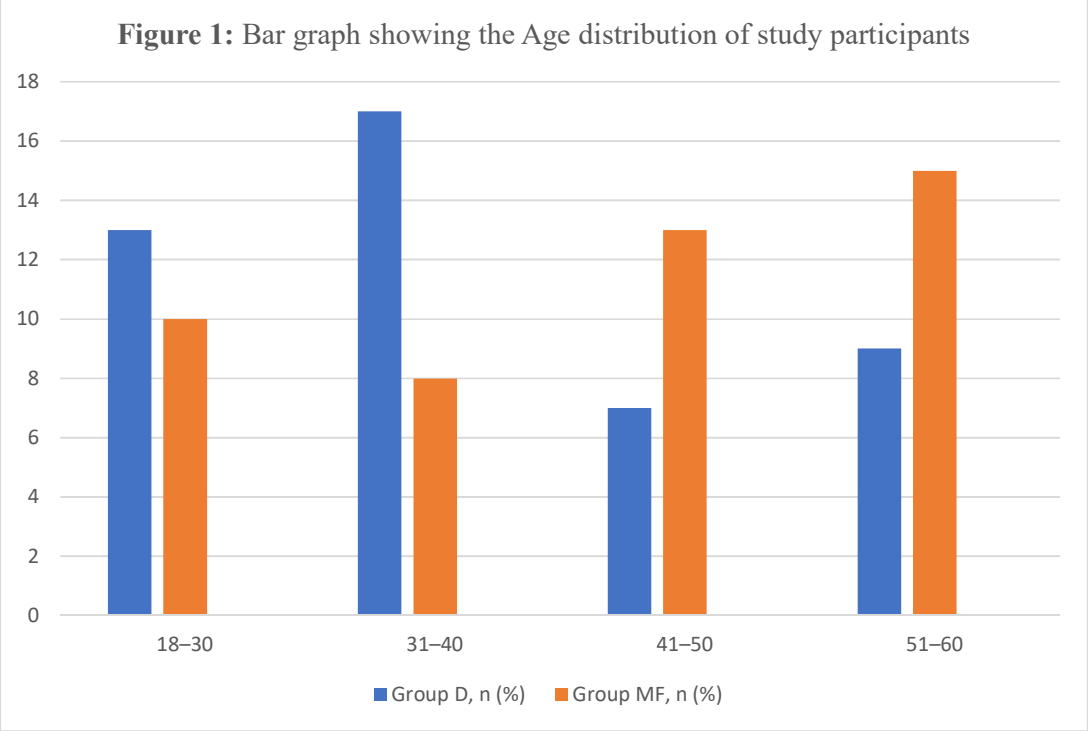


Figure 1: Bar graph showing the Age distribution of study participants

Most participants belonged to ASA III (37.0%), followed by ASA II (32.6%) and ASA I (30.4%). The distribution between Group D and Group MF was similar, and there was no statistically significant difference between the groups (p = 0.389), indicating comparable baseline physical status (Table 2).

Table 2: ASA physical status distribution of study participants

ASA class	Group D, n (%)	Group MF, n (%)	Total, n (%)
I	11 (39.3%)	17 (60.7%)	**28 (30.4%)**
II	16 (53.3%)	14 (46.7%)	**30 (32.6%)**
III	19 (55.9%)	15 (44.1%)	**34 (37.0%)**
Total	**46 (50.0%)**	**46 (50.0%)**	**92 (100.0%)**
$\chi^2 = 1.890$, df = 2, p = 0.389			

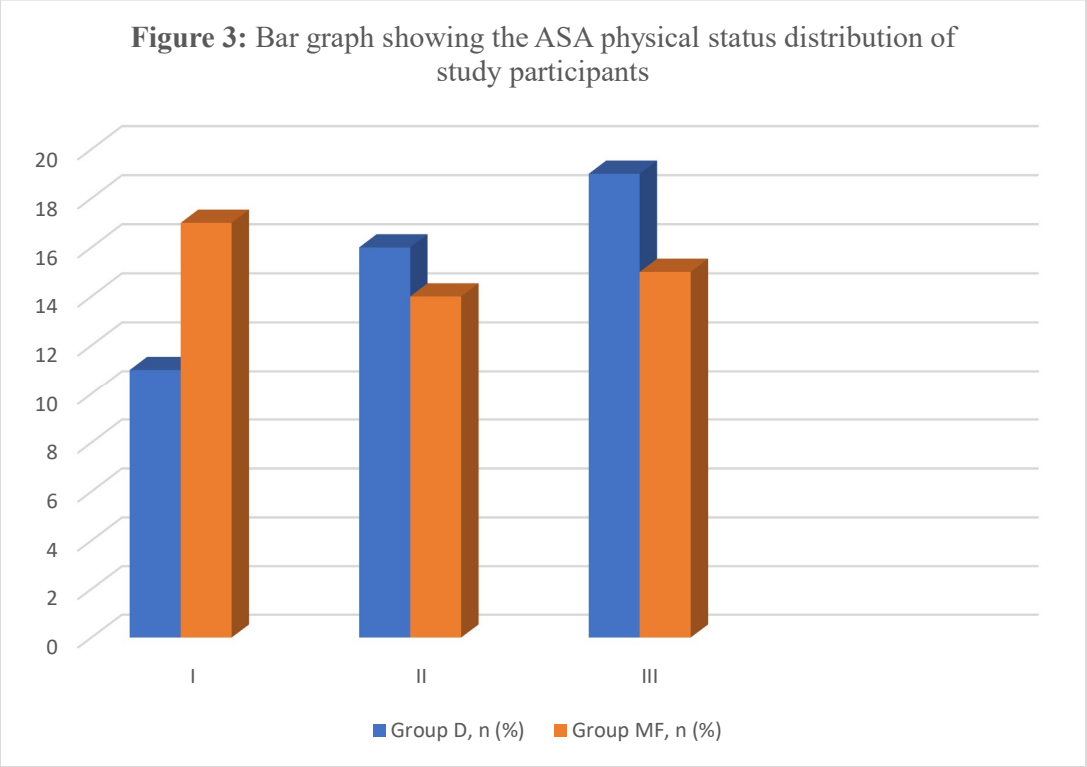


Figure 3: Bar graph showing the ASA physical status distribution of study participants

The mean RASS score at 24 hours was significantly lower in Group D (−3.54 ± 0.09) compared to Group MF (−3.15 ± 0.08). This indicates deeper sedation with dexmedetomidine ($p < 0.001$) (Table 3).

Table 3: Comparison of Richmond Agitation–Sedation Score at 24 hours between study groups

Group	n	Mean ± SD
Group D	46	−3.54 ± 0.09
Group MF	46	−3.15 ± 0.08
t = −21.025, df = 90, p < 0.001		

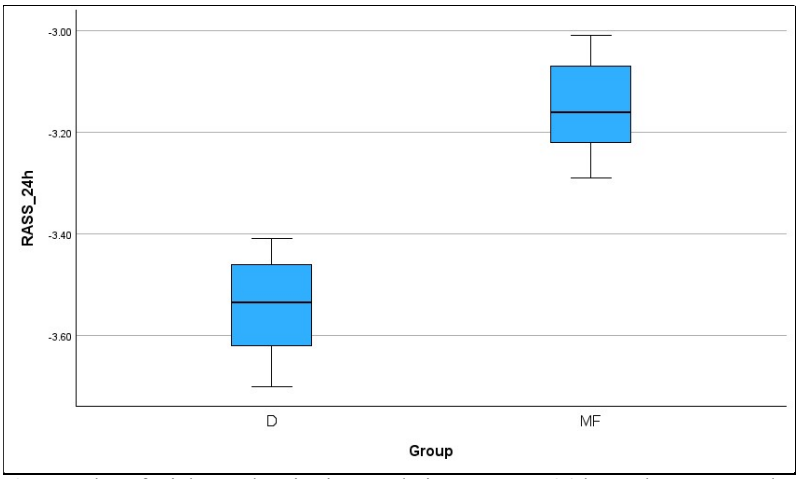


Figure 3: Boxplot of Richmond Agitation–Sedation Score at 24 hours between study groups

The mean behavioural pain scale score at 6 hours was lower in Group D (2.91 ± 0.16) compared to Group MF (3.91 ± 0.16), showing better analgesia in the dexmedetomidine group ($p < 0.001$) (Table 4).

Table 4: Comparison of behavioural pain scale score at 6 hours between study groups

Group	**n**	**Mean ± SD**
Group D	46	2.91 ± 0.16
Group MF	46	3.91 ± 0.16
t = −30.126, df = 90, p < 0.001		

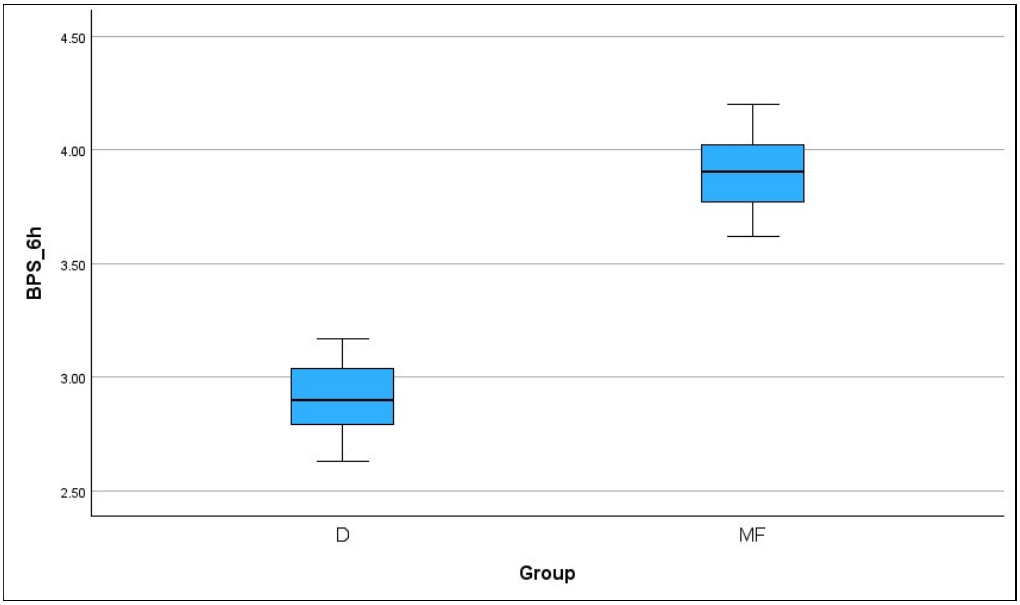
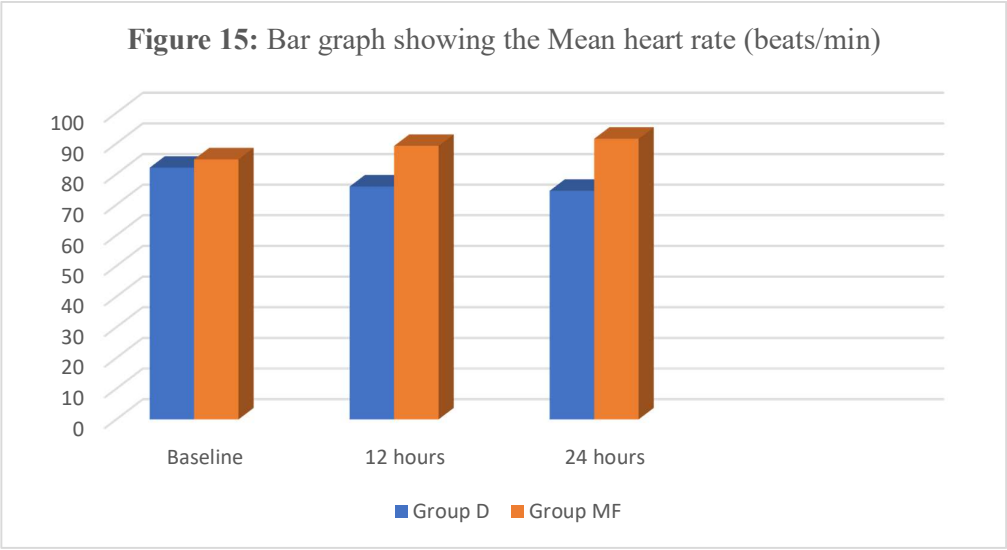


Figure 4: Boxplot of behavioural pain scale score at 6 hours between study groups

Group D showed lower mean heart rates compared to Group MF at baseline, 12 hours, and 24 hours. The difference was statistically significant at all time points ($p < 0.001$) (Table 5).

Table 5: Mean heart rate (beats/min)

Time	Group D	Group MF	p-value
Baseline	82.11 ± 2.85	84.85 ± 2.26	**< 0.001**
12 hours	75.98 ± 2.30	89.24 ± 2.13	**< 0.001**
24 hours	74.59 ± 2.67	91.57 ± 2.55	**< 0.001**



The mean time to extubation was significantly shorter in Group D (33.02 ± 5.09 minutes) compared to Group MF (56.98 ± 7.13 minutes) ($p < 0.001$) (Table 6).

Table 6: Comparison of time to extubation between study groups

Group	n	Mean ± SD (minutes)
Group D	46	33.02 ± 5.09
Group MF	46	56.98 ± 7.13
t = −18.551, df = 90, p < 0.001		

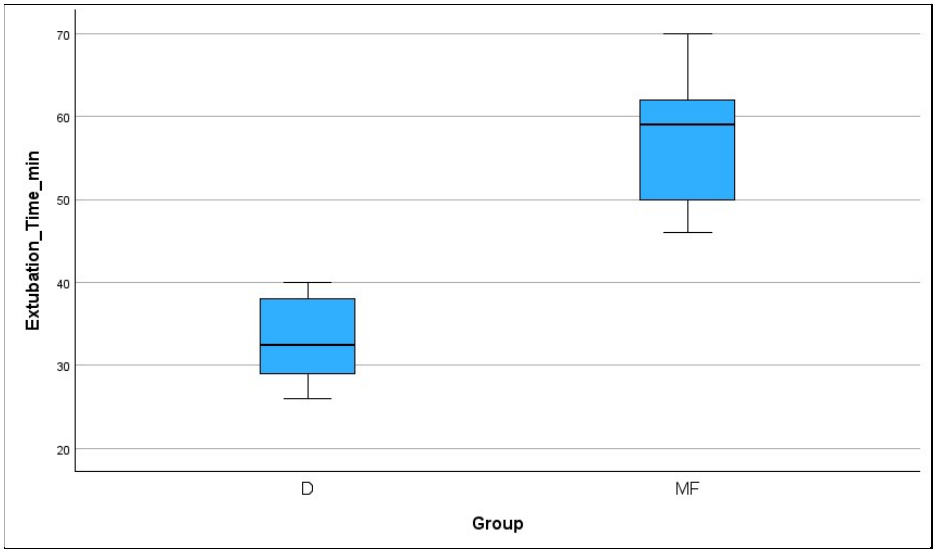


Figure 6: Boxplot of time to extubation between study groups

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The mean ICU stay was shorter in Group D (2.58 ± 0.25 days) than in Group MF (3.61 ± 0.37 days), and the difference was statistically significant ($p < 0.001$) (Table 7).

Table 7: Comparison of length of ICU stay between study groups

Group	**n**	**Mean ± SD (days)**
Group D	46	2.58 ± 0.25
Group MF	46	3.61 ± 0.37
t = −15.628, df = 90, p < 0.001		

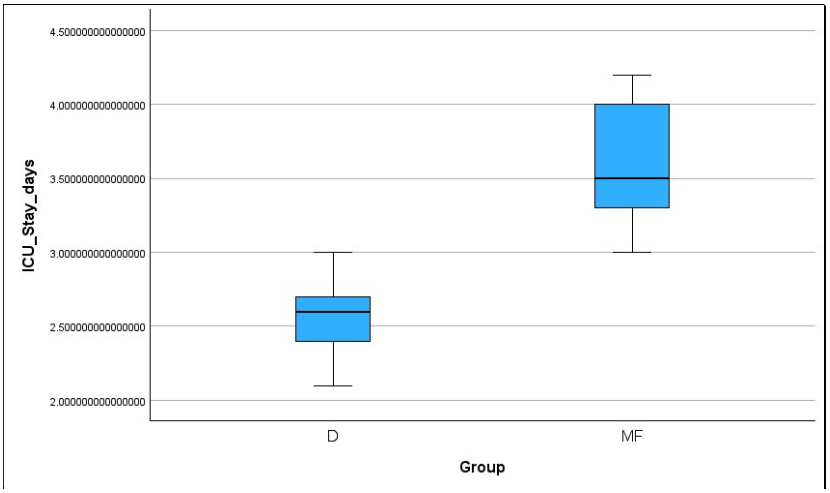

Figure 7: Boxplot of length of ICU stay between study groups

DISCUSSION

The present randomized controlled trial compared the sedative efficacy and clinical outcomes of intravenous dexmedetomidine with a combination of midazolam and fentanyl in patients requiring elective postoperative mechanical ventilation. The findings demonstrated that dexmedetomidine produced deeper and more consistent sedation, superior analgesia, improved hemodynamic stability, shorter extubation time, and reduced ICU stay when compared with the midazolam–fentanyl regimen. These observations support the growing preference for dexmedetomidine-based sedation protocols in critically ill mechanically ventilated patients.

Baseline demographic characteristics including age distribution and ASA physical status were comparable between the two groups in the present study, indicating adequate randomization and minimizing the influence of confounding variables on study outcomes. Comparable baseline profiles between dexmedetomidine and conventional sedation groups have also been reported in previous randomized studies evaluating ICU sedation practices. Dodhy demonstrated similar demographic comparability between dexmedetomidine and midazolam groups in mechanically ventilated patients, thereby strengthening the validity of comparative outcome assessment [11].

The present study demonstrated significantly lower mean Richmond Agitation–Sedation Scale (RASS) scores in the dexmedetomidine group at 24 hours, indicating more effective and controlled sedation. Adequate sedation is crucial for maintaining ventilator synchrony, reducing anxiety, and preventing agitation-related complications in critically ill patients. Ahmed et al. similarly observed that dexmedetomidine maintained target sedation levels more consistently than conventional midazolam-based regimens in mechanically ventilated ICU patients [12]. The sedative action of dexmedetomidine is mediated through selective stimulation of central α2-adrenergic receptors within the locus coeruleus, producing a form of sedation closely resembling physiological sleep while preserving respiratory drive. Myatra highlighted that dexmedetomidine provides “cooperative sedation,” enabling patients to remain calm yet easily arousable, which is particularly advantageous in critically ill patients requiring neurological assessment and early weaning from ventilatory support [13].

Another significant finding in the present study was the lower behavioural pain scale scores observed in the dexmedetomidine group at 6 hours, suggesting superior analgesic efficacy. Unlike benzodiazepines, dexmedetomidine possesses intrinsic analgesic properties mediated through spinal α2 receptor activation, thereby reducing sympathetic outflow and nociceptive transmission. Aydoğan et al. reported similar findings in

postoperative patients, where dexmedetomidine use resulted in lower pain scores and reduced fentanyl requirements compared with midazolam sedation [14]. Better analgesia not only improves patient comfort but may also reduce opioid-related adverse effects such as respiratory depression, nausea, and prolonged sedation.

Hemodynamic stability is an important consideration in sedated mechanically ventilated patients, particularly in the postoperative period. In the current study, heart rate values were significantly lower in the dexmedetomidine group at baseline, 12 hours, and 24 hours. The sympatholytic effect of dexmedetomidine decreases catecholamine release and attenuates stress responses, thereby promoting cardiovascular stability. Similar observations were made by Azeem et al., who demonstrated improved hemodynamic control with dexmedetomidine compared with midazolam–morphine sedation following cardiac surgery [15]. Although dexmedetomidine may occasionally produce bradycardia, its overall cardiovascular profile is considered favorable in carefully monitored ICU settings.

A clinically important outcome observed in the present study was the significantly shorter time to extubation among patients receiving dexmedetomidine. Early extubation reduces the risk of ventilator-associated complications, including pneumonia, airway trauma, and ICU-acquired weakness. The absence of significant respiratory depression with dexmedetomidine likely contributes to earlier recovery of spontaneous respiration and improved ventilator weaning. Dodhy reported reduced duration of mechanical ventilation and earlier extubation in patients sedated with dexmedetomidine compared with midazolam [11]. Similarly, Zhou et al. demonstrated that dexmedetomidine-based sedation protocols shortened weaning duration and accelerated recovery in critically ill mechanically ventilated patients [16].

The present study also demonstrated a significantly shorter ICU stay in the dexmedetomidine group. Reduction in ICU length of stay is clinically and economically important because prolonged ICU admission increases healthcare expenditure, nosocomial infection risk, and resource utilization. Cruickshank et al., in a systematic review of α2 agonists for ICU sedation, concluded that dexmedetomidine was associated with shorter duration of mechanical ventilation and reduced ICU stay compared with benzodiazepine-based sedation strategies [17]. Hasan et al. further reported that dexmedetomidine-based sedation improved recovery profiles and reduced ICU duration when compared with conventional sedative regimens in critically ill patients [18].

The beneficial outcomes observed in the present study may also be related to the reduced incidence of oversedation associated with dexmedetomidine. Excessive sedation with benzodiazepines has been linked to delirium, delayed awakening, prolonged ventilatory support, and cognitive dysfunction. Dexmedetomidine, by providing lighter yet effective sedation, may facilitate early mobilization and improved communication between patients and healthcare providers. These advantages have contributed to its increasing incorporation into contemporary ICU sedation guidelines.

Despite the favorable findings, certain limitations of the present study should be acknowledged. The study was conducted in a single tertiary care center with a relatively modest sample size, which may limit generalizability. Long-term neurological outcomes and incidence of ICU delirium were not assessed. In addition, the study evaluated patients requiring elective postoperative ventilation for less than 24 hours; therefore, the findings may not be directly applicable to prolonged ICU ventilation scenarios. Future multicentric studies with larger sample sizes and longer follow-up periods are required to further evaluate the long-term benefits and safety profile of dexmedetomidine-based sedation strategies.

Overall, the findings of the present study support the growing body of evidence suggesting that dexmedetomidine is an effective and beneficial sedative agent for postoperative mechanically ventilated patients. Its ability to provide adequate sedation, superior analgesia, hemodynamic stability, earlier extubation, and shorter ICU stay may contribute to improved patient outcomes compared with conventional benzodiazepine–opioid combinations.

CONCLUSION

The present study demonstrated that dexmedetomidine provided more effective and stable sedation compared to the midazolam–fentanyl combination in patients requiring elective postoperative mechanical ventilation. Patients in the dexmedetomidine group showed deeper sedation levels, lower pain scores, improved hemodynamic stability, earlier extubation, and shorter ICU stay. Although a slightly higher incidence of bradycardia was observed, overall outcomes favored dexmedetomidine. Therefore, dexmedetomidine can be considered a safe and effective sedative agent for postoperative mechanically ventilated patients

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