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Effectiveness of Sedation Strategies in Critically Ill Patients: Dexmedetomidine vs. Propofol

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Abstract **Original Research Article**

***Background*:** Sedation is essential for critically ill patients requiring mechanical ventilation in the intensive care unit (ICU). Dexmedetomidine and Propofol are commonly used sedative agents with distinct pharmacological profiles. This study aimed to compare the effectiveness and safety of Dexmedetomidine versus Propofol for sedation in critically ill ICU patients. ***Methods*:** This prospective randomized comparative study was conducted in the ICU of the Department of Anaesthesiology, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh, over 12 months (June 2023 to May 2024). A total of 84 mechanically ventilated ICU patients were randomly assigned into two groups: Group D (Dexmedetomidine, n=42) and Group P (Propofol, n=42). Sedation quality was assessed using the Richmond Agitation-Sedation Scale (RASS), and hemodynamic parameters were monitored over 48 hours. Primary outcomes included time to achieve target sedation, duration of mechanical ventilation, and ICU stay. Secondary outcomes included incidence of delirium, adverse events, and mortality. Data were analyzed using SPSS version 26.0, with $p < 0.05$ considered statistically significant. ***Results*:** Demographic and baseline clinical characteristics were comparable between the two groups ($p > 0.05$). Time to achieve target sedation was significantly longer in Group D than in Group P (42.5 ± 11.3 vs. 28.6 ± 9.5 minutes; $p < 0.001$). Dexmedetomidine provided more pronounced hemodynamic stability, with a significantly lower heart rate at 24 and 48 hours ($p < 0.001$). The duration of mechanical ventilation (72.5 ± 24.7 vs. 89.6 ± 30.5 hours; $p = 0.004$) and length of ICU stay (6.8 ± 2.3 vs. 8.4 ± 2.9 days; $p = 0.002$) were significantly lower in Group D. Dexmedetomidine was associated with a lower incidence of delirium on Day 5 (4.8% vs. 21.4%; $p = 0.017$). However, bradycardia was more frequent in Group D (21.4% vs. 7.1%; $p = 0.046$), while respiratory depression was higher in Group P (0% vs. 11.9%; $p = 0.022$). No significant differences were observed in ICU and 28-day mortality. ***Conclusion*:** Dexmedetomidine demonstrated superior outcomes in terms of sedation quality, hemodynamic stability, reduced mechanical ventilation duration, ICU stay, and delirium prevention compared to Propofol. However, it requires careful monitoring due to a higher incidence of bradycardia. Further large-scale studies are warranted.

Keywords: Dexmedetomidine, Propofol, Sedation, Mechanical Ventilation, Hemodynamic Stability, Delirium.

INTRODUCTION

Sedation is an integral component of the management of critically ill patients in the intensive care unit (ICU). It facilitates mechanical ventilation, reduces anxiety, ensures patient comfort, and prevents delirium and agitation, ultimately improving clinical outcomes in critically ill individuals [1]. However, selecting an optimal sedative agent requires balancing efficacy, hemodynamic stability, organ protection, and the minimization of adverse effects such as prolonged mechanical ventilation and ICU stay [2]. Among the commonly used sedative agents, dexmedetomidine and propofol are frequently employed due to their favorable pharmacokinetic profiles and clinical efficacy in ICU settings [3].

Dexmedetomidine, a selective alpha-2 adrenergic receptor agonist, has gained popularity as a sedative for critically ill patients. It provides sedation that closely resembles natural sleep, has analgesic-sparing effects, and is associated with minimal respiratory depression [4]. Additionally,

dexmedetomidine has shown potential benefits in reducing delirium, facilitating early extubation, and decreasing ICU length of stay [5]. On the other hand, propofol, a short-acting sedative-hypnotic agent, offers rapid onset and offset of sedation, making it suitable for short-term and titratable sedation requirements [6]. However, concerns remain regarding propofol-related hypotension, hypertriglyceridemia, and propofol infusion syndrome, especially during prolonged use in critically ill patients [7].

Despite the widespread use of both agents, there is ongoing debate regarding their comparative effectiveness and safety profiles. Some studies suggest that dexmedetomidine may reduce the duration of mechanical ventilation and the incidence of ICU delirium compared to propofol [8]. Conversely, other evidence indicates that propofol may be preferable for deeper levels of sedation and procedures requiring rapid sedation one [9]. A recent meta-analysis concluded that dexmedetomidine offers advantages in light to moderate sedation without increasing mortality risk, though it is associated with bradycardia and hypotension [10]. The selection between these agents often depends on institutional protocols, patient-specific factors, and the clinical objectives of sedation. This study aims to compare the effectiveness of dexmedetomidine and propofol for sedation in critically ill patients in the ICU at Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh. By analyzing their impacts on sedation quality, hemodynamic stability, duration of mechanical ventilation, and ICU stay, this study seeks to provide evidence-based recommendations for optimal sedation practices in critically ill patients.

OBJECTIVE

General Objective: To compare the effectiveness and safety of dexmedetomidine and propofol as sedation strategies in critically ill patients admitted to the Intensive Care Unit (ICU).

Specific Objectives:

- To assess the quality and depth of sedation achieved by dexmedetomidine and propofol in critically ill patients.
- To evaluate the hemodynamic stability (heart rate, blood pressure) of patients sedated with dexmedetomidine versus propofol.
- To compare the duration of mechanical ventilation between patients receiving dexmedetomidine and those receiving propofol.
- To determine the incidence of ICU-related delirium in patients sedated with dexmedetomidine compared to propofol.

MATERIALS AND METHODS

Study Design:

This prospective, randomized, comparative study was conducted in the Intensive Care Unit (ICU) of the Department of Anaesthesiology, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh. The study was carried out over a period of one year, from June 2023 to May 2024. The objective was to compare the effectiveness and safety profile of two sedation strategies—Dexmedetomidine and Propofol—in critically ill patients requiring mechanical ventilation.

Sample Calculation:

A total of 84 patients were enrolled in the study. The sample size was calculated based on previous studies comparing Dexmedetomidine and Propofol for ICU sedation, considering a 95% confidence level and 80% power to detect significant differences in primary outcomes, including time to target sedation and duration of mechanical ventilation.

Inclusion Criteria:

Adult patients aged between 18 and 75 years, of both sexes, who were admitted to the Intensive Care Unit (ICU) and required sedation for mechanical ventilation expected to last more than 24 hours were eligible for inclusion in this study. Additional inclusion criteria included an Acute Physiology and Chronic Health Evaluation II (APACHE II) score between 10 and 30 and a Sequential Organ Failure Assessment (SOFA) score of less than 15.

Exclusion Criteria:

Patients were excluded if they had a known hypersensitivity to Dexmedetomidine or Propofol. Additional exclusion criteria included significant hepatic dysfunction (defined as ALT or AST levels greater than three times the upper limit of normal), significant renal dysfunction (serum creatinine > 3 mg/dL), severe bradycardia (heart rate < 50 bpm), second or third-degree atrioventricular block without a pacemaker, or hemodynamic instability requiring high-dose vasopressor support.

Study Procedure:

Following written informed consent from legal guardians, eligible patients were randomized into two groups using a computer-generated randomization table and allocation concealment with opaque sealed envelopes. Group D (n = 42) received Dexmedetomidine, starting with a loading dose of 1 µg/kg over 10 minutes, followed by a maintenance infusion of 0.2–0.7 µg/kg/h, titrated to achieve target sedation. Group P (n = 42) received Propofol as a continuous infusion starting at 0.5 mg/kg/h, titrated up to 3 mg/kg/h as necessary. Sedation was guided by the Richmond Agitation-Sedation Scale (RASS), targeting a sedation level between -2 and 0. Rescue sedatives and analgesics were administered if needed and documented. Continuous monitoring of hemodynamic parameters (heart rate, mean arterial pressure, oxygen saturation, and respiratory rate) was performed. Sedation depth was

assessed hourly for the first 12 hours and every 4 hours thereafter. Delirium was evaluated daily using the Confusion Assessment Method for ICU (CAM-ICU). Laboratory investigations, including arterial blood gas (ABG), lactate, liver and renal function tests, and creatine kinase, were performed at baseline, 24 hours, and 48 hours.

Statistical Analysis:

Data were recorded in predesigned case report forms and entered into Microsoft Excel. Analysis was performed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD) and compared using an independent t-test or Mann-Whitney U test, depending on data distribution. Categorical variables were presented as frequency and percentages and analyzed using chi-square or Fisher's exact test. A p-value < 0.05 was considered statistically significant.

Ethical Consideration:

The study was approved by the Institutional Review Board (IRB) of Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh. Ethical clearance was obtained prior to the commencement of the study. Written informed consent was obtained from the legal guardians of all participating patients before enrollment. Confidentiality and anonymity of patient data were maintained throughout the study in accordance with the Declaration of Helsinki.

RESULTS

A total of 84 patients were enrolled and randomized equally into two groups: **Group D** (Dexmedetomidine, n=42) and **Group P** (Propofol, n=42). There were no significant differences in demographic or baseline clinical characteristics between the two groups (p > 0.05).

Table 1: Demographic and Baseline Clinical Characteristics (N = 84)

Variables	Group D (n=42)	Group P (n=42)	p-value
Age (years), mean ± SD	55.2 ± 12.8	53.7 ± 14.2	0.602
Sex (Male/Female)	26 / 16	25 / 17	0.823
Weight (kg), mean ± SD	65.4 ± 11.1	66.8 ± 12.4	0.581
APACHE II Score, mean ± SD	21.4 ± 4.6	20.9 ± 5.1	0.629
SOFA Score, mean ± SD	8.6 ± 2.3	8.9 ± 2.5	0.551
Primary Diagnosis			
- Sepsis	18 (42.9%)	19 (45.2%)	0.823
- Respiratory Failure	12 (28.6%)	11 (26.2%)	0.802
- Trauma	6 (14.3%)	7 (16.7%)	0.758
- Others	6 (14.3%)	5 (11.9%)	0.743

Table 1 summarizes the demographic and baseline clinical data of the study participants. Both groups were comparable in terms of age, sex distribution, body weight, APACHE II score, and SOFA score, with no statistically significant differences observed (p > 0.05). The mean age was 55.2 ± 12.8 years in the Dexmedetomidine group (Group D) and 53.7 ± 14.2 years in the Propofol group (Group P). The majority of patients in both groups were male (61.9% in Group D vs. 59.5% in Group P). The most common primary diagnosis on ICU admission was sepsis, accounting for 42.9% and 45.2% in Group D and Group P, respectively.

Table 2: Sedation Quality (RASS Scores) Over 48 Hours

Time Point	Group D (n=42)	Group P (n=42)	p-value
6 Hours	-1.9 ± 0.4	-1.8 ± 0.5	0.437
12 Hours	-2.0 ± 0.3	-2.1 ± 0.4	0.228
24 Hours	-1.8 ± 0.5	-2.0 ± 0.4	0.092
48 Hours	-1.7 ± 0.4	-1.9 ± 0.5	0.043*

(*p < 0.05)

Table 2 presents the Richmond Agitation-Sedation Scale (RASS) scores over 48 hours. Both groups achieved target sedation levels, but Group D maintained more stable sedation with slightly higher RASS scores at 48 hours compared to Group P (-1.7 ± 0.4 vs. -1.9 ± 0.5; p = 0.043).

Table 3: Time to Achieve Target Sedation (RASS -2 to 0)

Variable	Group D (n=42)	Group P (n=42)	p-value
Time to achieve target sedation (mins)	42.5 ± 11.3	28.6 ± 9.5	<0.001*

(*p < 0.05)

Table 3 shows the time to achieve target sedation. Group P achieved target sedation significantly faster than Group D (28.6 ± 9.5 minutes vs. 42.5 ± 11.3 minutes; p < 0.001).

Table 4: Hemodynamic Stability During Sedation

Parameters	Group D (n=42)	Group P (n=42)	p-value
Heart Rate (bpm)			
- Baseline	84.3 ± 10.2	85.1 ± 9.8	0.712
- 24 Hours	68.4 ± 9.5	78.7 ± 11.2	<0.001*
- 48 Hours	66.9 ± 10.3	77.9 ± 9.9	<0.001*
Mean Arterial Pressure (MAP, mmHg)			
- Baseline	78.6 ± 9.4	79.1 ± 10.1	0.764
- 24 Hours	74.8 ± 8.9	77.2 ± 9.5	0.112
- 48 Hours	73.1 ± 9.2	76.5 ± 10.4	0.043*

(*p < 0.05)

Table 4 outlines hemodynamic changes during sedation. There was a significant reduction in heart rate in Group D compared to Group P at both 24 and 48 hours (p < 0.001). Similarly, mean arterial pressure (MAP) was lower in Group D at 48 hours (p = 0.043), although differences at 24 hours were not statistically significant.

Table 5: Duration of Mechanical Ventilation and ICU Stay

Variables	Group D (n=42)	Group P (n=42)	p-value
Duration of Mechanical Ventilation (hours)	72.5 ± 24.7	89.6 ± 30.5	0.004*
Length of ICU Stay (days)	6.8 ± 2.3	8.4 ± 2.9	0.002*

(*p < 0.05)

Table 5 compares the duration of mechanical ventilation and length of ICU stay. Group D demonstrated a significantly shorter duration of mechanical ventilation (72.5 ± 24.7 hours vs. 89.6 ± 30.5 hours; p = 0.004) and ICU stay (6.8 ± 2.3 days vs. 8.4 ± 2.9 days; p = 0.002) compared to Group P.

Table 6: Incidence of Delirium (CAM-ICU Positive Patients)

Time of Assessment	Group D (n=42)	Group P (n=42)	p-value
Day 1	3 (7.1%)	7 (16.7%)	0.184
Day 3	4 (9.5%)	12 (28.6%)	0.027*
Day 5	2 (4.8%)	9 (21.4%)	0.017*

(*p < 0.05)

Table 6 presents the incidence of delirium as assessed by the CAM-ICU. Group D had a significantly lower incidence of delirium on Day 3 (9.5% vs. 28.6%; p = 0.027) and Day 5 (4.8% vs. 21.4%; p = 0.017), although no significant difference was observed on Day 1.

Table 7: Incidence of Adverse Effects

Adverse Events	Group D (n=42)	Group P (n=42)	p-value
Bradycardia (HR < 50 bpm)	9 (21.4%)	3 (7.1%)	0.046*
Hypotension (MAP < 60 mmHg)	6 (14.3%)	11 (26.2%)	0.162
Respiratory Depression	0 (0%)	5 (11.9%)	0.022*
Propofol Infusion Syndrome	0 (0%)	1 (2.4%)	0.313

(*p < 0.05)

Table 7 reports adverse events. Bradycardia occurred more frequently in Group D (21.4%) compared to Group P (7.1%), which was statistically significant (p = 0.046). Respiratory depression was observed exclusively in Group P (11.9%, p = 0.022). There was no significant difference in the incidence of hypotension or propofol infusion syndrome between groups.

Table 8: Biochemical Markers at 48 Hours

Parameters	Group D (n=42)	Group P (n=42)	p-value
Serum Creatinine (mg/dL)	1.2 ± 0.4	1.3 ± 0.5	0.384
ALT (U/L)	45.2 ± 18.7	48.9 ± 21.3	0.421
Lactate (mmol/L)	1.6 ± 0.5	2.1 ± 0.7	<0.001*
CK (U/L)	122.3 ± 33.4	210.4 ± 55.9	<0.001*

(*p < 0.05)

Table 8 highlights biochemical markers at 48 hours. Group P had significantly higher serum lactate (2.1 ± 0.7 mmol/L vs. 1.6 ± 0.5 mmol/L; $p < 0.001$) and creatine kinase (CK) levels (210.4 ± 55.9 U/L vs. 122.3 ± 33.4 U/L; $p < 0.001$). No significant differences were found in serum creatinine or ALT levels between the two groups.

Table 9: ICU and 28-Day Mortality

Mortality	Group D (n=42)	Group P (n=42)	p-value
ICU Mortality	5 (11.9%)	9 (21.4%)	0.233
28-Day Mortality	7 (16.7%)	12 (28.6%)	0.183

Table 9 presents ICU and 28-day mortality rates. Although Group D showed lower mortality rates (ICU mortality 11.9% vs. 21.4%, 28-day mortality 16.7% vs. 28.6%), these differences were not statistically significant ($p = 0.233$ and $p = 0.183$, respectively).

Table 10: Summary of Major Study Outcomes

Outcomes	Group D (n=42)	Group P (n=42)	p-value
Time to Target Sedation (min)	42.5 ± 11.3	28.6 ± 9.5	<0.001*
Hemodynamic Stability (HR drop)	Significant	Moderate	<0.001*
Mechanical Ventilation (hours)	72.5 ± 24.7	89.6 ± 30.5	0.004*
Length of ICU Stay (days)	6.8 ± 2.3	8.4 ± 2.9	0.002*
Delirium Incidence (Day 5)	4.8%	21.4%	0.017*
Adverse Events (Bradycardia)	21.4%	7.1%	0.046*
Respiratory Depression	0%	11.9%	0.022*
28-Day Mortality	16.7%	28.6%	0.183

(*$p < 0.05$)

Table 10 summarizes the major outcomes of the study. Dexmedetomidine (Group D) was associated with a longer time to achieve target sedation compared to Propofol (Group P), but it provided better hemodynamic stability with a significant reduction in heart rate. Group D showed a shorter duration of mechanical ventilation (72.5 vs. 89.6 hours) and a reduced ICU stay (6.8 vs. 8.4 days). Additionally, Dexmedetomidine was linked to a lower incidence of delirium on Day 5 (4.8% vs. 21.4%). However, bradycardia was more frequent in Group D (21.4%), while respiratory depression occurred only in Group P (11.9%). There was no significant difference in 28-day mortality between the two groups.

DISCUSSION

This prospective randomized comparative study assessed the efficacy and safety of Dexmedetomidine versus Propofol for sedation in critically ill ICU patients. The outcomes highlight important distinctions between the two agents regarding sedation onset, hemodynamic stability, mechanical ventilation duration, delirium incidence, and adverse events. In our study, Dexmedetomidine demonstrated a longer time to achieve the target sedation level compared to Propofol (42.5 ± 11.3 min vs. 28.6 ± 9.5 min, $p < 0.001$). This finding aligns with Riker et al., who reported that while Dexmedetomidine offers cooperative sedation, its onset is slower due to its selective α2-adrenoceptor agonism [11]. Propofol's faster onset is attributable to its GABA receptor-mediated rapid CNS depression [12]. Hemodynamic stability was superior with Dexmedetomidine, demonstrated by significantly lower heart rates at 24 and 48 hours. Our findings are consistent with Tan and Ho's meta-analysis, which confirmed Dexmedetomidine's sympatholytic effect, resulting in bradycardia and hypotension [13]. Jakob et al. in the PRODEX trial also found lower heart rates with Dexmedetomidine, although accompanied by increased bradycardia incidence [14].

Bradycardia was indeed more frequent in our Dexmedetomidine group (21.4% vs. 7.1%, $p = 0.046$). Although this side effect is well documented, it was clinically manageable in our population, supporting the drug's overall safety [15]. Importantly, Dexmedetomidine was associated with a reduced duration of mechanical ventilation (72.5 ± 24.7 hours) compared to Propofol (89.6 ± 30.5 hours, $p = 0.004$). The MENDS trial demonstrated a similar benefit, with patients sedated with Dexmedetomidine experiencing earlier extubation and reduced ventilator days[16]. Additionally, the SPICE III trial emphasized that lighter sedation achieved with Dexmedetomidine promotes earlier liberation from ventilation [17]. We observed a shorter ICU stay in the Dexmedetomidine group (6.8 ± 2.3 days vs. 8.4 ± 2.9 days, $p = 0.002$). This concurs with the findings of Reade et al., who noted reduced ICU length of stay with Dexmedetomidine-based sedation strategies [18]. A significant reduction in delirium incidence was observed on Days 3 and 5 in the Dexmedetomidine group. Pandharipande et al. demonstrated that Dexmedetomidine reduces acute brain dysfunction in ICU patients compared to benzodiazepines 6. This may be attributed to Dexmedetomidine's unique mechanism, preserving

sleep architecture and causing less cortical suppression [19]. Unlike Propofol, which caused respiratory depression in 11.9% of cases ($p = 0.022$), Dexmedetomidine maintained respiratory function with no reported episodes. This is consistent with the findings of Venn and Grounds, who highlighted Dexmedetomidine's ability to maintain ventilatory drive even at sedative doses [15]. Moreover, Dexmedetomidine was associated with lower lactate levels (1.6 ± 0.5 mmol/L vs. 2.1 ± 0.7 mmol/L, $p < 0.001$) and creatine kinase levels (122.3 ± 33.4 U/L vs. 210.4 ± 55.9 U/L, $p < 0.001$), suggesting reduced metabolic stress. Yildiz et al. demonstrated improved metabolic parameters with Dexmedetomidine, highlighting its stress-modulating properties [20]. Although 28-day mortality was lower with Dexmedetomidine (16.7% vs. 28.6%), this difference was not statistically significant ($p = 0.183$). Similar mortality trends were reported in the SPICE III trial, although secondary outcomes often favored Dexmedetomidine [17].

Limitations of the Study:

This study has several limitations that should be acknowledged. Firstly, it was conducted in a single center, limiting the generalizability of the findings to other ICU settings or populations. Secondly, the sample size, though adequate for detecting significant differences in primary outcomes, may not have been sufficient to detect differences in secondary outcomes such as 28-day mortality. Thirdly, the study duration was limited to short-term ICU outcomes; long-term follow-up regarding cognitive function, quality of life, and functional status post-ICU discharge was not performed.

CONCLUSION

Dexmedetomidine demonstrated comparable sedative efficacy to Propofol, with added benefits in hemodynamic stability, shorter ventilation duration, lower delirium incidence, and improved metabolic profiles, though with a higher incidence of bradycardia. Its role as a primary sedative in ICU settings appears justified, particularly in patients where respiratory function and cognitive outcomes are prioritized.

Recommendations:

Based on the findings of this study, Dexmedetomidine appears to offer clinical advantages over Propofol in terms of hemodynamic stability, reduced duration of mechanical ventilation, and lower incidence of ICU delirium. However, the increased risk of bradycardia necessitates careful patient selection and monitoring.

Conflict of Interest:

The authors declare no conflict of interest related to this study. The research was conducted independently, without any financial support or influence from pharmaceutical companies or other external organizations.

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