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CLINICAL TRIAL REPORT

The Effect of Low-Dose Dexmedetomidine on Perioperative Neurocognitive Dysfunction in Elderly Patients Undergoing Endoscopic Retrograde Cholangiopancreatography (ERCP): A Randomized, Controlled, Double-Blind Trial

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Objective: This study investigates the effect of low-dose dexmedetomidine infusion on perioperative neurocognitive function in elderly patients undergoing endoscopic retrograde cholangiopancreatography (ERCP).

Patients and Methods: This double-blind trial enrolled 80 elderly ERCP patients randomized to receive dexmedetomidine (Group D) or placebo (Group S). Group D received dexmedetomidine at 0.4 $\mu g \cdot kg^{-1} \cdot h^{-1}$ starting 15 minutes before surgery until completion, along with propofol at 1.5 mg/kg for anesthesia. Group S received saline and propofol in a similar manner. Anesthesia was maintained with dexmedetomidine at 0.4 $\mu g \cdot kg^{-1} \cdot h^{-1}$ and propofol at 1–2 mg/kg during surgery. Cognitive function was assessed using the Mini-Mental State Examination (MMSE) preoperatively and on postoperative days 1, 3, and 5. Primary outcome was perioperative neurocognitive disorder (PND) incidence on day 5; secondary outcomes included changes in perioperative IL-6, cortisol, S100-β, hemodynamics, anesthesia parameters, postoperative pain, agitation scores, and adverse events.

Results: All 80 patients completed the trial. On postoperative day 5, the cumulative probability of PND incidence was significantly lower in Group D than in Group S (12.5% vs 35%, P=0.018). Group D also had lower levels of IL-6 (F=199.472, P<0.001), S100-β (F=2681.964, P<0.001), and cortisol (F=137.637, P<0.001). Propofol doses were lower in Group D (706.1 ± 202.4 vs 1003.3 ± 203.7, P<0.001), and bradycardia rates were higher (45% vs 15%, P=0.003), though atropine use did not significantly differ between groups. Group D showed greater stability in mean arterial pressure. Postoperative complications and adverse reactions were similar across groups.

Conclusion: Perioperative low-dose dexmedetomidine infusion with propofol in elderly ERCP patients ensures safe and effective monitored anesthesia care (MAC), reducing PND incidence by mitigating peripheral inflammation and stress responses. Long-term follow-up is needed to fully evaluate PND incidence.

Keywords: ERCP, PND, dexmedetomidine, elderly patients

Introduction

With the global aging population on the rise, there's a growing need for endoscopic retrograde cholangiopancreatography (ERCP) procedures among elderly individuals.[1] In the United States alone, the annual count of ERCP procedures exceeds

Received: 27 March 2024
Accepted: 13 August 2024
Published: 23 August 2024

600,000 cases.[2] However, conducting various invasive tests, maneuvers,[3] and treatments in elderly patients presents challenges due to their often multiple comorbidities.[4,5] With the rise of the concept of comfort medicine, the use of painless ERCP surgical treatment performed under anesthesia has become a new option for both patients and physicians.[6]

Monitored Anesthesia Care (MAC) is currently the most commonly used anesthesia management protocol for elderly patients undergoing ERCP procedures.[7–9] Propofol is frequently used for MAC management during ERCP procedures, often in combination with opioids. However, propofol can cause cardiovascular and respiratory depression, particularly in high-risk patients. These propofol-related side effects are typically dose-dependent. Furthermore, the perioperative use of opioids may exacerbate propofol-induced respiratory and cardiovascular depression. Perioperative complications such as hypotension and respiratory depression can often lead to another common and severe risk, perioperative neurocognitive disorder (PND).[10] PND is one of the most common and severe complications in elderly patients under general anesthesia, potentially leading to compromised autonomy, reduced quality of life, prolonged hospital stays, increased complication rates, mortality, and impaired postoperative recovery.[11–13] Therefore, early intervention during the perioperative period is essential.

Dexmedetomidine is a highly selective α_2-adrenergic receptor agonist with sympatholytic, co-analgesic, anxiolytic, and sedative properties.[14] Studies have demonstrated that dexmedetomidine exhibits significant neuroprotective and anti-inflammatory effects, potentially preventing postoperative cognitive dysfunction in elderly surgical patients.[15] However, previous research often utilized loading doses (1 ug/kg) or relatively high maintenance doses (≥0.5 ug/kg/h), resulting in notable bradycardia.[16–21] Although one study has shown that extremely low-dose dexmedetomidine infusion (0.1 μg/kg/h) can significantly reduce the incidence of delirium within the first seven days postoperatively in patients aged 65 and older admitted to the intensive care unit after non-cardiac surgery.[22] Not all studies have reached consistent conclusions. Another study found that low-dose dexmedetomidine infusion (0.4 μg/kg/h) did not alter the risk of in-hospital delirium in elderly patients undergoing cardiac surgery.[23,24] Therefore, the protective effects of low-dose dexmedetomidine infusion on perioperative neurological function remain unclear. Additionally, there are no reported studies on the effects of dexmedetomidine infusion on postoperative neurocognitive function in elderly patients undergoing ERCP.

We hypothesize that dexmedetomidine offers multiple advantages during MAC for ERCP procedures. Firstly, low-dose dexmedetomidine possesses neuroprotective properties. Secondly, it can reduce the required dose of propofol, thereby decreasing the incidence of propofol-related side effects and PND. This double-blind, randomized study was designed to investigate the effects of low-dose dexmedetomidine infusion on perioperative cognitive function in elderly patients undergoing ERCP in search of a safe and effective anesthesia management protocol. We also investigated the effect of dexmedetomidine supplementation on recovery time and perioperative complications.

Material and Methods

Ethics and Registration

The study obtained approval from the Hospital Ethics Committee of the Second Hospital of Hebei Medical University (2023-R617) and was registered in the China Clinical Trial Registry on December 13, 2023 (registration number Chictr2300078598). All patients provided written informed consent.

Patient Inclusion and Exclusion Criteria

The study occurred at Hebei Medical University's Second Hospital's ERCP operating room from December 2023 to March 2024. Investigators, including nurses and anesthesiologists, underwent rigorous training. Researchers screened potential participants one day pre-surgery. Inclusion criteria comprised patients aged 65 years and older, ASA grades I to III, scheduled for elective ERCP under general anesthesia. Exclusion criteria involved patients lacking informed consent or with severe cardiovascular, respiratory, central nervous system, liver, or kidney dysfunction, glaucoma, communication or assessment impairments, and suspected severe neurocognitive impairment (MMSE score <24).[25] Also excluded were patients with anticipated airway difficulties, alcohol or drug dependence, current sedative, antidepressant, or corticosteroid use, allergy to dexmedetomidine or other anesthetics, baseline heart rate less than 50 beats per minute

due to bradycardia, sick sinus syndrome, or second-degree or higher atrioventricular block without a pacemaker, and those previously enrolled.

Randomization and Masking

An independent statistician utilized SPSS software to generate random numbers, assigning participants into two groups at a 1:1 ratio. Group allocations were sealed in numbered opaque envelopes by a study coordinator not involved in patient care. Medications were prepared based on random assignments and given to anesthesiologists. Patients received either dexmedetomidine or saline. All medicines were colorless and administered with identical syringes. Details of randomization and medication preparation were kept confidential. Blinding remained throughout the study, with unblinding permitted only for severe adverse events. Unblinded cases were included in the intention-to-treat population but excluded from per-protocol analysis for safety.

Technique

All patients fasted for 6 hours and refrained from drinking water for 2 hours before surgery without the use of anxiolytic medications. Corticosteroids and nonsteroidal analgesics were avoided during surgery. Upon entering the operating room, patients received routine intravenous fluid infusion and oxygen via a mask at 6 L/min and had intravenous access established. Lactated Ringer's solution was administered at a rate of 6–10 mL kg^{-1} h^{-1}. Monitoring included electrocardiography (ECG), heart rate (HR), non-invasive systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), pulse oxygen saturation (SpO_2) and bispectral index (BIS) (ConView YY-106, Pearlcare, Zhejiang, China). In addition, the End-Tidal Carbon Dioxide ($EtCO_2$) was measured using the Mindray iPM10 monitor (Mindray Medical International Limited, China).

Certified anesthesiologists administered anesthesia, while experienced endoscopists performed all procedures. Assessment points were: T0: Baseline before anesthesia; T1: Endoscope insertion; T2: 10 mins after surgery start; T3: 30 mins after surgery start; T4: 1 hr post-op; T5: 1 day post-op. After surgery, patients were closely monitored in the post-anesthesia care unit until discharge. Standard monitoring included MAP, HR, and SpO_2 values. Discharge to the general ward occurred when patients reached an Aldrete score of ≥9.

Grouping and Intervention

During the induction phase, patients were administered nalbuphine hydrochloride injection (1.5–2.0 mg/kg; Jiangsu Zilong Pharmaceutical Co., Ltd., China), dexmedetomidine (0.4 μg · kg^{-1} · h^{-1}; Beijing National Pharmaceutical Industry Co., Ltd., China), or normal saline. All patients received a slow intravenous injection of propofol (1.5 mg/kg; Fresenius Kabi AG, Graz, Austria) over more than 30 seconds. If the sedation depth was insufficient (BIS value > 60), patients were given additional intravenous injections of propofol (0.5 mg/kg per dose) until the BIS value was < 60 or the eyelash reflex disappeared, after which the endoscope was inserted. Dexmedetomidine infusion commenced 15 minutes pre-surgery. Lifting the lower jaw and/or providing pressure-assisted ventilation via a face mask should be performed in cases of respiratory depression (SpO_2 < 95% or RR < 8 bpm for more than 1 minute), airway obstruction, or apnea.

During maintenance, propofol was given at 1–2 mg·kg^{-1}·h^{-1}, and dexmedetomidine or saline at 0.4 μg·kg^{-1}·h^{-1} to sustain anesthesia. SpO_2 stayed above 95%, blood pressure within ±20% of baseline, nasopharyngeal temperature 36–37.5°C, and $EtCO_2$ 35–45 mmHg. Propofol stopped 10 mins before surgery ended, and dexmedetomidine continued until the end of surgery. Postoperatively, an opioid receptor agonist-antagonist (dezocine, 0.1 mg/kg, produced by Jiangsu Yangtze River Pharmaceutical Group Co., Ltd., China) was administered 10 min before the end of surgery for analgesia. Postoperatively, the use of corticosteroids, nonsteroidal anti-inflammatory drugs (NSAIDs), and long-acting sedatives should be avoided.

During surgery, vasoactive drugs may be administered as necessary to maintain stable circulation. Fluid intake is adjusted based on bleeding, and the propofol infusion rate is regulated to maintain anesthesia depth at a Bispectral Index (BIS) of 40–60. Oxygen mask starts if SpO_2 drops to 90%. Adverse hemodynamic events trigger interventions: hypotension (SBP < 90 mmHg, DBP < 50 mmHg, or ≥ 20% MAP decrease), treated with ephedrine or atropine; hypertension (SBP > 160 mmHg, DBP > 110 mmHg, or ≥ 20% increase), treated with urapidil. Tachycardia (HR > 120

bpm) receives esmolol or causal treatments. Desaturation (SpO_2 < 95%), managed by lifting the lower jaw and/or providing pressure-assisted ventilation via a face mask.

Outcomes

Primary Outcome

We assessed PND incidence on the 5th postoperative day. MMSE was conducted preoperatively and on postoperative days 1, 3, and 5, evaluating various cognitive domains. To address learning effects, 20 matched healthy volunteers were selected as controls. All tests were conducted by trained assessors in the same conditions. PND diagnosis followed international criteria, using z-scores to compare patients with controls. $|Z| \geq 1.96$ indicated PND.[11]

Secondary outcomes

Serum Biomarkers for Inflammation, Stress, and Neuronal Injury

Plasma biomarkers were measured at five time points: baseline (T0), endoscope insertion (T1), 10 and 30 minutes after surgery start (T2, T3), and 1 hour (T4) and one day postoperatively (T5). IL-6, cortisol, and S100-β protein levels were assessed using ELISA from 2 mL blood samples.[26,27] Samples were centrifuged, aliquoted, and stored at −70°C before analysis.

Monitoring of Adverse Reactions and Complications

Simultaneously record the mean arterial pressure (MAP) and heart rate (HR) at each time point. Adverse reactions, from drug administration to 2 hours post-surgery, include blood pressure fluctuations, coughing during endoscope insertion, nausea, vomiting, postoperative agitation, pain scores, respiratory depression, awareness during surgery, and vasopressor use. Agitation and sedation levels are assessed using the Richmond Agitation-Sedation Scale (RASS), while pain is evaluated with the Numeric Rating Scale (NRS). Criteria for low blood pressure are SBP < 90 mmHg, DBP < 50 mmHg, or a MAP decrease of ≥20%, and for high blood pressure, SBP > 160 mmHg, DBP > 110 mmHg, or a MAP increase of 20%. Severe bradycardia is defined as HR < 40 bpm, and tachycardia as HR > 120 bpm. Surgical details, such as propofol and vasopressor use, fluid balance, awakening time, and recovery room stay, are documented.

Statistical Analysis

Sample Size and Statistical Analysis

Based on previous studies, the incidence of PND in elderly patients ranges between 13% and 50%.[10,13] We hypothesize that the incidence of postoperative PND in the dexmedetomidine group will decrease from 50% to 20% (approximately a 60% reduction).[19] According to PASS 15.0, we calculated that with a power of 80% and a two-sided significance level of 0.05, 80 patients are needed to detect this difference. Considering an anticipated loss-to-follow-up rate of approximately 10%, we plan to enroll a total of 90 patients in the study.

Data analysis was performed using IBM SPSS Statistics software (version 25.0). The normality and homogeneity of variance were tested using the Shapiro–Wilk test and Levene's test, respectively. Normally distributed continuous variables are presented as mean ± standard deviation and were compared using the *t*-test. Non-normally distributed continuous variables are presented as median (interquartile range, IQR) and were compared using the Mann–Whitney test. Categorical data are presented as frequencies or percentages, and comparisons between groups were made using the chi-square test or Fisher's exact test. Statistical significance was set at $P < 0.05$. Plasma S-100β, IL-6, and cortisol levels, as well as hemodynamic data, were analyzed using repeated measures analysis of variance (ANOVA). Post hoc tests for repeated measures ANOVA were conducted using simple effects analysis with Bonferroni correction.

Results

Demographic Data and Surgical Characteristics

Figure 1 illustrates the study flowchart. Initially, 90 patients underwent elective ERCP procedures, with 20 volunteers recruited concurrently (Table S1). Exclusions (n=10) resulted from failure to meet inclusion criteria (n=6), refusal (n=2), and other reasons (n=2). Ultimately, 80 patients (Group D=40, Group S=40) were analyzed. Demographics, medical history,

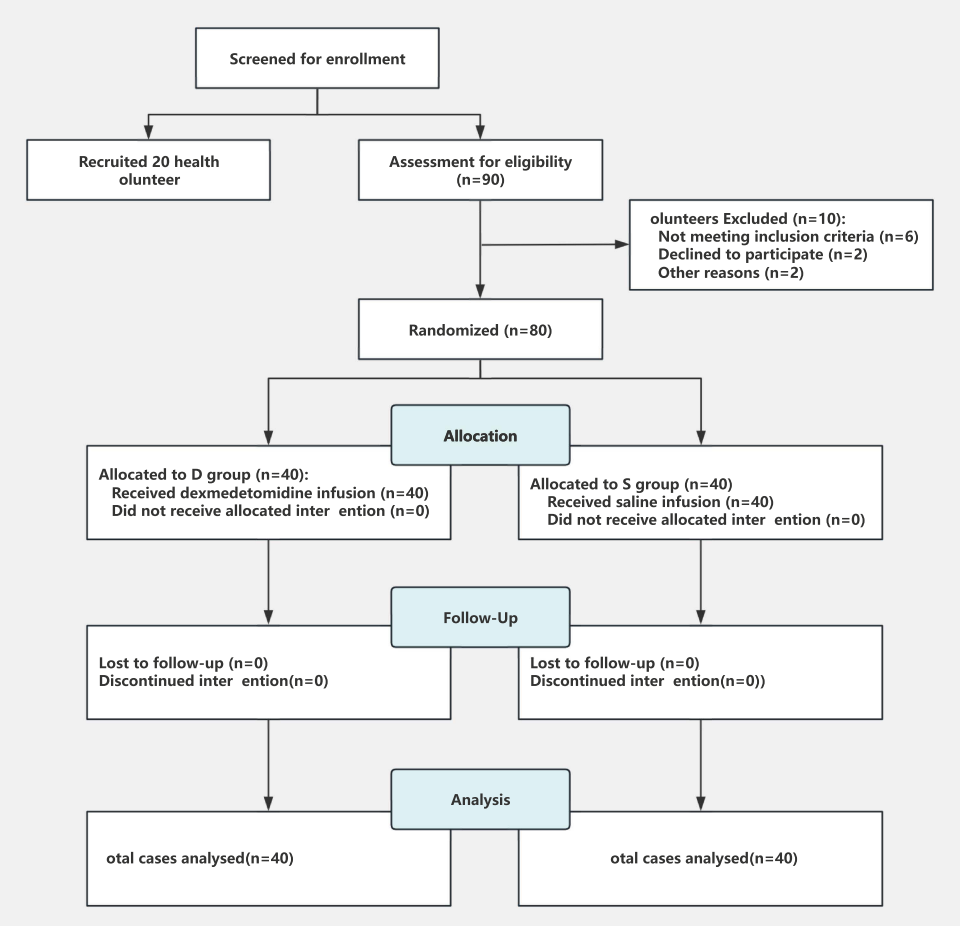

Figure 1 Consolidated Standards of Reporting Trials (CONSORT) Flowchart describing patients progress through the study.

and baseline MMSE scores showed no significant differences between groups (Table 1). Furthermore, intraoperative surgical and anesthesia data (Table 2) revealed a lower cumulative propofol dose during surgery in Group D compared to Group S (P=0.001).

The Incidence of PND

Based on Table 3 data, the cumulative PND incidence within 5 days post-op was lower in Group D than in Group S (p=0.018). On day 1 post-op, 4 PND cases were observed in Group D versus 12 in Group S. Notably, PND mainly occurred within 3 days post-ERCP, with 5 patients in Group S experiencing persistent PND. Figure 2 illustrates the cumulative PND incidence.

The Levels of Serum IL-6, Cortisol, and S100-β Protein

Both groups showed similar trends in IL-6, S100-β, and cortisol plasma levels. At 10 minutes into surgery, levels of these biomarkers significantly rose compared to baseline. Notably, at this point, Group D exhibited significantly lower levels than Group S ($p < 0.001$), as depicted in Figure S1.

Hemodynamic Changes During Surgery

As shown in Figure S2(A), in group S, HR increased significantly after post-endoscopy placement, while in group D, HR did not increase significantly and showed a gradual decrease, and the changes in heart rate in the two groups were statistically different at T2, T3, and T4 ($p<0.001$).

Table 1 Patient Demographic and Surgical Parameters

Variables	Group-D (n = 40)	Group-S (n = 40)	P value
Age, years	68.2 ± 2.2	68.0 ± 1.9	0.743
BMI, Kg/m^2	24.1 ± 1.4	23.7 ± 2.1	0.899
Sex, n (%)			0.823
Male	19 (47.5)	20 (50)	
Female	21 (52.5)	20 (50)	
ASA physical status, n (%)			0.745
II	35 (87.5)	34 (85)	
III	5 (12.5)	6 (15)	
Level of education, n (%)			0.327
Elementary	18 (45)	13 (32.5)	
Junior	21 (52.5)	22 (55)	
College and beyond	1 (2.5)	5 (12.5)	
Hypertension, n (%)	11 (27.5)	13 (32.5)	0.626
Electrocardiogram: Changes in the ST segment, n (%)	14 (35)	8 (20)	0.133
Preoperative MMSE score, points	28.2 ± 1.5	27.8 ± 1.4	0.174

Notes: Data are presented as Mean ± SD or Number (Percentage).
Abbreviations: BMI, Body Mass Index; ASA, American Society of Anesthesiologists; SD, standard deviation; MMSE, Mini-Mental State Examination.

Table 2 Surgery and Anaesthesia Data

Variables	Group-D (n = 40)	Group-S (n = 40)	P value
Duration of surgery, min	92.0 ± 11.9	89.6 ± 12.0	0.377
Duration of anesthesia, min	107.5 ± 12.7	104.8 ± 15.0	0.375
Accumulated consumption of propofol, mg	706.1 ± 202.4	1003.3 ± 203.7	0.001*
Crystalloid intake, mL	876.9 ± 126.1	852.7 ± 110.5	0.364
Urine output, mL	318.3 ± 86.0	326.4 ± 110.2	0.716
Time to consciousness recovery, min	8.6 ± 4.4	9.7 ± 4.5	0.276
Time to recover orientation, min	23.5 ± 3.3	23.8 ± 5.2	0.72
Recovery Room Bed Occupancy Time, min	33.9 ± 4.7	33.3 ± 4.9	0.564

Notes: Dates are presented as Mean ± SD, * denotes $p < 0.05$ between the two groups.
Abbreviation: SD, Standard Deviation.

There was no significant increase in MAP in group D at T1, and the changes in MAP in the two groups were statistically different at T1 (p=0.047), T2 (p=0.047), T4 (p<0.001), and T5 (p<0.001)were statistically distinct, as shown in Figure S2(B).

Table 3 Primary Outcomes

Variables	Group-D (n = 40)	Group-S (n = 40)	P value
MMSE Score, points			
POD 1	27.4±1.6	25.6±1.4	0.001*
POD 3	27.8±1.5	26.3±1.6	0.001*
POD 5	28.1±1.5	26.9±1.6	0.001*
PND, n (%)			
POD 1	4 (10)	12 (30)	0.025*
POD 3	1 (2.5)	7 (17.5)	0.201
POD 5	0 (0)	0 (0)	1
Cumulative Case of POD 3	5(12.5)	14(35)	0.018*
Cumulative Case of POD 5	5(12.5)	14(35)	0.018*

Notes: Data are presented as Mean ± SD or Number (Percentage), * denotes $p < 0.05$ between the two groups.
Abbreviations: PND, Postoperative Neurocognitive Disorders; POD, Postoperative Day.

Monitoring of Adverse Reactions and Complications

In group D, 18 patients exhibited sinus bradycardia during the procedure, while in group S, only 6 did, showing a statistically significant difference between the two groups (p=0.003). However, there was no significant statistical difference in the intraoperative use of atropine between the two groups (p=0.077). Additionally, the occurrence rates of other adverse reactions and complications were similar between the two groups (p>0.05), as depicted in Table 4.

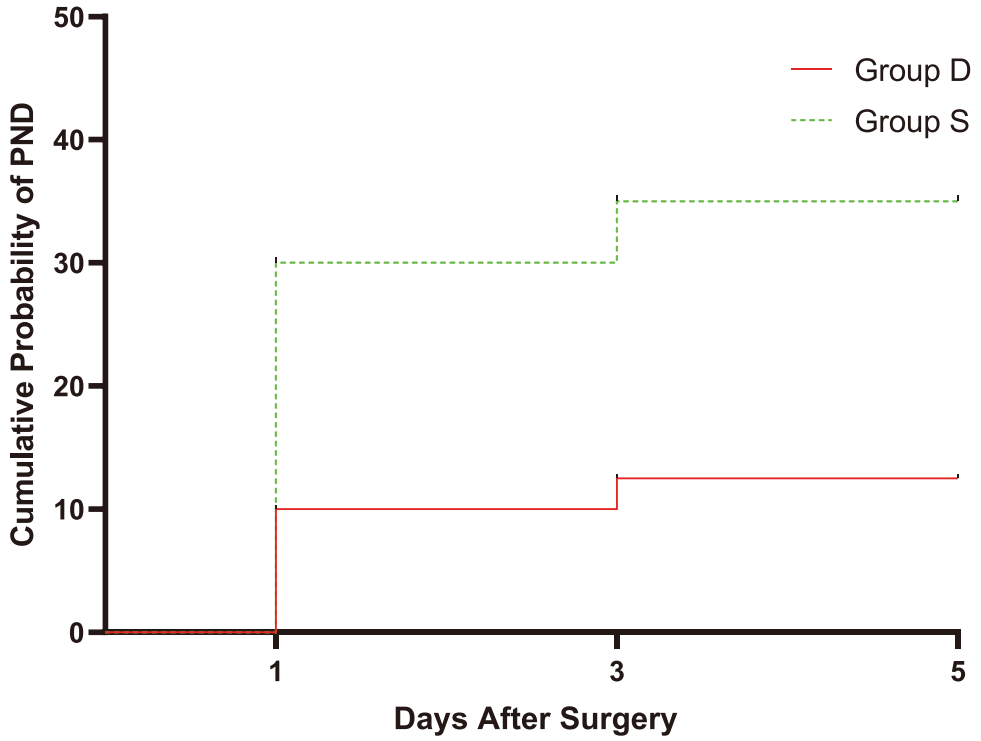

Figure 2 Cumulative incidence of PND in Group D (Red) and Group S (Green).

Table 4 Monitoring and Profiling Adverse Events

Variables	Group-D (n= 40)	Group-S (n = 40)	P value
Sinus bradycardia, n (%)	18 (45)	6 (15)	0.003*
Blood pressure fluctuations, n (%)	16 (40)	10 (25)	0.152
Hypotension, n (%)	8 (20)	5 (12.5)	0.363
Hypertension, n (%)	4 (10)	7 (17.5)	0.33
Cough reflex during placement, n (%)	3 (7.5)	5 (12.5)	0.712
Nausea and vomiting, n (%)	2 (5)	5 (12.5)	0.432
Postoperative agitation, n (%)	3 (7.5)	5 (12.5)	0.712
NRS scores, n (%)			0.191
1	28 (70)	21 (52.5)	
2	11 (27.5)	15 (37.5)	
3	1 (2.5)	4 (10)	
Respiratory depression, n(%)	7 (17.5)	5 (12.5)	0.531
Unconsciousness during surgery, n (%)	40 (100)	40 (100)	1
Use of vasoactive drugs, n (%)			
Atropine	10 (25)	4 (10)	0.077
Urapidil	4 (10)	7 (17.5)	0.33
Ephedrine Alkaloids	8 (20)	4 (10)	0.21

Notes: Data are presented as Number (Percentage), * denotes $p < 0.05$ between the two groups.
Abbreviation: NRS, Numeric Rating Scale.

Discussion

In this investigation, we assessed the short-term outcomes of PND in elderly patients undergoing elective ERCP surgery under MAC with low-dose dexmedetomidine, nalbuphine, and propofol. Among the 80 patients studied, 19 (23.8%) developed PND. The incidence rates of PND in Group D and Group S were 12.5% and 35.0%, respectively, with a statistically significant difference noted between the two groups. Additionally, plasma levels of IL-6, S100-β, and cortisol were notably lower in Group D compared to Group S. Patients receiving dexmedetomidine also had lower cumulative propofol doses, maintained stable hemodynamics, and experienced similar rates of postoperative complications and adverse reactions as the control group. These results suggest that low-dose dexmedetomidine infusion not only reduces the amount of propofol used and mitigates perioperative circulatory fluctuations but also helps alleviate perioperative stress and inflammatory responses. This contributes to reducing neuronal damage, thereby protecting cognitive function and decreasing the incidence of PND.

The organ-protective role of dexmedetomidine as an anti-inflammatory agent has been a subject of considerable interest. Research indicates its multifaceted effects: alleviating neuronal damage and inflammation in SD rat hippocampal CA1 region via VEGF-VEGFR2 or Rac1/AKT/NF-κB pathways, improving cognitive function.[28,29] Dexmedetomidine can also mitigate complement activation due to sleep deprivation, preventing related cognitive deficits.[30] Moreover, it inhibits sevoflurane-induced Tau protein phosphorylation and cognitive impairment by activating α2 adrenergic receptors.[31] However, findings have been mixed. An intervention study conducted in the ICU showed that the trial group receiving dexmedetomidine intervention had higher levels of cognitive impairment, which were unrelated to the release of brain injury markers S100-β and NSE.[32] Since elderly ERCP patients often have multiple comorbidities, organ decline, and complex medication, dexmedetomidine's effect on their postoperative cognitive function is unclear. Thus, this study investigates low-dose dexmedetomidine's impact on cognition.

In our study, patients in Group D had notably higher postoperative MMSE scores than the control, with fewer exceeding *Z* scores of 1.96. Research suggests early postoperative cognitive impairment is preventable or manageable, with interventions like pharmacological agents reducing oxidative stress and neuroinflammation.[33–35] In this trial, the intravenous infusion of low-dose dexmedetomidine during ERCP surgery in elderly patients was associated with a reduced incidence of PND postoperatively, particularly in patients with continuous neurocognitive dysfunction within three days postoperatively, compared to the control group. This finding suggests the potential value of low-dose dexmedetomidine infusion in improving postoperative cognitive function in elderly ERCP surgery patients, providing an essential reference for clinical practice.

This study revealed significantly lower plasma levels of IL-6, S100-β protein, and Cortisol in Group D compared to Group S, affirming low-dose dexmedetomidine's anti-inflammatory and neuroprotective effects in ERCP surgery. IL-6 elevation post-surgery correlates with trauma severity, serving as a surgery-related injury biomarker.[36,37] S100-β, prevalent in CNS glial cells, rises in peripheral blood following CNS and blood-brain barrier damage, indicating brain injury.[38] During ERCP surgery, patients experience physiological and psychological stress, prompting a cortisol-mediated stress response to maintain endocrine and metabolic stability.[39] We speculate that low-dose dexmedetomidine may play a role in cerebral protection by inhibiting ERCP surgery-induced peripheral inflammatory cytokine release, attenuating neuroinflammation, and reducing perioperative stress, thereby maintaining intracranial homeostasis.

Dexmedetomidine, a widely used sedative in clinical settings, is esteemed for its anti-inflammatory, stress-regulating, and organ-protective properties. It also minimizes respiratory depression and prevents histamine-induced bronchoconstriction, enhancing airway stability.[40,41] Our study results are consistent with the above conclusions, as patients in Group D exhibited more stable hemodynamics, a lower incidence of coughing, and reduced cumulative usage of sedative propofol. Despite the use of low-dose dexmedetomidine in this study, we still observed a higher number of cases with decreased heart rate in Group D. However, with minimal atropine or without intervention, the patient's heart rates remained within an acceptable range, did not affect circulation, and gradually recovered to baseline levels before surgery after discontinuation of anesthetic administration at the end of the procedure.

Indeed, there are areas for improvement in this study. Firstly, the small single-center sample may introduce bias. Although the sample size was calculated for 90 patients (dropout rate of 10%), our analysis showed that 80 patients (no dropouts) could still detect between-group differences. Secondly, due to time and manpower limitations, the long-term postoperative follow-up is insufficient, and the actual incidence of PND requires further evaluation. Thirdly, diagnosing PND relies on multiple assessment scales that lack objective standards and are susceptible to evaluator subjectivity. Future studies could incorporate additional scales for a comprehensive assessment to enhance objectivity and accuracy. Finally, we only measured the changes in serum inflammatory cytokine levels preoperatively, intraoperatively, and on the first postoperative day. We did not assess their levels over a long-term postoperative period. This is insufficient to reflect the dynamic changes in serum inflammatory cytokines and to determine the onset and duration of the anti-inflammatory effects of dexmedetomidine.

Conclusion

Continuous low-dose dexmedetomidine reduces PND incidence in elderly ERCP patients, promoting stable hemodynamics and reducing stress responses without significant adverse effects. It offers a safe and effective anesthesia monitoring strategy.

Data Sharing Statement

The datasets generated and/or analyzed during the current study are available from either of the two corresponding authors upon reasonable request.

Ethics Approval and Consent to Participate

The trial adhered to the Helsinki Declaration and China's Clinical Trial Guidelines. Ethics approval was granted by the Second Hospital of Hebei Medical University (Approval No. 2023-R617), and the trial was registered with the Chinese Clinical Trial Registry (Registration No. Chictr2300078598). Participants provided written informed consent, and the study protocol followed CONSORT guidelines.

Acknowledgments

We express our gratitude to the patients who participated in this study, as well as the physicians and nurses in the post-anesthesia care unit (PACU). In addition, an unauthorized version of the Chinese MMSE was used by the study team without permission, however this has now been rectified with PAR. The MMSE is a copyrighted instrument and may not be used or reproduced in whole or in part, in any form or language, or by any means without written permission of PAR (www.parinc.com). Therefore, we are very grateful to PAR Inc. for authorizing the use of the MMSE scale in this study.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

There is no funding to report.

Disclosure

The authors declare no conflicts of interest in this work.

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