Am J Transl Res 2025;17(9):7272-7282
www.ajtr.org /ISSN:1943-8141/AJTR0165133

Original Article

Analgesic efficacy, adverse events, and prognostic factors of low-dose intranasal dexmedetomidine combined with epidural anesthesia in ovarian cyst resection

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Received April 8, 2025; Accepted August 25, 2025; Epub September 15, 2025; Published September 30, 2025

Abstract: Objective: To evaluate the analgesic efficacy and safety of low-dose intranasal dexmedetomidine combined with epidural anesthesia in ovarian cyst resection, and identify influencing factors to optimize clinical analgesia strategies. Methods: From March 2022 to June 2024, a total of 359 patients undergoing ovarian cyst resection across multiple participating hospitals were enrolled. Patients were divided into either the control group (n = 206, receiving ropivacaine epidural anesthesia) or the observation group (n = 153, receiving intranasal dexmedetomidine combined with ropivacaine epidural anesthesia). Ramsay Sedation Scale (RSS), Visual Analog Scale (VAS) scores, Bruggrmann Comfort Scale (BCS) scores, surgical parameters, and postoperative adverse reactions were recorded. Logistic regression analysis was used to identify independent risk factors for postoperative adverse outcomes, and predictive efficacy was assessed using Receiver Operating Characteristic (ROC) curves. Results: Baseline characteristics, including age, body mass index (BMI), cyst diameter, disease location, pathological classification, American Society of Anesthesiologists (ASA) grade, and obstetric history, were comparable between the groups ($P > 0.05$). The observation group showed lower RSS scores at administration and completion, with fewer patients reaching levels 5-6 ($P < 0.05$). Postoperative VAS scores were significantly lower in the observation group at 3, 6, and 12 hours ($P < 0.05$), but not at 1 hour ($P > 0.05$). BCS scores were higher at 1, 3, 6, and 12 hours ($P < 0.05$). Operative time and blood loss were similar ($P > 0.05$); however, sedation onset, wake-up, and extubation times were shorter in the observation group ($P < 0.05$). The incidence of postoperative adverse events were lower in the observation group ($P < 0.05$). Logistic regression identified age, cyst diameter, blood loss, ASA grade, and anesthesia method as independent predictors of adverse events. ROC analysis confirmed age, cyst diameter, and blood loss as strong predictors of adverse outcomes. Conclusion: Low-dose intranasal dexmedetomidine combined with epidural anesthesia provides effective analgesia for ovarian cyst resection, with faster onset, reduced postoperative adverse events, and favorable safety. However, awakening time was prolonged in the observation group. Age, cyst diameter, and intraoperative blood loss were independent predictors of postoperative adverse events. Further studies are needed to validate these findings and clarify the effect on awakening time.

Keywords: Dexmedetomidine, epidural anesthesia, ovarian cyst resection, postoperative analgesia, adverse effects

Introduction

Ovarian cysts are among the most common benign neoplasms of the female reproductive tract, with a reported prevalence of 5-15% in women of reproductive age [1]. Although typically benign, they can impair quality of life by causing abdominal pain, constipation, and related discomforts; in severe cases, they may compromise ovarian reserve and ultimately lead to infertility [2, 3]. Prompt and effective treatment is therefore essential.

Surgical excision remains the standard therapy. In recent years, laparoscopic ovarian cystectomy has become the first-line technique, as it minimizes tissue trauma and accelerates postoperative recovery [4]. Nevertheless, the carbon-dioxide (CO_2) pneumoperitoneum required for laparoscopy can induce intra-operative

https://doi.org/10.62347/TSRQ8035

hemodynamic instability and delay postoperative recovery [5]. Accordingly, an anesthetic strategy capable of attenuating these effects is needed. Dexmedetomidine, a highly selective α2-adrenergic receptor (α2-AR) agonist, provides sedative, analgesic, and organ-protective effects, and has been shown to reduce anesthetic requirements while enhancing hemodynamic stability [6]. Among the available delivery routes, intranasal administration is increasingly favored, as it is painless, avoids venipuncture, offers high bioavailability, and provides a rapid onset of action [7].

In this study, we employed a low-dose intranasal regimen of Dexmedetomidine (100 $\mu g \cdot L^{-1}$; 1 mL per nostril; total 100 μg) to preserve its desirable sedative and analgesic effects while limiting dose-dependent adverse events such as bradycardia and hypotension. Previous studies have demonstrated that low-dose intranasal delivery maintains hemodynamic and respiratory stability while reducing the incidence of excessive sedation [7]. Compared with the standard intravenous infusion (0.5-1 $\mu g \cdot kg^{-1} \cdot h^{-1}$), the intranasal route also simplifies peri-operative management and reduces the risk of drug accumulation. For the regional component, epidural anesthesia with ropivacaine was selected. Ropivacaine, a long-acting amide local anesthetic, provides reliable sensory blockade with minimal motor impairment, a prolonged duration of action, and a favorable safety profile [8, 9].

The present study therefore evaluates whether low-dose intranasal dexmedetomidine combined with ropivacaine epidural anesthesia improves analgesia and peri-operative safety in women undergoing laparoscopic ovarian cystectomy. We compared hemodynamic responses, adverse events, and early postoperative recovery between epidural anesthesia alone and low-dose intranasal dexmedetomidine combined with epidural anesthesia, aiming to establish a pragmatic regimen suitable for minimally invasive gynecological surgery.

Information and methodology

Sample size calculation

To evaluate the analgesic efficacy of low dose intranasal dexmedetomidine combined with epidural anesthesia in ovarian cystectomy, we referenced the study by Hetta et al. [10], which demonstrated enhanced analgesic effects of dexmedetomidine in epidural anesthesia. Based on representative outcome data (e.g., VAS pain scores: 1.83 ± 0.75, n = 30 vs. 2.63 ± 0.56, n = 30), a sample size calculation was performed using a two-sample independent t-test (two-sided α = 0.05, 90% statistical power). The effect size (Cohen's d) was 1.208, derived from a pooled standard deviation of 0.6619 and a mean difference of 0.8. Using the sample size formula: $n = [2 * (Z\alpha/2 + Z\beta)^2 * \sigma^2_{pooled}]/(\mu1 - \mu2)^2$, where $Z_{\alpha/2} = 1.96$ (α = 0.05, two-sided), $Z_{\beta} = 1.282$ (90% power), $\sigma_{pooled} = 0.6619$, and μ1 - μ2 = 0.8, the calculation yields approximately 15 subjects per group, resulting in a minimal total sample size of 30. Accounting for a 10% dropout rate, the target sample size was increased to 17 subjects per group, yielding a total of 34 subjects. This sample size ensures 90% statistical power to detect clinically significant differences between groups, consistent with the findings of Hetta et al., who reported that dexmedetomidine combined with epidural anesthesia significantly improved analgesic effects and reduced adverse events.

General information

This retrospective cohort finally included 359 patients who underwent ovarian cyst resection at Xianyang Maternal and Child Health Hospital, Xi'an North Hospital and Affiliated Hospital of Xizang Minzu University between March 2022 and June 2024. Based on our institution's anesthesia protocol timeline, 206 patients who had surgery between March 2022 and June 2023 received ropivacaine epidural anesthesia (control group), whereas 153 patients treated between July 2023 to June 2024 received low-dose intranasal dexmedetomidine combined with ropivacaine epidural anesthesia (observation group).

Inclusion and exclusion criteria

Inclusion criteria: (1) ovarian cyst confirmed by imaging examination and clinical diagnosis [11]; (2) indication for surgical resection; (3) age > 18 years; (4) American Association of Anesthesiologists classification (ASA) grade II-III; (5) no contraindications to laparoscopic surgery; (6) complete clinical data.

Exclusion criteria: (1) history of chronic pain or long-term analgesic use; (2) severe coagulation dysfunction; (3) severe hepatic, renal, or other major organ dysfunction; (4) allergic to the study drug; or (5) psychiatric disorders.

Ethical approval for this retrospective study was Affiliated Hospital of Xizang Minzu University. The requirement for individual informed consent was waived due to the retrospective design.

Anesthesia method

After entering the operating room, peripheral venous access was established, and multifunctional monitors were used to monitor vital signs, including heart rate and mean arterial pressure. The control group received ropivacaine epidural anesthesia. Patients were placed in the chest-knee lateral position, and an epidural puncture was performed at the L2-L3 interspace with an epidural catheter inserted. After confirming the anesthesia plane with 3 mL of 2% lidocaine (Shanghai Hefeng Pharmaceutical Co., Ltd., Approval No. H20023775), 7.5 g/L ropivacaine (Guangdong China Resources Shunfeng Pharmaceutical Co., Ltd., Approval No. H20050325) was infused continuously at a rate of 4-8 mL/h to maintain the anesthesia plane below T10 during surgery, resulting in a total intraoperative dose of 12-15 mg. Intraoperative oxygen was provided via a nasal cannula. Postoperatively, epidural analgesia was maintained using 2 g/L ropivacaine via a patient-controlled analgesia (PCA) pump at a basal rate of 4 mL/h, with a bolus dose of 2 mL (lockout interval: 15 minutes) as needed. The observation group received additional low-dose intranasal dexmedetomidine combined with ropivacaine epidural anesthesia. Before anesthesia induction, dexmedetomidine (100 μg/mL, total dose 100 μg; 1 mL per nostril; Sichuan Meida Kanghuang Pharmaceutical Co., Ltd., Approval No. H20213533) was administered bilaterally via the nasal route. This low-dose regimen was selected to achieve sedation and analgesia while minimizing dose-dependent adverse effects, such as bradycardia and excessive sedation, given the favorable pharmacokinetic profile of intranasal administration. Anesthesia induction, maintenance, and postoperative analgesia with ropivacaine in the observation group were identical to those in the control group. Both groups received the same ropivacaine dosing regimen intraoperatively (7.5 mg/mL at 4-8 mL/h, resulting in an approximate total dose of 30-60 mg depending on surgery duration) and postoperatively to ensure comparability.

Observational indicators

Primary outcomes: (1) Ramsay Sedation Scale (RSS) scores were assessed during anesthesia induction and at the end of surgery to evaluate sedation depth and patient responsiveness [12]; (2) Visual Analog Scale (VAS) pain scores were recorded at 1, 3, 6, and 12 hours postoperatively to monitor pain intensity over time [13]; (3) Bruggrmann Comfort Scale (BCS) scores were recorded at 1, 3, 6, and 12 hours postoperatively to evaluate patient comfort [14].

Secondary outcomes: (1) Surgery- and anesthesia-related parameters that reflect anesthetic efficiency and recovery quality, including operative time, intraoperative blood loss, sedation onset time, awakening time, and extubation time, were recorded [9]; (2) Postoperative adverse events, such as nausea, dizziness, bradycardia, agitation, and chills, were documented to assess the safety profile of the anesthetic regimens [9].

Statistical method

Data were analyzed using Graphpad prism 9.1.1 software and RStudio. Continuous variables conforming to normal distribution were expressed as mean ± standard deviation ($\bar{x}$±sd) and compared using the independent-samples t-test. Non-normally distributed data were presented as median [M (P25, P75)] and analyzed using the Mann-Whitney U rank sum test. Count data were presented as frequency (n) and percentage (%) and compared using the chi-square test. For risk factor analysis, a two-step logistic regression was applied. First, univariate logistic regression was conducted for clinically relevant variables (e.g., age, cyst diameter, intraoperative blood loss, sedation onset time, ASA grade, anesthesia method). Variables with $P < 0.05$ were entered into a multivariate logistic regression model to identify independent predictors of postoperative adverse events. Receiver Operating Characteristic (ROC) curves were used to evaluate

Table 1. Comparison of the baseline data between the two patient groups

Groups	Control group (n = 206)	Observation group (n = 153)	t/χ^2	*P*
Age	40.12±8.00	40.14±7.21	-0.028	0.977
BMI (kg/m^2)	22.77±3.26	22.42±3.69	0.948	0.344
Cyst Diameter (mm)	6.47±1.58	6.43±1.26	0.235	0.814
Diseased position				
Left	83	73	1.970	0.374
Right	88	57		
Bilateral	35	23		
Pathological type				
Serous cyst	57	42	1.652	0.648
Mucocele	49	45		
Endometrial translocated cysts	53	34		
Teratoma	47	32		
ASA classification				
II	137	112	1.853	0.173
III	69	41		
Reproductive history				
Yes	171	134	1.436	0.231
No	35	19		

Note: BMI, Body Mass Index; ASA, American Society of Anesthesiologists classification.

the predictive efficacy of significant indicators. A *P* value < 0.05 was considered statistically significant.

Results

Comparison of baseline data

No significant differences were observed between the groups in baseline characteristics, including age (P = 0.977), body mass index (BMI) (P = 0.344), cyst diameter (P = 0.814), disease location (P = 0.374), pathological classification (P = 0.648), ASA grade (P = 0.173), and obstetric history (P = 00.231) (**Table 1**).

Comparison of sedation effects

At induction and surgery completion, the distribution of RSS scores differed significantly between the groups (P < 0.001). The observation group had a higher proportion of patients with moderate sedation (RSS 2-4: 86.27% and 86.93% vs. 66.02% and 67.48%) and a lower proportion with deep sedation (RSS 5-6: 9.80% and 7.84% vs. 28.64% and 24.76%) compared to the control group (**Table 2**).

Comparison of pain and comfort scores

Postoperative VAS scores showed no significant difference at 1 hour (P = 0.09). However, at 3, 6, and 12 hours, VAS scores were significantly lower in the observation group compared with the control group (P < 0.001) (**Figure 1A**). Within-group analysis revealed a progressive decline in VAS scores over time in both groups, with significant differences between each time point (all P < 0.0001).

BCS scores were significantly higher in the observation group than those in the control group at 1, 3, 6, and 12 hours postoperatively (P < 0.001) (**Figure 1B**). Both groups demonstrated time-dependent improvements in comfort, with significant increases across successive time points (all P < 0.01).

Comparison of surgery-related indicators

Operative time (t = -1.941, P = 0.053) and intraoperative blood loss (37.63 ± 5.06 mL vs. 36.75 ± 5.45 mL; t = 1.579, P = 0.115) did not differ significantly between the two groups. Sedation onset time was significantly shorter in the observation group (8.47 ± 1.51 min vs. 11.85 ± 2.47 min, t = 15.014, P < 0.001). Awakening time was longer in the observation group (13.58 ± 2.69 min vs. 11.42 ± 1.51 min, t = -9.647, P < 0.001), consistent with the sedative effects of dexmedetomidine. Extubation time, however, was shorter in the observation

Table 2. Comparison of Ramsay scores between the two groups at the time of induction and completion of surgery

Groups	Induction			Operation completion		
	1 Point	2-4 Points	5-6 Points	1 Point	2-4 Points	5-6 Points
Control group (n = 206)	11 (5.34)	136 (66.02)	59 (28.64)	16 (7.77)	139 (67.48)	51 (24.76)
Observation group (n = 153)	6 (3.92)	132 (86.27)	15 (9.80)	8 (5.23)	133 (86.93)	12 (7.84)
χ^2		20.312			19.542	
P		< 0.001			< 0.001	

Note: RSS, Ramsay Sedation Score.

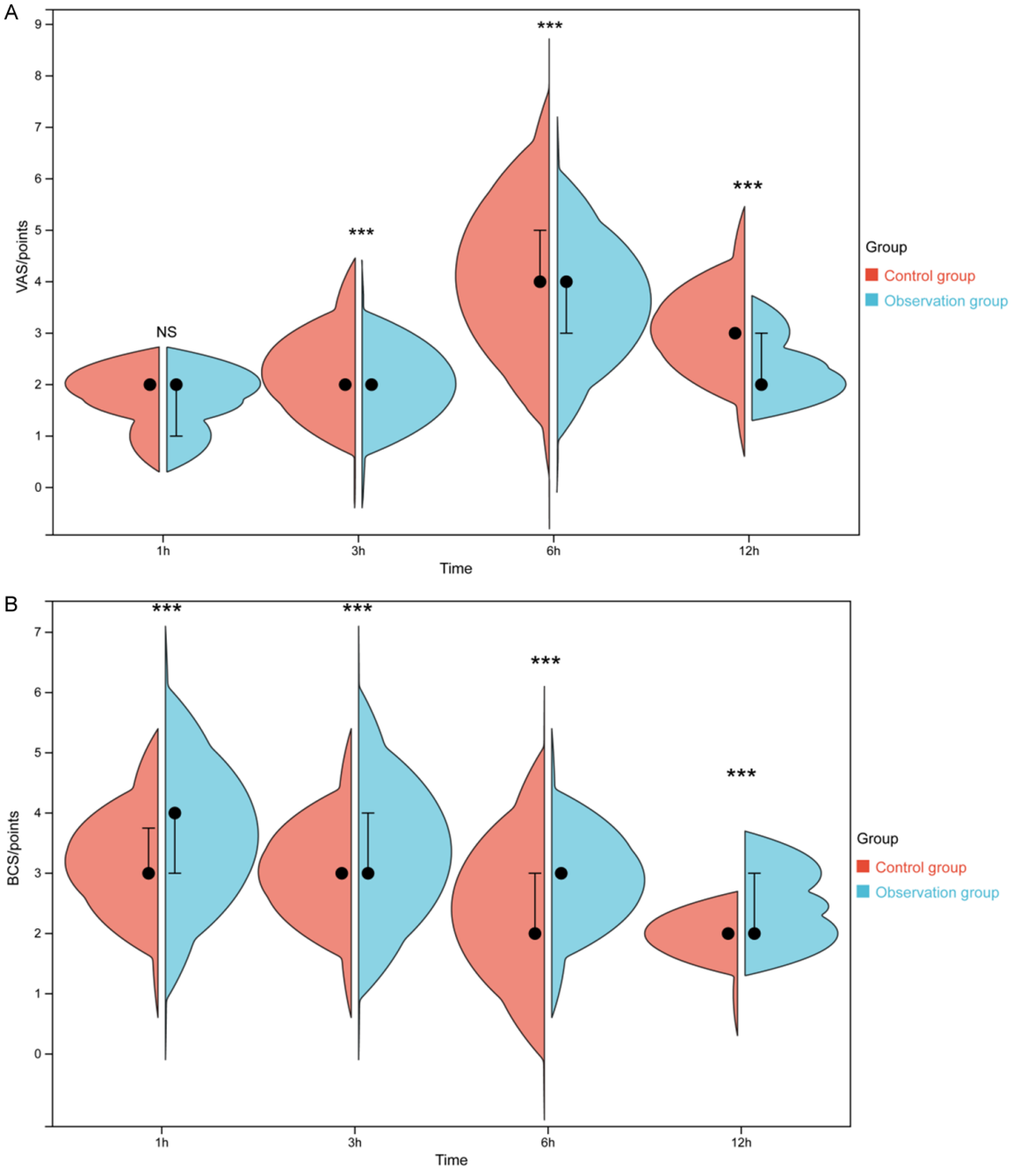

Figure 1. Comparison of VAS and BCS scores between the two groups at various time points. A. Comparison of VAS scores at 1 h, 3 h, 6 h and 12 h between the two groups. B. Comparison of BCS scores at 1 h, 3 h, 6 h and 12 h between the two groups. Note: VAS, Visual Analog Scale; BCS, Bruggrmann Comfort Scale; ns P > 0.05, ***P < 0.001.

Table 3. Comparison of operation time, intraoperative blood loss, sedation onset time, wake up time and extubation time between the two groups

Groups	Operation time	Blood loss	Sedation onset time	Wake up time	Extubation time
Control group (n = 206)	44.29±6.81	37.63±5.06	11.85±2.47	11.42±1.51	18.54±3.03
Observation group (n = 153)	45.75±7.38	36.75±5.45	8.47±1.51	13.58±2.69	15.07±2.98
χ^2	-1.941	1.579	15.014	-9.647	10.808
P	0.053	0.115	< 0.001	< 0.001	< 0.001

Table 4. Comparison of the incidence of postoperative adverse reactions between the two groups

Groups	Adverse reactions					Overall incidence
	Nausea and vomiting	Dizziness	Bradycardia/ tachycardia	Agitation	Chills/ groaning	
Control group (n = 206)	16	13	6	9	7	41 (19.90%)
Observation group (n = 153)	6	5	3	7	3	12 (7.84%)
χ^2						10.151
P						0.001

group (15.07 ± 2.98 min vs. 18.54 ± 3.03 min, t = 10.808, P < 0.001) (**Table 3**).

Comparison of postoperative adverse effects

The incidence of adverse events (7.84%, 12/153) was significantly lower in the observation group than that in the control group (19.90%, 41/206) (t = 10.151, P = 0.001). Reported adverse events included nausea/vomiting (6 vs. 16), dizziness (5 vs. 13), bradycardia/tachycardia (3 vs. 6), agitation (7 vs. 9), and chills/groaning (3 vs. 7) (**Table 4**).

Comparison of baseline data between patients with and without postoperative adverse effects

Patients were divided into those with (n = 53) and without (n = 306) postoperative adverse events. Compared with the non-adverse event group, the age (45.00 ± 7.22 years vs. 39.31 ± 7.30 years), cyst diameter (7.45 ± 1.17 mm vs. 6.28 ± 1.38 mm), intraoperative blood loss (40.73 ± 4.53 mL vs. 36.52 ± 5.18 mL), and ASA grade were significantly higher in the adverse event group (all P < 0.05). In addition, the proportion of patients receiving programmed intermittent epidural bolus (PIEB) alone was higher in the adverse event group (χ^2 = 10.147, P < 0.05). No significant differences were found in BMI, disease location, pathological classification, obstetric history, operative time, sedation onset, awakening, or extubation times (all P > 0.05) (**Table 5**).

Logistic regression analysis of risk factors for adverse effects

Logistic regression was performed with post operative adverse events (0 = none, 1 = occurrence) as the dependent variable. Univariate analysis identified age (OR = 1.107, P < 0.001), cyst diameter (OR = 1.787, P < 0.001), intraoperative blood loss (OR = 1.138, P < 0.001), sedation onset time (OR = 0.862, P = 0.022), ASA grade (OR = 0.298, P < 0.001), and anesthesia method (OR = 0.343, P = 0.002) as associated factors (**Table 6**). Multivariate analysis confirmed that higher age (OR = 1.111, P < 0.001), larger cyst diameter (OR = 1.731, P < 0.001), and greater intraoperative blood loss (OR = 1.169, P < 0.001) were associated with increased risk of postoperative adverse events. In contrast, patients with ASA II (compared with ASA III) showed a protective association (OR = 0.345, P = 0.003), and the combined use of intranasal dexme-

Table 5. Comparison of baseline data of patients between patients with and without adverse effects after surgery

Groups	Occurrence group (n = 306)	No-occurrence group (n = 53)	t/χ^2	*P*
Age	45.00±7.22	39.31±7.30	5.249	< 0.001
BMI (kg/m^2)	23.21±3.20	22.46±3.55	1.539	0.128
Cyst Diameter (mm)	7.45±1.17	6.28±1.38	6.487	< 0.001
Cyst location				
Left	137	19	1.561	0.458
Right	120	25		
Bilateral	49	9		
Pathological type				
Serous cyst	83	16	0.709	0.871
Mucocele	81	13		
Endometrial translocated cysts	76	11		
Teratoma	66	13		
ASA classification				
II	225	24	16.960	< 0.001
III	81	29		
Reproductive history				
Yes	264	41	2.810	0.094
No	42	12		
Operative time	45.37±7.09	45.09±7.19	0.263	0.793
Intraoperative blood loss	40.73±4.53	36.52±5.18	6.068	< 0.001
Effective sedation	9.39 [8.00, 10.57]	9.59 [8.22, 11.70]	-1.516	0.130
Wake up time	12.63 [10.44, 14.61]	12.52 [10.95, 14.11]	-0.137	0.891
Extubation time	16.41±2.94	16.57±3.53	-0.344	0.732
Anesthesia mode				
Epidural anesthesia	165	41	10.147	0.001
Intranasal dexmedetomidine combined with epidural anesthesia	141	12		

Note: BMI, Body Mass Index; ASA, American Society of Anesthesiologists classification.

Table 6. Univariate logistic analysis of factors associated with postoperative adverse effects

Variable	β	S.E.	P	OR	95% CI	
					Lower	Upper
Age	0.102	0.022	0.000	1.107	1.061	1.158
BMI	0.062	0.043	0.149	1.064	0.979	1.159
Cyst diameter	0.581	0.122	0.000	1.787	1.417	2.290
Operative time	0.006	0.021	0.789	1.006	0.965	1.048
Intraoperative blood loss	0.130	0.031	0.000	1.138	1.073	1.212
Sedation onset time	-0.149	0.065	0.022	0.862	0.755	0.974
Wake up time	0.080	0.058	0.171	1.083	0.965	1.215
Extubation time	-0.044	0.044	0.309	0.957	0.878	1.041
Cyst location	0.186	0.203	0.358	1.205	0.806	1.789
Pathological classification	-0.010	0.134	0.941	0.990	0.760	1.287
ASA grade	-1.211	0.305	0.000	0.298	0.163	0.540
Reproductive history	-0.610	0.368	0.097	0.544	0.270	1.156
Type of anesthesia	-1.071	0.348	0.002	0.343	0.167	0.658

Note: β, Regression Coefficient; S.E., Standard Error; OR, Odds Ratio; CI, Confidence Interval.

detomidine with epidural anesthesia (compared with epidural anesthesia alone) also demonstrated a protective effect (OR = 0.196, P = 0.003) (**Table 7**).

Table 7. Multivariate logistics-analysis affecting the occurrence of postoperative adverse effects in patients

Variable	β	S.E.	P	OR	95% CI	
					Lower	Upper
Age	0.105	0.026	0.000	1.111	1.058	1.171
Cyst diameter	0.548	0.148	0.000	1.731	1.308	2.342
Intraoperative blood loss	0.156	0.038	0.000	1.169	1.088	1.263
Sedation onset time	-0.089	0.102	0.382	0.915	0.747	1.114
ASA grade	-1.064	0.354	0.003	0.345	0.171	0.689
Type of anesthesia	-1.629	0.549	0.003	0.196	0.063	0.549

Note: β, Regression Coefficient; S.E., Standard Error; OR, Odds Ratio; CI, Confidence Interval.

Table 8. ROC curve analysis of independent prognostic factors

Marker	AUC	Cut off	Specificity	Sensitivity	Youden index
Age	0.717	43.5	72.88%	62.26%	35.14%
Cyst diameter	0.772	6.575	57.19%	83.02%	40.21%
Intraoperative blood loss	0.732	38	59.48%	77.36%	36.84%
ASA grade	0.641	-	73.53%	54.72%	28.25%
Type of anesthesia	0.617	-	46.08%	77.36%	23.44%

Note: ROC, Receiver Operating Characteristic curve; AUC, Area Under the Curve; ASA, American Society of Anesthesiologists classification.

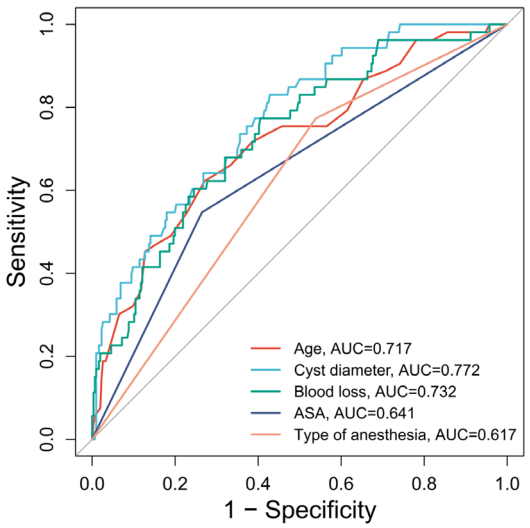

Figure 2. ROC curves for each independent factor for predicting postoperative adverse events. Note: ROC, Receiver Operating Characteristic; AUC, Area Under the Curve; ASA, American Society of Anesthesiologists classification.

Evaluation of independent prognostic factors

ROC curve analysis demonstrated that age (AUC = 0.717, cutoff = 43.5 years, sensitivity = 62.26%, specificity = 72.88%, Youden index = 35.14%), cyst diameter (AUC = 0.772, cutoff = 6.575 mm, sensitivity = 83.02%, specificity = 57.19%, Youden index = 40.21%), and intraoperative blood loss (AUC = 0.732, cutoff = 38 mL, sensitivity = 77.36%, specificity = 59.48%, Youden index = 36.84%) had relatively high predictive efficacy for postoperative adverse events. By contrast, ASA grade (AUC = 0.641, sensitivity = 54.72%, specificity = 73.53%, Youden index = 28.25%) and anesthesia method (AUC = 0.617, sensitivity = 77.36%, specificity = 46.08%, Youden index = 23.44%) showed lower discriminatory power for clinical application (**Table 8**; **Figure 2**).

Discussion

Ovarian cysts are a prevalent gynecological disorder in clinical practice, particularly affecting young and middle-aged women. These lesions may affect unilateral or bilateral ovaries and, when large, can cause urinary symptoms such as bladder pressure, frequent urination, urgency, and voiding difficulties [15]. Surgical intervention remains the gold standard for ovarian cyst management, with laparoscopic cystectomy being preferred for its minimal invasive nature and enhanced postoperative recovery [16, 17].

Selecting an appropriate anesthetic technique is fundamental to surgical success, while effective postoperative analgesia is equally critical for attenuating surgical stress responses and accelerating patient recovery [18]. The present investigation evaluated the analgesic efficacy and safety of low-dose intranasal dexmedetomidine combined with epidural anesthesia in patients undergoing ovarian cyst resection, and further explored factors influencing postoperative complications.

Our findings demonstrate that the observation group exhibited a significantly lower proportion of patients achieving deep sedation (RSS 5-6) during induction and at surgery completion, compared to control group, indicating that intranasal dexmedetomidine combined with epidural anesthesia provides stable and appropriate sedation. Regarding pain assessment, VAS scores were comparable at 1-hour postoperatively; however, the observation group showed significantly lower pain scores at 3, 6, and 12 hours. Concurrently, BCS scores were consistently higher across all postoperative time points in the observation group. These results underscore the synergistic benefits of dexmedetomidine-epidural combination therapy in enhancing sedation quality, optimizing pain control, and improving overall patient comfort in ovarian cystectomy.

The observation group demonstrated faster sedation onset and extubation times, though awakening time was prolonged compared to controls. This profile is consistent with the unique pharmacological characteristics of dexmedetomidine. Epidural anesthesia exerts its effects by interrupting spinal afferent nerve pathways, thereby inhibiting ascending reticular activation and producing anesthesia. Nevertheless, complications including hypotension, bradycardia, and excessive sedation remain common concerns [19, 20].

Li et al. reported that ropivacaine epidural anesthesia alone in abdominal surgery yielded suboptimal anesthetic outcomes, with inadequate RSS scores postoperatively, highlighting the advantages of adjuvant sufentanil administration [8]. Dexmedetomidine, a highly selective α2-adrenergic receptor agonist, provides sedation through brainstem α2 receptor activation while inhibiting spinal pain transmission. Its favorable hemodynamic profile enhances intraoperative stability and recovery performance [21, 22]. Previous evidence further indicates that dexmedetomidine attenuates perioperative stress responses, reduces airway reactivity, and facilitates smooth extubation [23]. Zhao's investigation revealed that combined ropivacaine-dexmedetomidine therapy resulted in a prolonged duration of sensory and motor blockade compared to epidural anesthesia with ropivacaine alone [20]. Wang et al. similarly reported that ropivacaine-dexmedetomidine combination provided safe and effective anesthesia in vaginal delivery and cesarean sections, with particular benefit in hypertensive patients [24]. These findings corroborate our results and validate the clinical utility of dexmedetomidine-ropivacaine combinations in ovarian cyst surgery.

Postoperative adverse events were significantly less frequent in the observation group (7.84% vs. 19.90%), mainly including nausea, dizziness, cardiac rhythm disturbances, agitation, and chills/groaning. Dexmedetomidine produces dose-dependent, reversible sedation with minimal respiratory depression, facilitating natural awakening patterns that distinguish it from conventional sedatives [25]. Liu et al. compared midazolam with dexmedetomidine in patients undergoing laparoscopic ovarian cancer surgery and reported superior hemodynamic stability and lower IL-6 levels in the dexmedetomidine group, suggesting effective postoperative stress modulation [26]. Furthermore, dexmedetomidine's anxiolytic properties reduce postoperative anxiety and discomfort, thereby minimizing agitation and related complications [23]. The multimodal analgesic strategy combining dexmedetomidine with ropivacaine addresses pain pathways through complementary mechanisms, while reducing drug-specific adverse effects [27]. Clinical evidence demonstrates inferior efficacy of ropivacaine monotherapy compared to comprehensive epidural approaches [20]. Additionally, dexmedetomidine enhances hemodynamic stability by minimizing postoperative cardiovascular fluctuations, potentially reducing incidence of adverse events [28, 29].

Several factors demonstrated strong associations with postoperative adverse reactions, including patient age, cyst diameter, intraoperative blood loss, ASA classification, and anes-

thetic methodology. Age-related physiological deterioration, including reduced metabolic capacity and drug tolerance, increases complication risks [30]. Larger cysts often necessitate extended operative duration and extensive dissection, thereby elevating bleeding and infection risks [31]. Intraoperative blood loss is a critical determinant, as significant hemorrhage may precipitate anemia, immune dysfunction, and delayed recovery [32]. Higher ASA scores reflect increased comorbidity burden and compromised baseline health status, correlating with elevated adverse event risks [33].

ROC analysis revealed moderate predictive capability for age, cyst diameter, and intraoperative blood loss (AUC 0.6-0.8), demonstrating reasonable diagnostic utility for high-risk patient identification. While individual indicators with moderate AUC values cannot serve as standalone clinical decision-making tools, they function effectively as preoperative warning signals. Values exceeding established thresholds should trigger comprehensive anesthetic assessment and enhanced perioperative monitoring. Integration of these predictive variables with ASA classification, anesthetic technique, and additional clinical parameters into comprehensive multivariable models or composite scoring systems may further improve risk stratification and guide individualized anesthesia protocols and analgesic strategies.

Despite the encouraging outcomes, several limitations should be acknowledged. The single-center retrospective design may have introduced selection bias. Follow-up was restricted to immediate postoperative periods, without long-term recovery evaluation. Although the sample size was substantial, external validity requires multicenter validation. Future prospective investigations with expanded cohorts and extended monitoring periods are necessary to confirm and extend these findings.

Conclusion

This investigation demonstrates that low-dose intranasal dexmedetomidine combined with epidural anesthesia delivers effective analgesia with enhanced safety profiles in patients undergoing ovarian cyst resection. The combination approach reduces postoperative complications while improving patient comfort compared to epidural anesthesia alone. Multivariate analysis identified age, cyst diameter, and intraoperative blood loss as independent predictors of postoperative adverse events, with anesthetic modality and ASA classification providing additional risk stratification value.

Disclosure of conflict of interest

None.

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