Am J Transl Res 2025;17(6):4409-4420
www.ajtr.org /ISSN:1943-8141/AJTR0165574

Original Article

Dexmedetomidine combined with propofol improves hemodynamic stability and recovery in elderly patients undergoing thoracoscopic lung cancer resection

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Received April 23, 2025; Accepted May 27, 2025; Epub June 15, 2025; Published June 30, 2025

Abstract: Objective: To evaluate the effects of dexmedetomidine combined with propofol versus propofol alone on intraoperative hemodynamic stability and postoperative recovery in elderly patients undergoing thoracoscopic lung cancer resection. Methods: This retrospective comparative study included 123 patients aged ≥ 65 years scheduled for thoracoscopic lung cancer resection. Patients were divided into two groups: the dexmedetomidine-propofol group (observation group, n = 61) and the propofol-only group (control group, n = 62). Hemodynamic parameters - heart rate (HR), mean arterial pressure (MAP), systolic blood pressure (SBP), and diastolic blood pressure (DBP) - were recorded at predefined time points. Postoperative recovery times, stress and inflammatory markers (tumor necrosis factor-alpha [TNF-α], interleukin-6 [IL-6]), adverse events, sedation scores, and pain scores were assessed. Multivariable regression and subgroup analyses were conducted to identify independent treatment effects and explore heterogeneity across patient subgroups. Results: The observation group demonstrated significantly more stable hemodynamic profiles, with lower HR, MAP, SBP, and DBP fluctuations across time points (all $P < 0.05$). Postoperative awakening and orientation recovery times were significantly shorter in the observation group (both $P < 0.05$). Levels of norepinephrine, epinephrine, TNF-α, and IL-6 were significantly lower postoperatively in the observation group (all $P < 0.05$). Incidences of respiratory depression and nausea/vomiting were also reduced (all $P < 0.05$). Multivariable analysis confirmed the independent benefit of the combined regimen. Subgroup analyses revealed greater efficacy in patients with ASA class II and those over 75 years of age. Conclusion: The combination of dexmedetomidine and propofol enhances intraoperative hemodynamic stability, accelerates recovery, reduces perioperative stress and inflammation, and lowers the incidence of adverse events in elderly patients undergoing thoracoscopic lung cancer resection. These results support its clinical value, particularly in high-risk subpopulations. Further studies are needed to refine dosing strategies and optimize safety.

Keywords: Dexmedetomidine, propofol, thoracoscopic lung cancer resection, hemodynamic stability, post-operative recovery quality

Introduction

Lung cancer remains a major global health burden, with surgical resection serving as a cornerstone treatment for eligible patients [1]. Thoracoscopic lung cancer resection has gained widespread adoption due to its minimally invasive nature, offering advantages such as reduced postoperative pain, shorter hospital stays, and quicker recovery compared to traditional open surgery [2]. However, this procedure poses particular challenges in elderly patients, who often exhibit diminished physiological reserve and lower tolerance to surgical stress.

Age-related declines in cardiovascular, respiratory, and neurological function render elderly patients more vulnerable to intraoperative and postoperative complications [3]. These changes can lead to marked hemodynamic instability during anesthesia, increasing the risk of adverse outcomes such as myocardial ischemia, arrhythmias, and postoperative cognitive dysfunction [4]. Therefore, maintaining hemodynamic stability and facilitating smooth recov-

https://doi.org/10.62347/XCOK4904

ery are critical goals in this population, with anesthesia management playing a central role.

Propofol, a widely used intravenous anesthetic, is favored for its rapid onset and short duration of action. However, it can cause dose-dependent cardiovascular depression - including hypotension and bradycardia - which is especially concerning in elderly patients [5]. Moreover, propofol alone may provide inadequate analgesia, potentially triggering sympathetic activation and further hemodynamic fluctuations [6].

Dexmedetomidine, a highly selective α_2-adrenergic agonist, has emerged as a valuable adjunct in anesthesia practice [7]. It provides sedation, analgesia, and anxiolysis with minimal respiratory depression [8]. By reducing central sympathetic outflow through α_2 receptor activation, dexmedetomidine promotes hemodynamic stability. It has also been shown to blunt the stress response to tracheal intubation, surgical stimulation, and emergence from anesthesia, thereby potentially lowering postoperative complication rates. While previous studies have reported benefits of dexmedetomidine - alone or in combination with propofol - in various surgical contexts [9], its specific effects in elderly patients undergoing thoracoscopic lung cancer resection remain underexplored.

This study aimed to compare the effects of dexmedetomidine combined with propofol versus propofol alone on intraoperative hemodynamic stability and postoperative recovery in elderly patients undergoing thoracoscopic lung cancer resection. The findings may offer valuable guidance for optimizing anesthetic strategies and improving perioperative care in this high-risk population.

Materials and methods

Study design and patient selection

This retrospective comparative study was conducted at The First Affiliated Hospital of Jinan University between January 2020 and January 2023. A total of 123 elderly patients (age ≥ 65 years) scheduled for thoracoscopic lung cancer resection were included. Based on the anesthesia regimen, patients were assigned to either the dexmedetomidine combined with propofol group (observation group, n = 61) or the propofol-only group (control group, n = 62).

Inclusion criteria: (1) Pathologically confirmed non-small cell lung cancer, clinical stage I-IIIA (American Joint Committee on Cancer 8th edition) [10] deemed resectable by a multidisciplinary team; (2) American Society of Anesthesiologists (ASA) physical status classification I or II [11].

Exclusion criteria: (1) Other malignancies; (2) Severe hepatic or renal dysfunction, hematologic disorders, or autoimmune disease; (3) Psychiatric illness; (4) Immunodeficiency or recent use of immunosuppressants; (5) Coagulopathy; (6) Use of corticosteroids or anticoagulants within the past 2 months.

Sample size was determined using G*Power 3.1 [1]. With an assumed effect size (Cohen's d) of 0.5 for the primary outcome (hemodynamic stability), $\alpha = 0.05$, and power = 0.8, the minimum required sample size was 64 per group. Considering a 10% attrition rate, 70 patients per group were initially enrolled. After applying inclusion/exclusion criteria, 61 and 62 patients remained in the observation and control groups, respectively, which was sufficient for statistical power.

Anesthesia protocol

All patients received standardized preoperative preparation, including 12-hour fasting and an intramuscular injection of atropine sulfate (0.5 mg; Tianjin Heping Pharmaceutical Co., China; Batch No. H12020382, 1 mL: 0.5 mg) before surgery.

Upon entering the operating room, patients were administered oxygen via mask at 4 L/min. Venous access was established, and lactated Ringer's solution (Sichuan Kelun Pharmaceutical Co., China; Batch No. H20055488, 500 mL) was infused at 5 mL/kg (max 500-1000 mL) to maintain fluid-electrolyte balance.

Vital signs, including mean arterial pressure (MAP), were continuously monitored (Philips Medizin Systeme, Germany; Model 866066). Anesthesia induction included intravenous midazolam (0.04 mg/kg, max 5 mg; Yichang Humanwell Pharmaceutical Co., Batch No. H20067040, 2 mL: 2 mg) and alfentanil hydrochloride (20 μg/kg, max 25 μg/kg; Batch No. H20203054, 2 mL: 1 mg).

After successful induction, endotracheal intubation was performed, and mechanical ventilation was initiated with a tidal volume of 10 mL/kg and a respiratory rate of 10 breaths/min. Oxygen saturation (SpO_2) was maintained above 98%.

Anesthesia maintenance: Control group: Propofol (1.5-2.5 mg/kg bolus; 5.0 mg/kg/h infusion; Zhongshan Huangpu Huaqiao Pharmaceutical Co., Batch No. H20013267). Observation group: Propofol (3.0 mg/kg/h infusion, max 12 mg/kg/h) + dexmedetomidine (0.2 μg/kg/h, max 4 μg/kg/h; Yangtze River Pharmaceutical Group, Batch No. H20183219, 2 mL: 0.2 mg). All anesthetic agents were discontinued 30 minutes before the end of surgery.

Intraoperative management: Hypotension (SBP < 90 mmHg): IV ephedrine hydrochloride (6 mg; Northeast Pharmaceutical Group, Batch No. H21022412, 1 mL: 30 mg). Respiratory depression (SpO_2 < 90%): Positive pressure mask ventilation. Insufficient analgesia: Sufentanil citrate (0.1 μg/kg, max 8-30 μg/kg; Jiangsu Nhwa Pharmaceutical Co., Batch No. H2020-3650, 1 mL: 50 μg).

Outcome measures

Hemodynamic parameters: Heart rate (HR), MAP, systolic blood pressure (SBP), and diastolic blood pressure (DBP) were recorded at T_0 (before induction), T_1 (5 min post-induction), T_2 (immediately post-extubation), and T_3 (5 min post-extubation) [12].

Recovery characteristics: Time to consciousness recovery, time to orientation recovery, and incidence of emergence agitation were documented [13].

Biomarkers: Serum norepinephrine, epinephrine, tumor necrosis factor-α (TNF-α), and interleukin-6 (IL-6) were measured using the following kits: Norepinephrine: Eagle Biosciences (Lot NE-1001-01) [14]; Epinephrine: Rocky Mountain Diagnostics (Lot EPI-2205) [15]; TNF-α: R&D Systems (Lot DTA00D) [16]; IL-6: Abcam (Lot ab46027) [17].

Adverse events: Bradycardia, respiratory depression, cough, movement, nausea, vomiting, were recorded based on the Common Terminology Criteria for Adverse Events guidelines [18].

Sedation and pain scores: Ramsay Sedation Scale (RSS) [19]: Before and 6 hours post-surgery; scores 2-4 indicate adequate sedation. Visual Analog Scale (VAS) [20]: Pain was scored from 0 (no pain) to 10 (worst pain), assessed before and 6 hours postoperatively. A higher score indicated more severe pain.

Statistical analysis

All analyses were performed using SPSS version 23.0. Continuous variables presented as mean ± standard deviation were compared using independent-samples t-tests, while categorical variables expressed as counts and rates, were compared using chi-square tests. For intra-group and inter-group comparisons over time, repeated measures analysis of variance (ANOVA) with Greenhouse-Geisser correction was employed to address violations of the sphericity assumption. When significant main effects or interaction effects were detected, post-hoc pairwise comparisons were performed using the Bonferroni method to control for the increased Type I error rate associated with multiple testing.

Univariate linear regression identified potential predictors of hemodynamic changes and recovery outcomes. Variables with $P < 0.10$ or clinical relevance (treatment group, age, ASA class) were included in the multivariable linear regression model. Adjusted analyses included covariates such as age, BMI, and ASA classification.

Subgroup analyses were conducted based on age (≤ 75 vs. > 75 years), ASA class (I vs. II), sex (male vs. female), and BMI (< 22 vs. ≥ 22 kg/m^2). Interaction terms were tested to assess heterogeneity of treatment effects. Statistical significance was set at $P < 0.05$.

Results

Comparison of general information

There were no statistically significant differences between the two groups in terms of gender distribution, age, BMI, or lesion diameter (all $P > 0.05$), confirming baseline comparability (**Table 1**).

Comparison of hemodynamic indicators at different time points

Hemodynamic indicators, including HR, MAP, SBP, and DBP, were compared between the observation and control groups at multiple time

Table 1. General information of the two groups of patients

Item	Observation Group	Control Group	χ^2/t value	*P*-value
Male/Female (cases)	35/26	33/29	0.139	0.71
Age (years, x±s)	73.12±4.89	72.38±5.02	0.492	0.625
Body Mass Index (kg/m^2, x±s)	22.35±1.92	21.98±2.13	0.503	0.614
Lesion Diameter (cm, x±s)	2.52±0.73	2.48±0.69	0.428	0.668
ASA Grading - Grade I (cases, %)	32 (52.46)	30 (48.39)	0.041	0.839
ASA Grading - Grade II (cases, %)	29 (47.54)	32 (51.61)		
Pathological Types - Adenocarcinoma (cases, %)	38 (62.30)	34 (54.84)	0.337	0.563
Pathological Types - Squamous Carcinoma (cases, %)	23 (37.70)	28 (45.16)		

Note: ASA: American Society of Anesthesiologists.

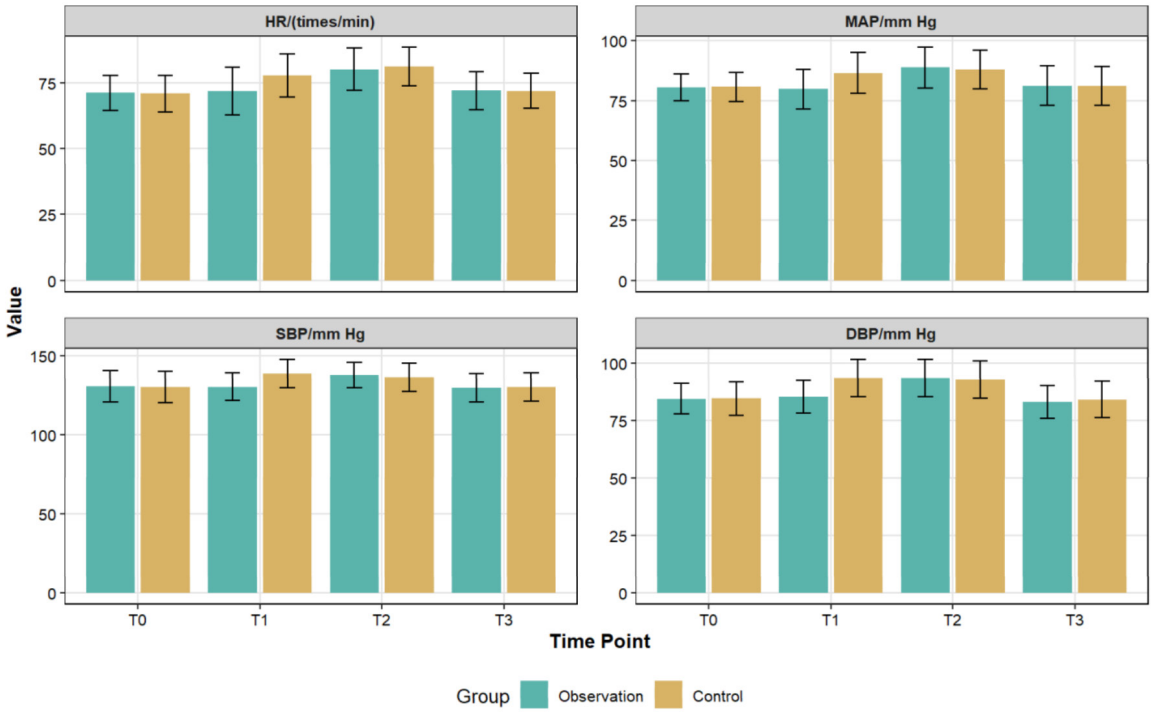

Figure 1. Comparison of hemodynamic indicators of the two groups. HR: heart rate, MAP: mean arterial pressure, SBP: systolic blood pressure, DBP: diastolic blood pressure.

points. Significant differences were observed in all four parameters across the perioperative period (all P < 0.05), indicating better hemodynamic stability in the observation group (**Figure 1**; **Table 2**).

Comparison of postoperative recovery parameters

The observation group showed significantly shorter awakening and orientation recovery times compared to the control group (both P < 0.01), indicating improved postoperative recovery. However, no significant difference was found in the incidence of agitation during the recovery period between the two groups (t = 0.632, P = 0.442, **Figure 2**; **Table 3**).

Comparison of biochemical markers before and after surgery

All patients showed significant postoperative increases in norepinephrine, epinephrine, TNF-α, and IL-6 levels (all P < 0.001). However, the magnitude of these increases was significantly lower in the observation group compared to the control group (all P < 0.001), indicating a reduced stress and inflammatory response

Table 2. Comparison of hemodynamic indicators of the two groups

Group		Observation Group	Control Group	t	*P*-value	F	*P*-value
HR/(times/min)	T0	71.23±6.72	70.93±6.87	0.033	0.974	3.21	0.025
	T1	71.94±9.07	77.78±8.22	-3.740	0.000		
	T2	80.12±8.07	81.23±7.32	-0.730	0.467		
	T3	72.08±7.23	71.99±6.72	0.060	0.952		
MAP/mm Hg	T0	80.48±5.62	80.73±6.17	-0.170	0.865		
	T1	79.83±8.27	86.48±8.57	-4.420	0.000	2.89	0.038
	T2	88.83±8.47	87.98±7.97	0.570	0.570		
	T3	81.23±8.27	81.13±8.17	0.070	0.944		
SBP/mm Hg	T0	130.48±9.97	129.99±9.87	0.270	0.787		
	T1	130.23±8.87	138.48±8.97	-5.480	0.000	3.05	0.03
	T2	137.68±8.17	136.23±8.82	0.960	0.339		
	T3	129.53±8.99	130.13±8.99	-0.390	0.697		
DBP/mm Hg	T0	84.53±6.67	84.68±7.22	-0.100	0.920	4.12	0.01
	T1	85.33±7.17	93.48±8.07	-5.420	0.000		
	T2	93.58±8.07	93.03±8.17	0.360	0.720		
	T3	83.23±7.07	84.28±8.07	0.620	0.537		

Note: HR: heart rate, MAP: mean arterial pressure, SBP: systolic blood pressure, DBP: diastolic blood pressure.

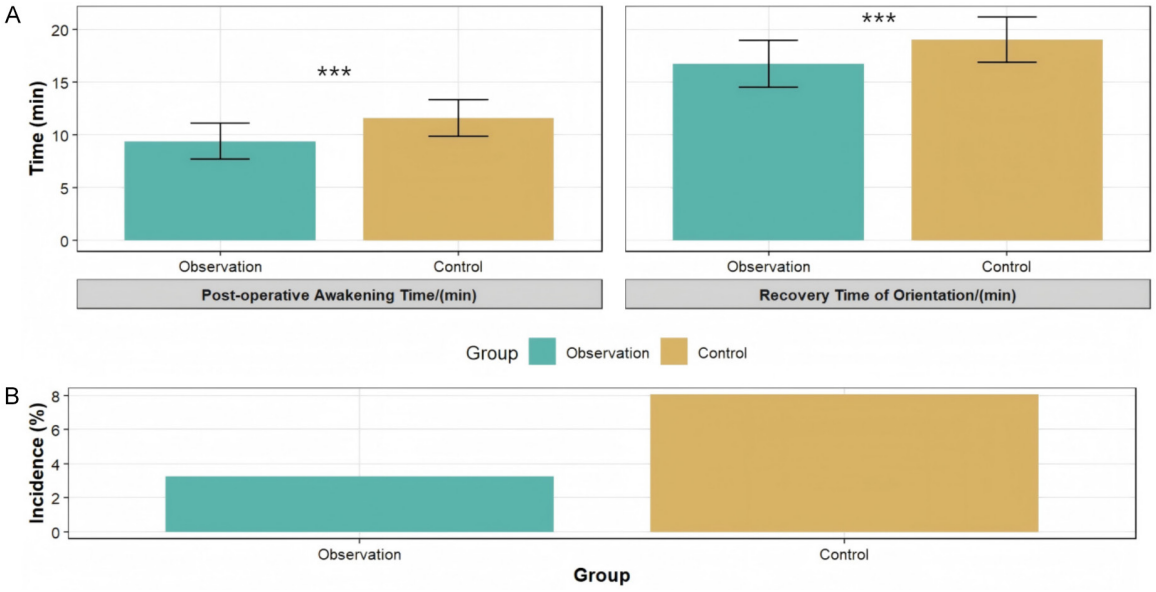

Figure 2. Comparison of post-operative awakening-related indicators between different groups. A. Comparison of post-operative awakening-related indicators. B. Incidence of agitation during awakening period. ***P < 0.001.

associated with dexmedetomidine combined with propofol (**Figure 3**; **Table 4**).

Comparison of adverse events

Significant differences in adverse reactions were observed between the two groups. The incidence of respiratory depression and nausea/vomiting was significantly lower in the observation group compared to the control group (all P < 0.05). No significant differences were found in the rates of bradycardia, choking cough, or body movement (all P > 0.05, **Table 5**).

Comparison of sedation and pain scores (RSS and VAS)

There were no significant differences in preoperative RSS or VAS pain scores between the

Table 3. Comparison of post-operative awakening-related indicators between different groups

Group	Post-operative Awakening Time/(min)	Recovery Time of Orientation/(min)	Incidence of Agitation during Awakening Period (%)
Observation Group	9.37±1.69	16.73±2.23	2 (3.27)
Control Group	11.57±1.74	18.97±2.16	5 (8.06)
χ^2/t value	-6.832	-5.481	0.632
P-value	0.001	0.001	0.442

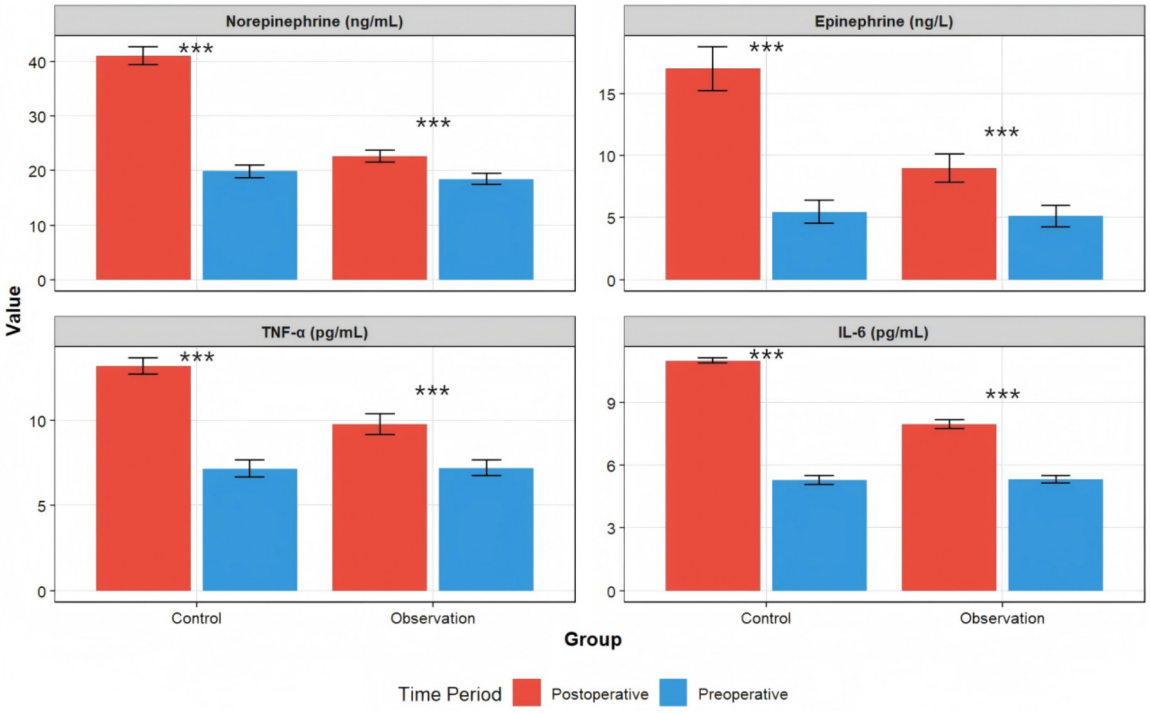

Figure 3. Comparison of Biochemical Indices between groups. ***P < 0.001. TNF-α: Tumor necrosis factor-α, IL-6: interleukin-6.

Table 4. Comparison of biochemical indicators between and within groups

Biomarker	Group	Preoperative (Mean ± SD)	Post-operative (Mean ± SD)	Δ (Post-Pre)	Intra-group *P*-value	Inter-group *P*-value (Δ)
Norepinephrine (ng/mL)	Observation	18.42±1.02	22.63±1.12	+4.21±0.51	< 0.001	< 0.001
	Control	19.87±1.15	41.07±1.65	+21.20±1.32	< 0.001	
Epinephrine (ng/L)	Observation	5.13±0.87	8.97±1.13	+3.84±0.72	< 0.001	< 0.001
	Control	5.45±0.92	16.99±1.75	+11.54±1.24	< 0.001	
TNF-α (pg/mL)	Observation	7.22±0.45	9.79±0.62	+2.57±0.38	< 0.001	< 0.001
	Control	7.18±0.49	13.19±0.48	+6.01±0.43	< 0.001	
IL-6 (pg/mL)	Observation	5.33±0.18	7.97±0.22	+2.64±0.15	< 0.001	< 0.001
	Control	5.28±0.21	10.99±0.13	+5.71±0.19	< 0.001	

Note: TNF-α: Tumor necrosis factor-α, IL-6: interleukin-6.

two groups (both P > 0.05). At 6 hours postoperatively, the observation group showed significantly higher RSS scores and lower VAS scores, indicating deeper sedation and better pain control (both P < 0.01). These findings suggest that the combination of dexmedetomidine and propofol provides more effective postoperative sedation and analgesia (**Table 6**; **Figure 4**).

Table 5. Comparison of adverse reactions between the observation group and the control group

Group	Bradycardia	Respiratory Depression	Choking Cough	Body Movement	Nausea and Vomiting
Observation Group	8 (13.11%)	1 (1.64%)	2 (3.28%)	4 (6.56%)	2 (3.28%)
Control Group	10 (16.13%)	10 (16.13%)	6 (9.68%)	7 (11.29%)	10 (16.13%)
χ^2 value	0.322	7.341	0.673	0.492	5.210
P-value	0.570	0.007	0.412	0.483	0.022

Table 6. Comparison of RSS and VAS pain scores between the two groups of patients

Group	RSS score		VAS pain score	
	Before operation	6 h after operation	Before operation	6 h after operation
Observation	1.0±0.0	2.7±0.3	6.2±0.3	1.7±0.3
Control	1.0±0.0	1.9±0.5	6.0±0.6	2.9±0.5
t-value	-	10.75	1.62	15.9
P-value	-	0.002	0.225	< 0.001

Note: RSS (Ramsay Sedation Scale; scores: 1 = anxious/agitated, 2 = cooperative/calm, 3 = responsive to commands, 4 = responsive to tactile/auditory stimuli, 5 = sluggish response, 6 = unresponsive; scores 2-4 indicate optimal sedation). VAS: Visual Analog Scale.

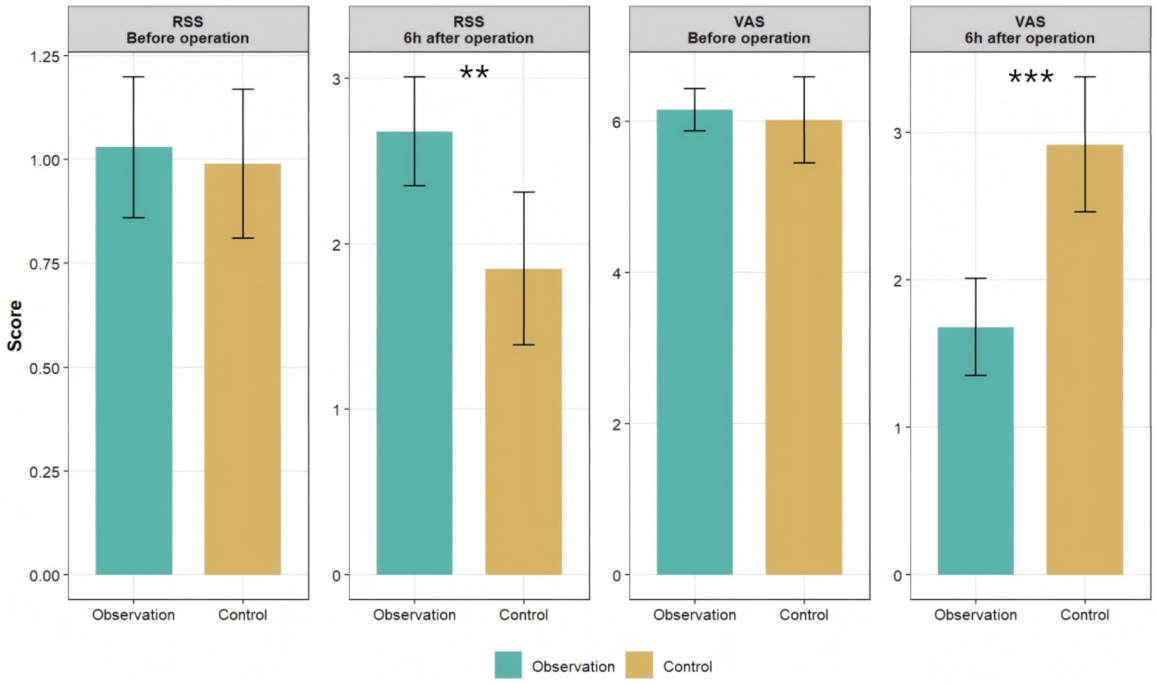

Figure 4. Comparison of Ramsay Sedation Scale (RSS) and Visual Analog Scale (VAS) pain scores between two groups of patients. **P < 0.01, ***P < 0.001.

Univariate regression analysis

Univariate regression identified treatment group, age, and ASA classification as significant predictors of hemodynamic stability and recovery (all P < 0.05, **Table 7**). Specifically, the observation group was associated with lower HR (β = -5.12, 95% CI: -6.82 to -3.42, P < 0.001) and MAP (β = -7.75, 95% CI: -9.47 to -6.03, P < 0.001). Age was positively linked with increased HR (β = 0.29 per year, 95% CI: 0.05-0.53, P = 0.018) and MAP (β = 0.26 per year, 95% CI: 0.01-0.51, P = 0.032). ASA class II patients exhibited prolonged recovery time compared to class I (β = 2.28, 95% CI: 0.06-4.50, P = 0.044). BMI, gender, and lesion diam-

Table 7. Univariate linear regression analysis of predictors for hemodynamic and recovery outcomes

Variable	β Coefficient	95% CI	*P*-Value
Treatment Group			
HR	-5.12	(-6.82, -3.42)	< 0.001
MAP	-7.75	(-9.47, -6.03)	< 0.001
SBP	-8.32	(-10.1, -6.54)	< 0.001
DBP	-6.05	(-7.81, -4.29)	< 0.001
Age (per year)			
HR	0.29	(0.05, 0.53)	0.018
MAP	0.26	(0.01, 0.51)	0.032
ASA Class II	2.28	(0.06, 4.50)	0.044
BMI (per kg/m^2)	-0.15	(-0.49, 0.19)	0.841
Gender (Male)	0.87	(-1.20, 2.94)	0.407
Lesion Diameter	0.12	(-0.35, 0.59)	0.615

Note: HR: heart rate, MAP: mean arterial pressure, SBP: systolic blood pressure, DBP: diastolic blood pressure, ASA: American Society of Anesthesiologists, BMI: body mass index, CI: confidence interval.

Table 8. Multivariable regression analysis of hemodynamic and recovery outcomes

Variable	β Coefficient	95% CI	*P*-Value
Treatment Group			
HR	-5.23	(-6.87, -3.59)	< 0.001
MAP	-7.89	(-9.54, -6.24)	< 0.001
SBP	-8.45	(-10.2, -6.70)	< 0.001
DBP	-6.12	(-7.88, -4.36)	< 0.001
Age (per year)			
HR	0.31	(0.07, 0.55)	0.012
MAP	0.28	(0.03, 0.53)	0.025
ASA Class II (vs. I)			
Recovery Time	2.34	(0.12, 4.56)	0.038
BMI (per kg/m^2)			
Recovery Time	-0.18	(-0.52, 0.16)	0.291

Note: HR: heart rate, MAP: mean arterial pressure, SBP: systolic blood pressure, DBP: diastolic blood pressure, ASA: American Society of Anesthesiologists, BMI: body mass index, CI: confidence interval.

eter showed no significant associations (P > 0.10). Based on these results, treatment group, age, and ASA classification were included in the subsequent multivariable regression analysis.

Multivariable regression analysis

Multivariable linear regression confirmed that the observation group was independently associated with improved hemodynamics: HR: β = -5.23 (95% CI: -6.87 to -3.59, P < 0.001); MAP: β = -7.89 (95% CI: -9.54 to -6.24, P < 0.001); SBP: β = -8.45 (95% CI: -10.2 to -6.70, P < 0.001); DBP: β = -6.12 (95% CI: -7.88 to -4.36, P < 0.001). Age remained a positive predictor of hemodynamic variability. ASA class II was associated with longer recovery time. BMI showed no significant association (P = 0.291) (**Table 8**; **Figure 5**).

Comparison of subgroup effects and interaction analysis

Subgroup analyses by age, ASA class, gender, and BMI revealed consistent treatment benefits across all groups. Notable interactions: ASA class II patients had greater reductions in ΔHR (-8.2 vs. -5.1 bpm; Pinteraction = 0.012) and ΔMAP (-9.4 vs. -6.7 mmHg; Pinteraction = 0.008). Patients > 75 years showed greater benefit (ΔHR: -7.9 vs. -4.3 bpm; Pinteraction = 0.015). No significant interactions were found for gender or BMI (Pinteraction > 0.05) (**Table 9**; **Figure 6**).

Discussion

Lung cancer is a malignant tumor originating from the bronchial mucosa and glandular epithelium. Epidemiological data indicate that it ranks first in both incidence and mortality among all malignancies [21]. Thoracoscopic radical lung cancer resection is increasingly favored for its minimal invasiveness, reduced intraoperative bleeding, less postoperative pain, faster recovery, and wider applicability across early, middle, and advanced disease stages [22]. However, in elderly patients, age-related declines in organ resilience and cardiopulmonary reserve increase the risk of hemodynamic instability during and after surgery. Thus, selecting anesthetic agents that mitigate perioperative stress and complications is essential. Hemodynamic monitoring serves as a vital tool for assessing patient stability, anesthesia depth, and organ function.

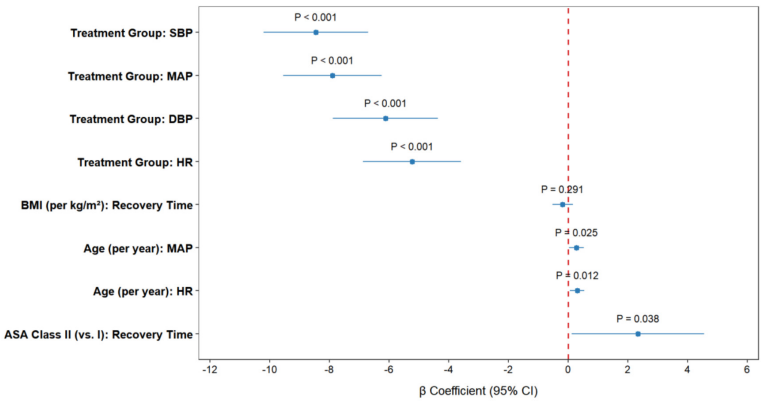

Figure 5. Multivariate regression analysis of forest plot. HR: heart rate, MAP: mean arterial pressure, SBP: systolic blood pressure, DBP: diastolic blood pressure, ASA: American Society of Anesthesiologists, BMI: body mass index, CI: confidence interval.

Table 9. Subgroup analysis of hemodynamic stability (HR and MAP)

Subgroup	ΔHR (bpm, Mean ± SD)	P-interaction	ΔMAP (mmHg, Mean ± SD)	P-interaction
Age				
≤ 75 years	-5.1±1.2	0.015	-6.7±1.5	0.008
> 75 years	-7.9±1.4		-9.4±1.8	
ASA Class				
I	-5.1±1.1	0.012	-6.7±1.3	0.008
II	-8.2±1.3		-9.4±1.6	
Gender				
Male	-6.3±1.2	0.452	-7.8±1.4	0.387
Female	-6.5±1.3		-8.1±1.5	
BMI				
< 22 kg/m^2	-6.4±1.1	0.621	-7.9±1.3	0.534
≥ 22 kg/m^2	-6.2±1.3		-7.6±1.4	

Note: HR: heart rate, MAP: mean arterial pressure, ASA: American Society of Anesthesiologists, BMI: body mass index, SD: standard deviation, bpm: beats per minute, mmHg: millimeters of mercury, Δ: change/delta.

In the present study, patients receiving dexmedetomidine combined with propofol demonstrated significantly more stable hemodynamic parameters - including HR, MAP, SBP, and DBP - at various perioperative time points. These findings are consistent with previous studies suggesting that dexmedetomidine enhances cardiovascular stability when used alongside propofol. For example, Zhang et al. [23] reported that this combination reduced the incidence of hypotension and tachycardia in elderly patients undergoing major abdominal surgery, attributing the benefit to dexmedetomidine's central sympatholytic action. The mechanism likely involves α_2-adrenergic receptor activation, which inhibits catecholamine release, thereby reducing sympathetic outflow and attenuating stress-induced cardiovascular responses [24-26].

In addition, patients in the observation group exhibited shorter emergence and orientation recovery times, indicating improved postoperative recovery quality. These results corroborate the findings of Gao et al. [27], who demonstrated that dexmedetomidine accelerates recovery while reducing residual sedation in elderly surgical patients. Pharmacologically dexmedetomidine, though not a GABA_A receptor agonist like propofol, promotes CNS inhibition by enhancing the activity of chloride ion channels, leading to membrane hyperpolarization and analgesia [28, 29]. Its lower lipophilicity and more uniform tissue distribution may also contribute to more stable clinical effects [30, 31].

Biochemically, the observation group showed significantly lower postoperative increases in norepinephrine, epinephrine, TNF-α, and IL-6 compared with controls, reflecting reduced stress and inflammatory responses. This is consistent with Liao et al. [32], who demonstrated that dexmedetomidine suppresses TNF-α and other inflammatory mediators more effectively than saline in elderly surgical patients. However, unlike our study which used propofol as the comparator, Liao's study compared dexmedetomidine with remimazolam in gastric cancer surgery, and noted a higher incidence of intraoperative hypotension with dexmedetomidine - highlighting a possible trade-off between anti-inflammatory efficacy and hemodynamic stability [32]. This effect may be attributed to dexmedetomidine's selective ago-

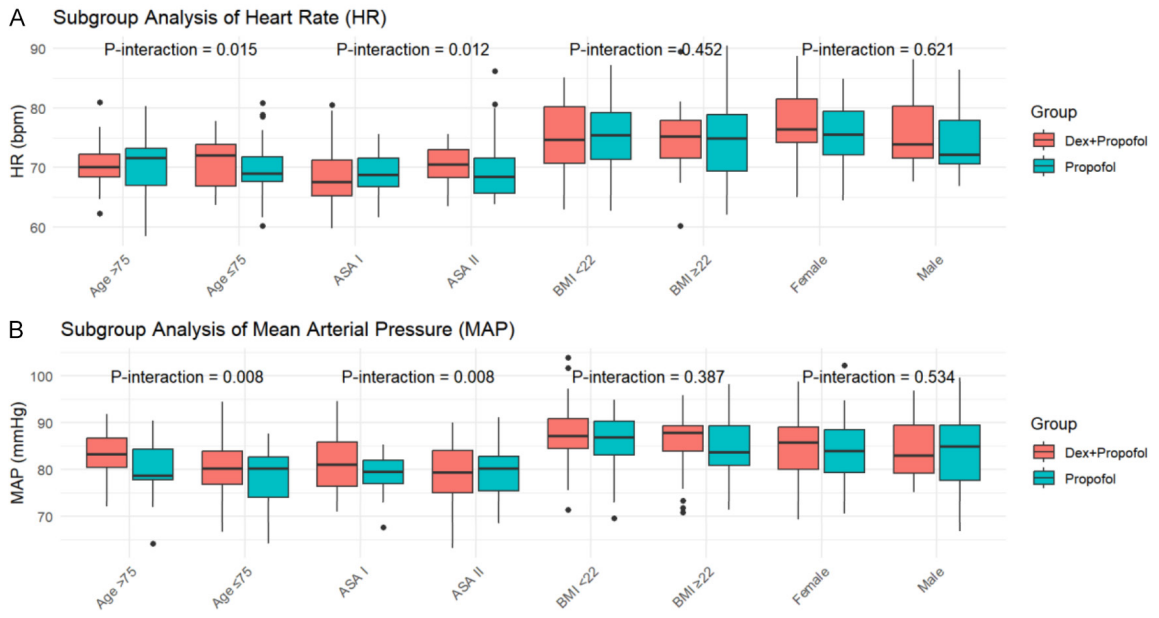

Figure 6. Subgroup analysis of hemodynamic stability. Boxplots illustrate differences in (A) heart rate (HR) and (B) mean arterial pressure (MAP) between the dexmedetomidine+propofol and propofol-only groups across age, American Society of Anesthesiologists (ASA) class, gender, and body mass index (BMI) subgroups. Interaction *P*-values are annotated for each subgroup comparison. The combined regimen showed significant benefits in ASA II and older patients (> 75 years).

nism of α_2-adrenergic receptors, which suppresses sympathetic outflow and catecholamine release, thereby mitigating perioperative stress responses. Unlike propofol, which enhances GABA_A receptor-mediated inhibitory neurotransmission, dexmedetomidine induces sedation and analgesia through distinct α_2-receptor-dependent pathways [33]. This difference in mechanism likely explains its superior suppression of stress and inflammatory markers observed in our study.

Additionally, the incidence of respiratory depression and postoperative nausea and vomiting was significantly lower in the observation group. Dexmedetomidine's favorable safety profile may be attributed to its dual metabolic clearance: through UDP-glucuronosyltransferase conjugation and cytochrome P450-mediated oxidative metabolism, both pathways producing inactive, renally excreted metabolites [34-36]. This efficient clearance supports its predictable pharmacokinetics and reduced risk of accumulation or prolonged adverse effects.

Multivariable regression analysis confirmed the independent association of dexmedetomidine use with improved intraoperative hemodynamic parameters, even after adjusting for confounders such as age, BMI, and ASA classification. Older age was positively associated with greater hemodynamic fluctuation, and ASA class II patients showed prolonged recovery times. Subgroup analyses further highlighted enhanced efficacy in high-risk populations, particularly those aged > 75 years and ASA class II patients, indicating that the benefit of the combination regimen is consistent across vulnerable subgroups.

This study contributes several novel insights to anesthesia management for thoracic surgery in elderly patients. First, it is among the few studies focusing specifically on thoracoscopic lung cancer resection in a geriatric population, a group particularly prone to hemodynamic instability and delayed recovery. Second, it incorporates a multidimensional evaluation framework, integrating hemodynamic, biochemical, and clinical recovery endpoints. Third, it provides stratified evidence through subgroup and regression analyses, offering practical implications for personalized anesthesia protocols in high-risk populations.

This study has several limitations. First, its retrospective design may introduce selection bias

and unmeasured confounders. Second, the sample size, though adequately powered, was limited to a single center and ASA I-II patients, which may restrict generalizability to higher-risk populations or other institutions. Third, we did not compare different dosing regimens of dexmedetomidine and propofol, leaving optimal titration strategies unresolved. Future prospective multicenter trials with larger cohorts, broader ASA classifications, and standardized dosing protocols are warranted to validate these findings and optimize individualized anesthetic strategies for elderly patients with lung cancer.

In conclusion, dexmedetomidine combined with propofol provides significant advantages over propofol alone in elderly patients undergoing thoracoscopic radical lung cancer resection. The combination yields improved hemodynamic stability, enhanced postoperative recovery, attenuated stress and inflammatory responses, and fewer adverse events. These findings support the clinical utility of this anesthetic approach, particularly in high-risk subgroups such as ASA class II patients and those over 75 years of age.

Disclosure of conflict of interest

None.

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