

Hemodynamic Stability and Rapid Recovery with Remimazolam versus Propofol in Bronchoscopy: A Single-Center Retrospective Cohort Study

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Abstract

Introduction: Remimazolam is an ultra-short-acting benzodiazepine with rapid onset, stable hemodynamics, and complete reversibility. These features make it well suited for bronchoscopy, where airway sharing and quick turnover demand predictable anesthesia and recovery. Although FDA-approved in 2020 for procedural sedation lasting ≤ 30 minutes, its off-label use for general anesthesia is expanding. We hypothesized that remimazolam provides shorter anesthesia and recovery intervals while maintaining comparable hemodynamic and respiratory stability to propofol. **Methods:** We conducted a single-center retrospective cohort study of adult lung-transplant recipients undergoing bronchoscopy between January 2019 and July 2025. Data were extracted from anesthesia information management, pharmacy, and electronic medical record systems. The remimazolam group included cases receiving remimazolam without propofol, and the propofol group included cases receiving propofol without remimazolam. **Primary endpoints** were anesthetic and recovery intervals measured chronologically as: Anesthesia start → stop, Procedure end → extubation or LMA out, Extubation/LMA out → out of room, and PACU arrival → discharge. **Secondary endpoints** included hypotension (MAP < 60 mm Hg or vasopressor use) and hypoxemia (SpO₂ < 90 % or airway escalation). **Results:** Among 454 bronchoscopies analyzed (Propofol = 325; Remimazolam = 129), baseline demographics were comparable between groups. Anesthetic durations were significantly shorter with remimazolam ($p = 0.0017$), while rates of hypotension and hypoxemia did not differ ($p > 0.05$). **Conclusion:** Remimazolam achieved similar intraoperative hemodynamic and respiratory stability to propofol while providing faster anesthesia and recovery intervals. These findings support remimazolam as a rapid, reversible anesthetic option for high-throughput bronchoscopic procedures in lung-transplant patients. Analyses of the full 5,000-case dataset are ongoing to expand evaluation of recovery intervals and PACU outcomes.

Table 1	Propofol (n≈325)	Remimazolam (n≈129)	Total (n=454)	p -value
Male, n (%)	200 (61.5%)	80 (62.0%)	303 (61.8%)	0.94
Female, n (%)	125 (38.5%)	49 (38.0%)	187 (38.2%)	
Age (years, mean)	59.4	58.8	58	0.72
BMI (kg/m ² , mean)	25.8	25.7	25.8	0.84
Inpatient	62 (19.1%)	23 (17.8%)	100 (22.4%)	0.85
Outpatient	262 (80.9%)	106 (82.2%)	346 (77.6%)	
COPD	74 (22.8%)	26 (20.2%)	109 (22.0%)	0.56
OSA	43 (13.2%)	13 (10.1%)	61 (13.4%)	0.41
IPF	0 (0%)	2 (1.6%)	2 (0.4%)	0.11
CF	8 (2.5%)	3 (2.3%)	12 (2.4%)	0.91
Adverse Events*	146 (44.9%)	56 (43.4%)	207 (45.6%)	0.78

Table 1. Baseline demographics and clinical characteristics of lung-transplant recipients undergoing bronchoscopy under remimazolam- or propofol-based anesthesia. No significant differences were observed between groups across sex, age, BMI, inpatient status, or comorbidities including COPD, OSA, IPF, or cystic fibrosis (all $p > 0.05$), supporting baseline equivalence. Rates of adverse events were also similar between cohorts (44.9 % vs 43.4 %; $p = 0.78$).

Table 2. Abbreviations for All Tables and Figures

ASA – American Society of Anesthesiologists
AIMS – Anesthesia Information Management System
BMI – Body Mass Index
CF – Cystic Fibrosis
COPD – Chronic Obstructive Pulmonary Disease
EBUS – Endobronchial Ultrasound
ICU – Intensive Care Unit
IPF – Idiopathic Pulmonary Fibrosis
LMA – Laryngeal Mask Airway
MAP – Mean Arterial Pressure
PACU – Post-Anesthesia Care Unit
OSA – Obstructive Sleep Apnea
SD – Standard Deviation
SpO₂ – Peripheral Oxygen Saturation
* $p < 0.05$,
** $p < 0.01$
*** $p < 0.001$.

Methods

Study Design and Setting: We conducted a single-center, retrospective cohort study at a tertiary lung-transplant center reviewing all adult bronchoscopies performed between January 2019 and July 2025 under general anesthesia or deep sedation. Institutional review board approval was obtained.

Patient Selection: Eligible cases included lung-transplant recipients aged ≥ 18 years undergoing first outpatient bronchoscopy following transplantation. **Exclusion criteria** were: Bronchoscopies performed during the same admission as transplantation. Repeat procedures within the same inpatient stay. Missing anesthetic or PACU data.

Exposure Groups: *Remimazolam group:* Cases receiving remimazolam without propofol. *Propofol group:* Cases receiving propofol without remimazolam.

Data Acquisition: Anesthesia information management system (AIMS) exports, pharmacy administration logs, and perioperative vital-sign records were merged using encounter identifiers. Collected variables included: Demographics: age, sex, BMI, ASA class, comorbidities (COPD, OSA, IPF, cystic fibrosis), and MELD or renal indices. Anesthetic data: remimazolam, remifentanyl, and rocuronium total doses (mg/μg/kg or mg), propofol total dose, flumazenil or sugammadex reversal use. Intraoperative variables: procedure duration, lowest MAP, duration of MAP < 60 mmHg, and SpO₂ < 90 %. PACU outcomes: Aldrete and MPADSS discharge scores, time to discharge readiness, re-sedation, nausea/vomiting, and unplanned ICU admission.

Endpoints: The *primary endpoints* were anesthetic recovery intervals, including Extubation–Stop Procedure, LMA Out–Stop Procedure, and Stop Recovery–Extubation, comparing Remimazolam and Propofol. *Secondary endpoints* included incidence and duration of intra-procedural hypotension (MAP < 60 mmHg) and hypoxemia (SpO₂ < 90 %), as well as vasopressor use.

Statistical Analysis: Continuous variables were summarized as mean ± SD or median [IQR] and compared using Student’s t test or Mann–Whitney U test as appropriate. Categorical variables were analyzed using χ^2 or Fisher’s exact tests. Statistical significance was set at $p < 0.05$.

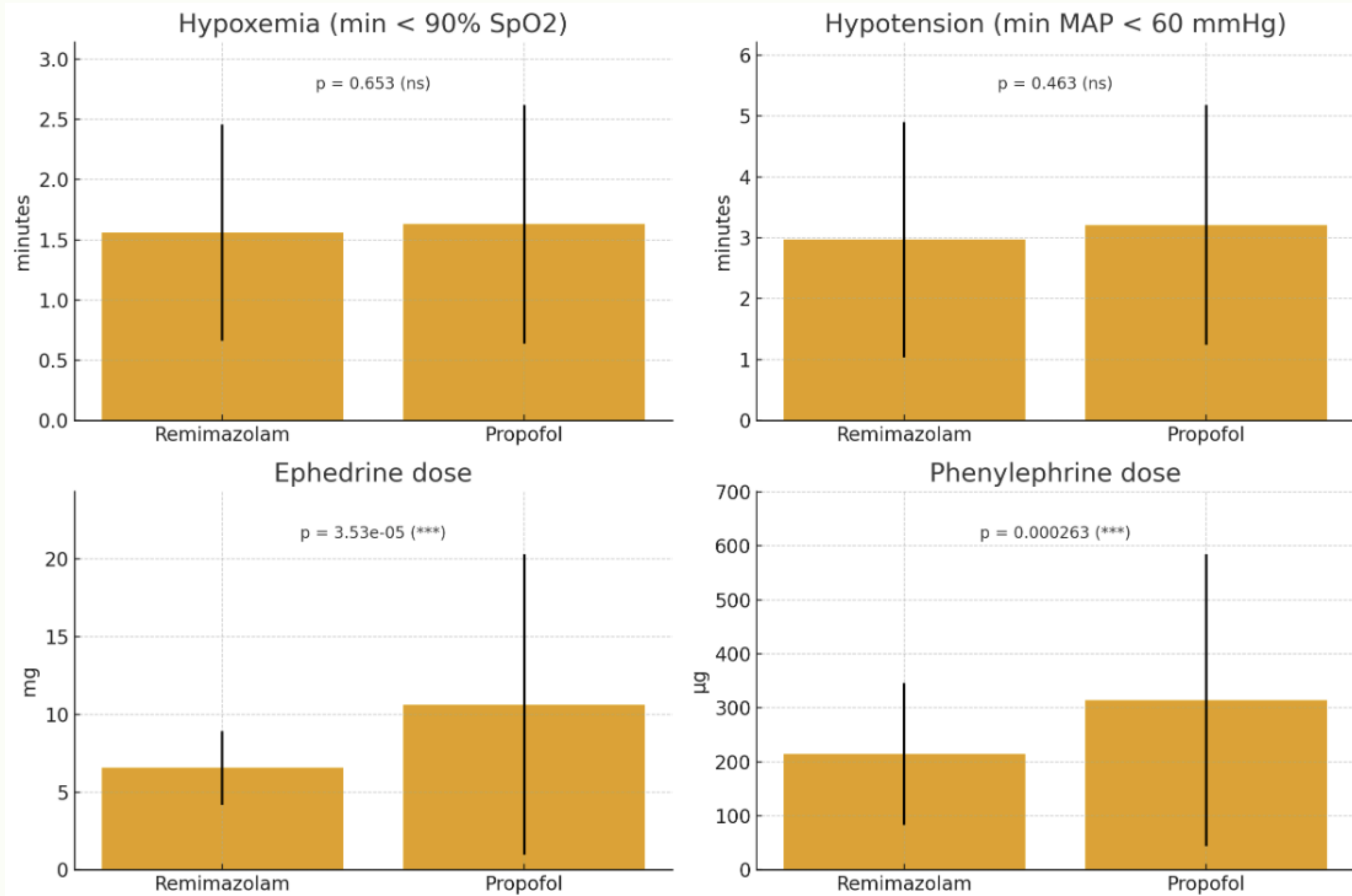


Figure 1. Hemodynamic and respiratory stability under Remimazolam vs. Propofol anesthesia. Bar plots display mean ± SD for intra-procedural hypoxemia (minutes < 90 % SpO₂), hypotension (minutes MAP < 60 mm Hg), and cumulative vasopressor doses (Ephedrine mg; Phenylephrine μg). No significant differences were observed in hypoxemia ($p = 0.65$) or hypotension ($p = 0.46$), whereas vasopressor requirements were significantly lower with Remimazolam (Ephedrine: $p = 3.5 \times 10^{-5}$; Phenylephrine: $p = 0.000263$). These findings indicate comparable intra-procedural stability with reduced pressor use in the Remimazolam cohort.

Results

Patient and Procedural Characteristics: A total of 454 bronchoscopies were analyzed (Propofol = 325, Remimazolam = 129). Baseline characteristics were comparable between groups (Table 1). The cohort was 61.8 % male with a mean age of 58.9 ± 10.7 years and mean BMI 25.8 ± 3.9 kg/m². Inpatient procedures accounted for 22.4 %, and outpatient cases comprised 77.6 %. No significant differences were observed in COPD, OSA, IPF, or cystic fibrosis prevalence (all $p > 0.4$), and overall adverse event rates were similar (44.9 % vs 43.4 %; $p = 0.78$). These findings support baseline equivalence between cohorts.

Anesthetic and Recovery Durations: Remimazolam demonstrated significantly shorter perioperative intervals compared with Propofol. Mean Extubation–Stop Procedure (5.4 ± 3.8 min vs 8.0 ± 4.0 min, $p = 0.0008$) and LMA Out–Stop Procedure (5.4 ± 3.8 min vs 8.0 ± 4.0 min, $p = 0.0008$) were both shorter with Remimazolam. *Extubation–Intubation* and *LMA Out–LMA In* intervals also favored Remimazolam ($p = 0.0028$ and 0.0051, respectively). Recovery intervals (*Stop Recovery–Extubation*, *Stop Recovery–LMA Out*) trended shorter without reaching statistical significance ($p = 0.36$ and 0.063).

Hemodynamic and Respiratory Stability: The incidence and duration of intra-procedural hypotension (MAP < 60 mm Hg) and hypoxemia (SpO₂ < 90 %) were similar between groups ($p > 0.4$). However, vasopressor requirements were lower with Remimazolam (*Ephedrine*, $p = 3.5 \times 10^{-5}$; *Phenylephrine*, $p = 0.0006$). No re-intubations, unplanned ICU admissions, or PACU complications occurred in either group.

Summary: Remimazolam provided comparable hemodynamic and respiratory stability to Propofol while achieving significantly faster emergence and shorter recovery intervals in lung-transplant bronchoscopy cases.

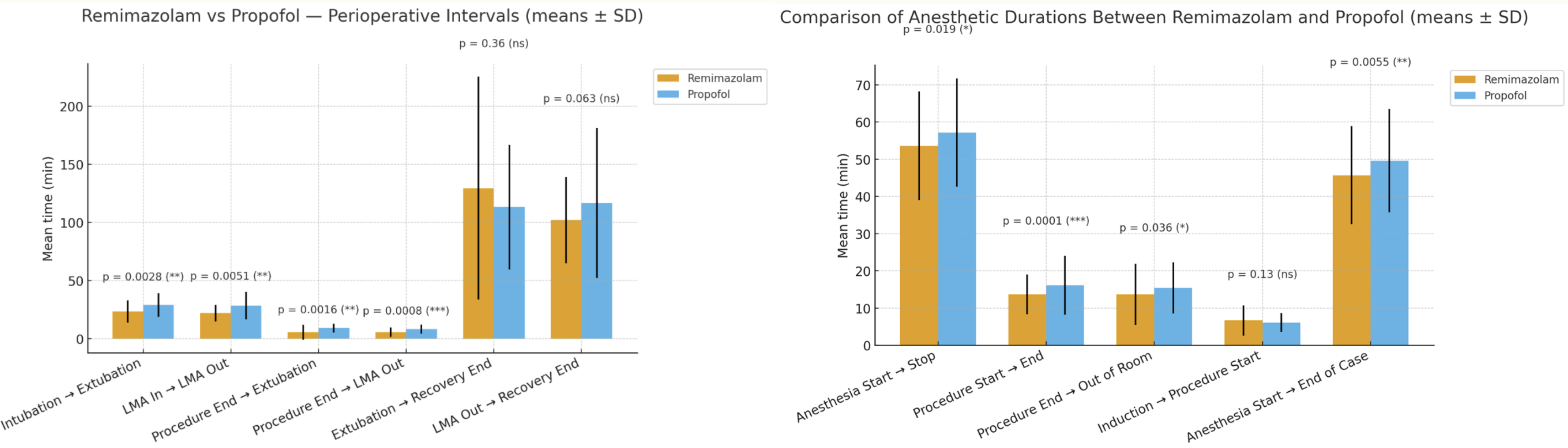


Figure 2. Remimazolam vs. Propofol — Perioperative Intervals. Comparison of mean perioperative recovery intervals between Remimazolam and Propofol. Remimazolam demonstrated significantly shorter Procedure End → Extubation and Procedure End → LMA Out intervals ($p = 0.0016$ and 0.0008 , respectively), as well as reduced Intubation → Extubation and LMA In → LMA Out durations ($p = 0.0028$ and 0.0051). Extubation → Recovery End and LMA Out → Recovery End trended shorter without reaching statistical significance. Error bars represent standard deviation.

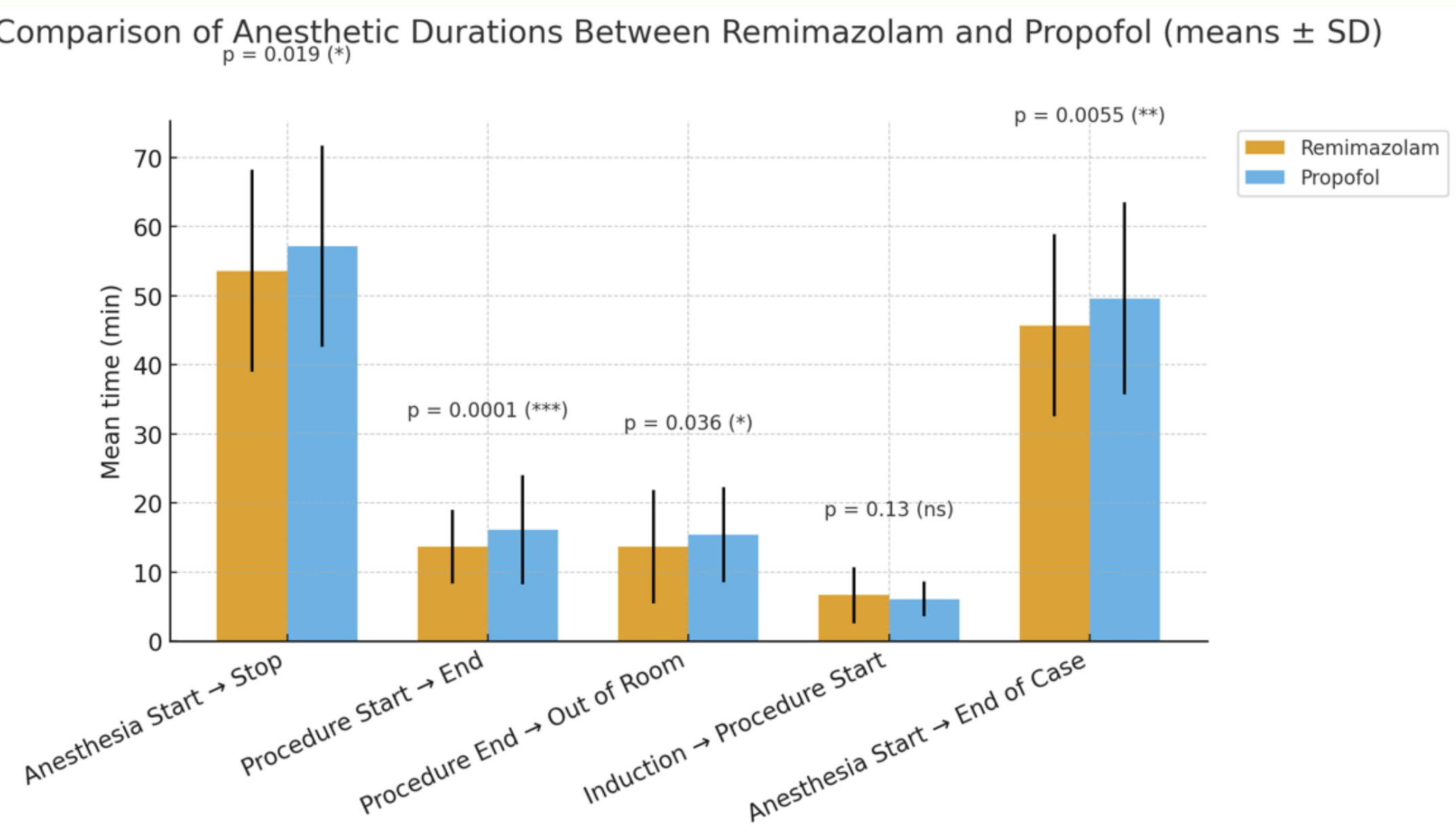


Figure 3. Comparison of Anesthetic Durations Between Remimazolam and Propofol. Mean anesthetic and procedural time intervals across cohorts. Remimazolam was associated with shorter Procedure Start → End and Procedure End → Out of Room durations, while Anesthesia Start → Stop and Anesthesia Start → End of Case were comparable between groups. Error bars represent standard deviation. Statistical significance denoted as * $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$.

Discussion / Conclusion

Discussion: In this cohort of 454 lung-transplant bronchoscopies, Remimazolam, used without propofol, produced comparable intraoperative hemodynamic and respiratory stability to propofol-only anesthesia while significantly shortening several perioperative recovery intervals. These findings are consistent with Remimazolam’s ultra-short-acting benzodiazepine profile and suggest potential workflow advantages without compromising safety. Importantly, the current analysis focuses on time-based recovery metrics as the primary endpoint, with hypotension and hypoxemia serving as secondary outcomes. Procedure duration was not analyzed, given its dependence on case complexity rather than anesthetic choice. Vasopressor requirements were notably lower with Remimazolam, aligning with its known cardiovascular stability. Although preliminary, these results provide an early signal that Remimazolam may enable faster emergence and turnover in high-acuity lung-transplant patients. Ongoing analyses of the full institutional dataset will explore stratification by procedure type (rigid vs. flexible), anesthetic adjuncts, and flumazenil reversal timing to validate these trends and expand clinical relevance.

Conclusion: Among lung-transplant bronchoscopy cases, Remimazolam achieved similar hemodynamic and respiratory outcomes to Propofol while significantly reducing anesthetic recovery times. These findings highlight its feasibility as an efficient and stable alternative for deep sedation or general anesthesia in this population. Future work incorporating the full >5,000-case dataset will include stratified analyses, reversal dynamics, and multivariate modeling to define predictors of delayed recovery and refine dosing protocols.

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