Am J Transl Res 2026;18(2):1186-1194
www.ajtr.org /ISSN:1943-8141/AJTR0167673

Case Report

Remimazolam for hemodynamic stabilization in patients with perioperative arrhythmia: report of two cases

Hyeon-Tae Kim*, Joo-Yong Lee*

*Department of Anesthesiology and Pain Medicine, Chungbuk National University Hospital, College of Medicine, Chungbuk National University, Chungbuk 28644, Korea. *Equal contributors.*

Received July 24, 2025; Accepted January 27, 2026; Epub February 15, 2026; Published February 28, 2026

Abstract: Intraoperative arrhythmias pose significant risks during surgical procedures, occurring not only in patients with preexisting cardiac conditions, but also in response to anesthetic agents or surgical stimuli. Remimazolam, an ultra-short-acting benzodiazepine, demonstrates rapid recovery and stable hemodynamic properties; however, clinical evidence of its efficacy in patients with perioperative arrhythmias remains limited. Herein, we report two cases in which remimazolam was successfully used for hemodynamic stabilization in patients with perioperative arrhythmias. In both patients, conventional inhalational anesthesia was converted to remimazolam-based anesthesia because of arrhythmia-related hemodynamic instability. Conversion to remimazolam resulted in stable heart rate and blood pressure maintenance in patients with existing or intraoperative arrhythmias. No additional arrhythmic episodes or uncontrolled tachyarrhythmias occurred during the remainder of the anesthesia and surgery. This hemodynamic stability may be partly attributed to the minimal cardiac depressant effects of remimazolam and limited sympathetic nervous system stimulation. Therefore, remimazolam may be a viable anesthetic alternative for patients with preexisting or newly developed arrhythmias, providing stable cardiovascular control during the induction and maintenance phases. Although larger prospective studies are warranted, these cases demonstrate the clinical utility of remimazolam in high-risk cardiac patients requiring surgical intervention.

Keywords: Remimazolam, cardiac arrhythmia, general anesthesia, hemodynamic stability, atrial fibrillation, perioperative management

Introduction

Preoperative and postoperative arrhythmias are associated with prolonged hospitalization, increased morbidity, and high mortality rates [1, 2]. Diagnosis, prevention, and management of arrhythmias are essential to maintain cardiac stability and reduce surgery-related complications. Although some arrhythmias that occur during or after general anesthesia are benign, others may lead to serious outcomes, underscoring the importance of early detection and intervention [3]. Because intraoperative arrhythmias can be triggered by surgical stimuli or anesthetic agents, the selection or adjustment of anesthetic drugs to maintain hemodynamic stability is critical.

Commonly used intravenous anesthetics such as propofol cause dose-dependent cardiovascular depression [4]. Inhalational agents have been associated with various cardiac effects, including sympathetic stimulation, QT interval prolongation, myocardial sensitization, and bradycardia, all of which may increase the risk of arrhythmia [5], particularly patients with impaired cardiac function or preexisting arrhythmias. Thus, alternative anesthetic strategies that minimize cardiac depression while ensuring adequate anesthetic depth are required.

Remimazolam is an ultra-short-acting benzodiazepine characterized by rapid onset and recovery, availability as a reversal agent, and minimal cardiovascular effects [4]. These pharmacokinetic properties maay make it useful treatment for patients with cardiac disease or impaired cardiac function. In a previous report, successful anesthetic management using remimazolam was demonstrated in a patient with atrial flutter, highlighting its clinical applicability in such settings [6].

https://doi.org/10.62347/UYUZ6951

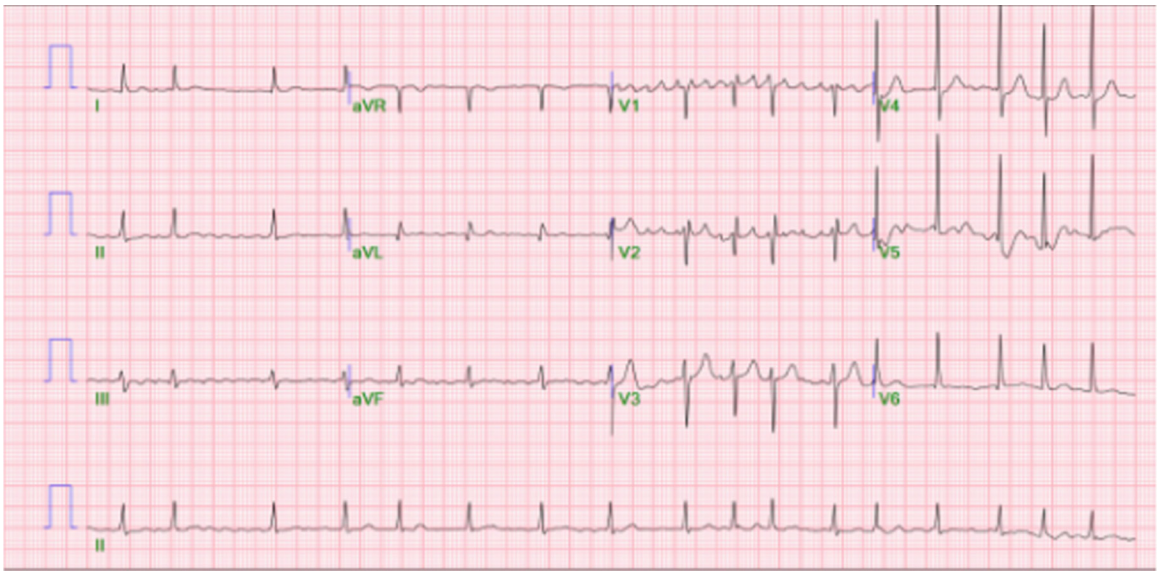

Figure 1. Preoperative electrocardiogram showing atrial fibrillation with rapid ventricular response.

However, clinical data on the use of remimazolam in diverse patient populations with arrhythmia remain limited. The current study presents two cases illustrating the utility of remimazolam in different clinical contexts. The first involves a patient with preexisting atrial fibrillation who developed hemodynamic instability with conventional anesthetics, necessitating surgical postponement and subsequent reinduction with remimazolam. The second case involves intraoperative development of ventricular arrhythmia following the use of inhalational agents, which prompted a switch to remimazolam during surgery. In both cases, conversion to remimazolam led to cardiovascular stabilization and successful surgical completion. This study aims to highlight the role of remimazolam in the management of perioperative arrhythmias and discuss its clinical implications in light of the existing literature.

Case report

This study was approved by the Hospital Clinical Research Review Committee (approval number 2026-01-002). Both patients provided written informed consent for the publication of their data.

Case 1

A 56-year-old male patient (184 cm, 70 kg) was scheduled to undergo subtotal gastrectomy (Billroth II) for gastric cancer. Preoperative electrocardiography (ECG) revealed atrial fibrillation with a rapid ventricular response (**Figure 1**), with no other notable abnormalities in laboratory tests. In the operating room, his heart rate and blood pressure were 110-120 bpm and 132/78 mmHg, respectively. Anesthesia was induced with lidocaine 4 mg, etomidate 8 mg, and rocuronium 50 mg; remifentanil was continuously infused at 3 μg/kg/hr. Owing to preexisting atrial fibrillation and elevated heart rate, glycopyrrolate was omitted, and propofol was avoided considering the risk of cardiovascular depression.

Following induction, the patient's heart rate increased to 170-190 bpm (**Figure 2**). Intravenous esmolol 10 mg was administered at 2-3-minute intervals, but no significant reduction in heart rate was observed. Subsequently, labetalol 5 mg was administered intravenously; however, the heart rate remained above 150 bpm. During this period, the blood pressure ranged from 130/100 to 150/120 mmHg. Owing to persistent atrial fibrillation with tachycardia and concerns regarding intraoperative safety, the procedure was aborted, and the patient was awakened. He was transferred to the intensive care unit (ICU) for further cardiac evaluation and cardiology consultation.

Electrocardiography performed after cancellation of the procedure revealed atrial flutter with variable atrioventricular (AV) block, incomplete right bundle branch block, and nonspecific T-

Figure 2. Intraoperative atrial fibrillation electrocardiogram.

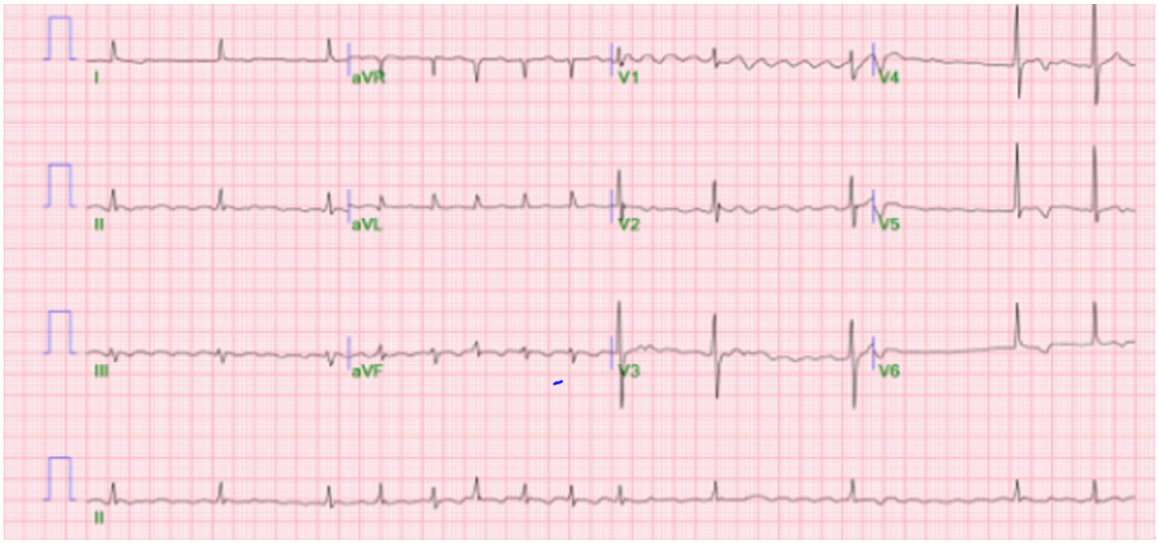

Figure 3. Post-anesthesia electrocardiogram showing atrial flutter with variable atrioventricular block, incomplete right bundle branch block, and nonspecific T-wave abnormalities.

wave abnormalities (**Figure 3**), suggesting a transition from atrial fibrillation to atrial flutter. Transthoracic echocardiography revealed non-valvular atrial fibrillation, biatrial enlargement (BAE), and preserved left ventricular systolic function. Laboratory tests revealed CK-MB 1.18 ng/mL, high-sensitivity troponin T 18 ng/L, pro-BNP 356.2 pg/mL, and myoglobin 26.77 ng/mL, with a notably increased pro-BNP level.

Given the patient's cardiac condition, the anesthetic plan was revised, and the surgery was rescheduled. In the second procedure, remimazolam was administered for both induction and maintenance. The pre-induction heart rate was

Figure 4. Vital signs and electrocardiogram during the second surgery using remimazolam.

125-130 bpm, and blood pressure was 118/72 mmHg. Remimazolam (5 mg/mL) was administered at 6 mg/kg/h for induction and then reduced to 1 mg/kg/h for maintenance. Rocuronium 50 mg and remifentanil at 3 μg/kg/h were also used. During the second surgery, the heart rate remained stable, ranging from 120-130 bpm during induction and 110-120 bpm intraoperatively (**Figure 4**). Blood pressure was maintained at 120/65-140/80 mmHg without significant fluctuations. The procedure was successfully completed without cardiac complications and the patient recovered uneventfully in the ICU without chest pain, hypotension, or ECG abnormalities. At the time of conversion to remimazolam, no additional beta-blockers, antiarrhythmic agents, or vasoactive medications were administered. Hemodynamic stabilization was achieved without the initiation of continuous vasopressor or antiarrhythmic support.

Case 2

A 69-year-old male patient (170 cm, 70 kg) was scheduled to undergo ileostomy reversal surgery. Preoperative ECG showed a normal sinus rhythm. Anesthesia was induced using glycopyrrolate 0.2 mg, lidocaine 40 mg, propofol 80 mg, rocuronium 50 mg, and remifentanil at 3.0 μg/kg/h. Maintenance was achieved using desflurane at 6.0 vol% (1 MAC) and remifentanil at 1.0 μg/kg/h. Immediately after induction, the ECG showed a normal sinus rhythm. Approximately 5 min after induction, abnormal ECG findings emerged during surgical skin preparation. The patient initially exhibited 2-3 ventricular premature complexes (VPCs), which progressed to a bigeminy pattern and then intermittently reverted to isolated VPCs. These arrhythmic patterns recurred repeatedly (**Figures 5** and **6**).

Considering the possibility that desflurane contributed to the arrhythmia, the anesthetic agent was switched to remimazolam. During the transition, the bispectral index (BIS) remained between 30 and 35; therefore, only the maintenance dose of remimazolam at 1.0 mg/kg/h was administered without an additional induction dose. The depth of anesthesia was subsequently adjusted based on BIS monitoring. Following remimazolam infusion, the ECG returned to normal sinus rhythm (**Figure 7**), and the surgery was completed without further arrhythmias or cardiovascular complications.

Figure 5. Electrocardiogram changes observed 5 min after induction with desflurane.

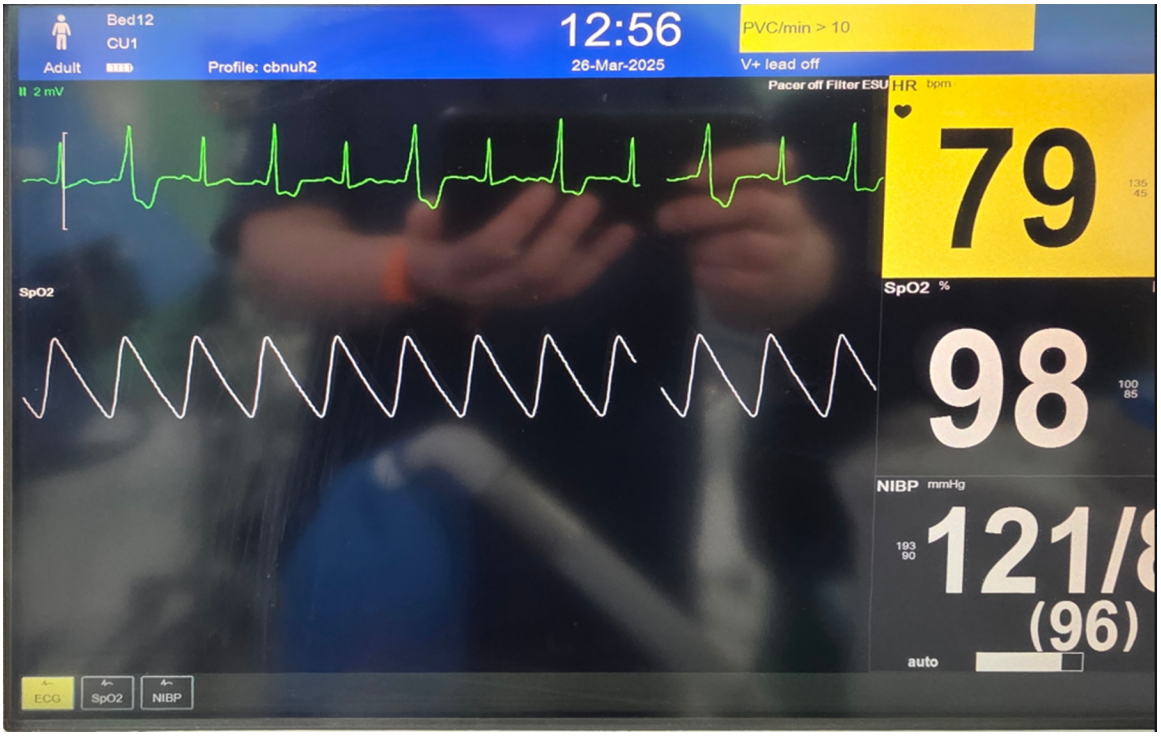

Figure 6. Ongoing electrocardiographic changes during anesthesia.

Figure 7. Electrocardiogram showing return to normal sinus rhythm after conversion to remimazolam.

Apart from the discontinuation of desflurane, no new antiarrhythmic agents, beta-blockers, or vasoactive drugs were administered during the transition to remimazolam. Thereafter, heart rate and blood pressure remained stable without pharmacological cardiovascular support. Careful review of serial ECG recordings revealed no evidence of QT or corrected QT (QTc) interval prolongation, QRS widening, or other conduction abnormalities before or after conversion to remimazolam. No additional arrhythmic events were observed in the post-anesthesia care unit or during inpatient stay.

Discussion

Similar to other benzodiazepines, remimazolam acts on GABA-A receptors but is characterized by its ultra-short-acting profile because of its rapid metabolism by tissue esterases [7]. This metabolic pathway is independent of organ function, allowing predictable recovery and rapid drug clearance with minimal accumulation, even during prolonged infusion [7]. These properties make remimazolam suitable for both the induction and maintenance of anesthesia, offering particular advantages to patients at risk of cardiovascular instability.

Although remimazolam and propofol have similar elimination half-lives, remimazolam is distinguished by its minimal cardiovascular depressant effects. Propofol causes a dose-dependent reduction in systemic vascular resistance and myocardial contractility, leading to hypotension and decreased cardiac output [8]. This can result in significant intraoperative hemodynamic instability in patients with arrhythmias or impaired cardiac function. In contrast, several clinical studies have shown that remimazolam is associated with smaller reductions in systolic and mean arterial pressures, reduced vasopressor requirements, and improved overall hemodynamic stability compared to propofol [9, 10].

Compared to commonly used inhalational agents for anesthesia maintenance, remimazolam affords notable cardiovascular safety. Inhalational agents, particularly desflurane, can induce arrhythmias through various mechanisms, including sympathetic stimulation, QT interval prolongation, and myocardial sensitization [11]. Studies have reported transient arrhythmias and ECG changes in healthy subjects immediately after desflurane administration [12]. These findings suggest that compared

Table 1. Clinical characteristics and perioperative courses of the two cases

Variable	Case 1	Case 2
Patient information	56-year-old male, 184 cm, 70 kg	69-year-old male, 170 cm, 70 kg
Preoperative ECG	Atrial fibrillation → converted to atrial flutter	Normal sinus rhythm
Initial anesthetic agents	Etomidate + Rocuronium + Remifentanil (1st surgery)	Propofol + Rocuronium + Remifentanil + Desflurane
Onset of arrhythmia	Immediately after induction, persistent tachyarrhythmia.	5 min after induction, before incision
Arrhythmia pattern	Persistent tachycardia, atrial flutter	Ventricular premature complexes, bigeminy
Agent after conversion	Remimazolam (6 mg/kg/hr → 1 mg/kg/h)	Remimazolam (1 mg/kg/h, BIS-guided)
ECG after conversion	Stable sinus rhythm (110-120 bpm)	Return to normal sinus rhythm
Surgical outcome	Successfully completed without complications	Successfully completed without complications

In both patients, arrhythmias developed or worsened following the use of conventional anesthetic agents. After switching to remimazolam, hemodynamic stability was restored, allowing successful completion of surgery.

to inhalational agents, remimazolam has a lower proarrhythmic potential and less effect on cardiac conduction [13]. This is consistent with the second case in the current report, in which a patient without preexisting cardiac disease developed VPCs and bigeminy following induction with propofol and desflurane but subsequently returned to normal sinus rhythm and maintained stable vital signs after conversion to remimazolam.

Currently, clinical data on the anesthetic efficacy and safety of remimazolam in patients with arrhythmias remain limited, and most studies have been conducted in healthy or low-risk populations. Real-world evidence involving high-risk patients with cardiac diseases is scarce, highlighting the need for case-based reports. The favorable safety profile of remimazolam in patients with arrhythmias may be attributed to several mechanistic factors. First, remimazolam does not prolong cardiac repolarization [13]. Second, its minimal impact on autonomic balance compared to that by propofol or inhalational agents allows for more stable heart rate control [14]. Third, its limited effect on myocardial contractility supports the maintenance of cardiac output and coronary perfusion [15]. Finally, a lower incidence of hypotension may reduce compensatory tachycardia, which is particularly relevant for patients with atrial fibrillation or flutter [16].

Although clinical data on the use of remimazolam in patients with arrhythmias remain limited, growing evidence suggests that it provides relatively stable anesthesia with fewer episodes of hypotension and heart rate variability [14-16]. A recent meta-analysis confirmed that remimazolam offers superior overall cardiovascular stability than propofol does [17], further supporting its emerging clinical utility.

The two cases presented herein highlight the potential advantages of remimazolam in clinical practice. The first case allowed for a direct comparison within the same patient, demonstrating that surgery, which was initially postponed because of tachycardia and instability with conventional intravenous agents, was successfully performed under remimazolam, with restored hemodynamic stability. The second case illustrates the resolution of arrhythmias that emerged during anesthesia with standard agents, suggesting that remimazolam has minimal effects on cardiac conduction and may serve as a viable alternative for patients with rhythm disturbances. The clinical characteristics and anesthetic responses of the two patients are summarized in **Table 1**.

In both cases, serial ECG assessments demonstrated rhythm stabilization without accompanying QT or QTc interval prolongation or other indicators of impaired cardiac conduction. These ECG findings, together with the stable hemodynamic values observed after conversion to remimazolam, were consistent with a favorable electrophysiological profile. Nevertheless, given the observational nature of this study and the discontinuation of potentially arrhythmogenic anesthetic agents, a direct

causal relationship cannot be definitively established.

This study was inherently limited by its small sample size and observational nature. While both patients demonstrated favorable hemodynamic responses following the switch to remimazolam, the absence of a control group and variability in the underlying cardiac rhythms and perioperative contexts prevented definitive conclusions. Further controlled studies are required to validate the reproducibility and generalizability of our findings.

In conclusion, the cases presented herein suggest that remimazolam may be an alternative anesthetic option for patients with preexisting or intraoperatively developed arrhythmias. However, given the limited number of cases and observational nature of this report, the observed hemodynamic stabilization cannot be attributed solely to the direct pharmacologic effects of remimazolam. The clinical improvement may have been partially influenced by the discontinuation of anesthetic agents with known arrhythmogenic or sympathomimetic properties. Therefore, these findings should be interpreted with caution, and further prospective studies are required to delineate the independent effects of remimazolam on perioperative arrhythmia and hemodynamic stability.

Disclosure of conflict of interest

None.

Address correspondence to: Dr. Joo-Yong Lee, Department of Anesthesiology and Pain Medicine, Chungbuk National University Hospital, College of Medicine, Chungbuk National University, 776, 1 Sunhwan-ro, Seowon-Gu, Cheongju, Chungbuk 28644, Korea. Tel: +82-010-4454-3384; Fax: +82-43-272-0264; E-mail: C503016@cbnuh.or.kr

References

[1] Atlee JL. Perioperative cardiac dysrhythmias: diagnosis and management. Anesthesiology 1997; 86: 1397-1424.
[2] Dua N and Kumra VP. Management of perioperative arrhythmias. Indian J Anaesth 2007; 51: 310-323.
[3] Pecha S, Kirchhof P and Reissmann B. Perioperative arrhythmias. Dtsch Arztebl Int 2023; 120: 564-574.
[4] Goodchild CS and Serrao JM. Propofol-induced cardiovascular depression: science and art. Br J Anaesth 2015; 115: 641-642.
[5] Schmeling WT, Warltier DC, McDonald DJ, Madsen KE, Atlee JL and Kampine JP. Prolongation of the QT interval by enflurane, isoflurane, and halothane in humans. Anesth Analg 1991; 72: 137-44.
[6] Lee JY, Kim HT, Kim YJ, Lee JS, Park JW and Shin YD. Anesthetic management using remimazolam in a patient with atrial flutter: a case report. Am J Transl Res 2022; 14: 5754-5759.
[7] Schüttler J, Eisenried A, Lerch M, Fechner J, Jeleazcov C and Ihmsen H. Pharmacokinetics and pharmacodynamics of remimazolam (CNS 7056) after continuous infusion in healthy male volunteers: Part I. Pharmacokinetics and clinical pharmacodynamics. Anesthesiology 2020; 132: 636-651.
[8] Claeys MA, Gepts E and Camu F. Haemodynamic changes during anaesthesia induced and maintained with propofol. Br J Anaesth 1988; 60: 3-9.
[9] Doi M, Morita K, Takeda J, Sakamoto A, Yamakage M and Suzuki T. Efficacy and safety of remimazolam versus propofol for general anesthesia: a multicenter, single-blind, randomized, parallel-group, phase IIb/III trial. J Anesth 2020; 34: 543-553.
[10] Sheng XY, Liang Y, Yang XY, Li LE, Ye X, Zhao X and Cui YM. Safety, pharmacokinetic and pharmacodynamic properties of single ascending dose and continuous infusion of remimazolam besylate in healthy Chinese volunteers. Eur J Clin Pharmacol 2020; 76: 383-391.
[11] Atlee JL 3rd and Bosnjak ZJ. Mechanisms for cardiac dysrhythmias during anesthesia. Anesthesiology 1990; 72: 347-374.
[12] Ebert TJ and Muzi M. Sympathetic hyperactivity during desflurane anesthesia in healthy volunteers. A comparison with isoflurane. Anesthesiology 1993; 79: 444-453.
[13] Kleiman RB, Darpo B, Thorn M, Stoehr T and Schippers F. Potential strategy for assessing QT/QTc interval for drugs that produce rapid changes in heart rate: electrocardiographic assessment of the effects of intravenous remimazolam on cardiac repolarization. Br J Clin Pharmacol 2020; 86: 1600-1609.
[14] Hasegawa G, Hirata N, Yoshikawa Y and Yamakage M. Differential effects of remimazolam and propofol on heart rate variability during anesthesia induction. J Anesth 2022; 36: 239-245.
[15] Yoshikawa Y, Oura S, Kanda M, Chaki T, Hirata N, Edanaga M and Yamakage M. Comparison of the negative effect of remimazolam and propofol on cardiac contractility: analysis of a ran-

domised parallel-group trial and a preclinical ex vivo study. Clin Exp Pharmacol Physiol 2024; 51: e13840.

[16] Minghong L, Feng Q, Chen H, Li J and Shi J. Effects of different doses of remimazolam on the quality of sedation and cardiac function in elderly patients: a double-blind randomised controlled study. Front Cardiovasc Med 2025; 11: 1453608.

[17] Wegner BM, Wegner GM, Spagnol LW, Costa LA, Spagnol VW and Paiva DF. Comparison between hemodynamic effects of remimazolam and propofol during general anesthesia: a systematic review and meta-analysis. Minerva Anestesiol 2024; 90: 901-911.