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# Comparison of Effects of Remimazolam and Midazolam plus Sevoflurane on Intraoperative Hemodynamics and Opioid Administration: A Retrospective Cohort Study

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**Background:** Remimazolam is an ultrashort-acting benzodiazepine that maintains stable hemodynamics during anesthesia. However, few reports have focused on hemodynamic stability and opioid use during cardiac surgery with remimazolam. We hypothesized that administration of remimazolam for induction and maintenance of anesthesia for transcatheter aortic valve implantation would maintain hemodynamics as effectively as conventional anesthetics and allow use of an appropriate dose of opioids. We compared intraoperative hemodynamics and opioid use in patients with severe aortic stenosis who received remimazolam or conventional anesthetics.

**Methods:** This retrospective cohort study analyzed data for patients who underwent transcatheter aortic valve implantation from October 2022 to September 2023. The 23 patients were divided into two groups: a remimazolam group and midazolam + sevoflurane group. The primary outcome was intraoperative blood pressure. The secondary outcomes were the doses of vasoconstrictors, vasodilators, and opioids used.

**Results:** There was no significant difference in any patient characteristic or intraoperative blood pressure between the two groups (before anesthesia: 92.0 [87.0-99.8] vs. 91.0 [86.0-107.0] mm Hg, $P$=0.935; 1 minute after induction of anesthesia: 91.0 [83.0-98.5] vs. 90.0 [86.3-95.3] mm Hg, $P$=0.843; at the start of surgery: 77.0 [70.0-79.0] vs. 82.5 [75.5-105.5] mm Hg, $P$=0.072; at the end of surgery: 74.0 [71.0-78.0] vs. 82.5 [75.5-90.8] mm Hg, $P$=0.082). The maximum rate of remifentanil administration was significantly higher in the remimazolam group (0.10 [0.10-0.20] vs. 0.10 [0.013-0.10] μg/kg/min, $P$=0.012).

**Conclusions:** Remimazolam maintained hemodynamics as effectively as midazolam + sevoflurane, even when used in combination with opioids. Remimazolam thus appears to be noninferior to midazolam + sevoflurane. (J Nippon Med Sch 2025; 92: 313–320)

**Key words:** remimazolam, hemodynamics, opioid, transcatheter aortic valve implantation

## Introduction

Remimazolam is an ultrashort-acting benzodiazepine used for induction and maintenance of anesthesia[1]. Remimazolam has been shown to maintain stable hemodynamics during anesthesia[2]. Some studies reported that the total vasoconstrictor dose was lower in patients receiving remimazolam than in those receiving sevoflurane, even in patients receiving high doses of remifentanil, which affects hemodynamic stability[3,4]. However, few reports have examined hemodynamic stability and opioid use during cardiac surgery with remimazolam.

Transcatheter aortic valve implantation (TAVI) is a minimally invasive treatment for patients with severe aortic stenosis (AS). TAVI is a novel therapeutic alterna-

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tive for older patients and patients with severe illness who are at high risk for operative complications[5,6]. However, maintaining normal hemodynamics is challenging for many patients undergoing TAVI because such patients often have conditions that increase hemodynamic instability. Older adults and those with a higher American Society of Anesthesiologists physical status (ASA-PS) are at high risk for hypotension after induction of anesthesia and were more likely to develop hemodynamic instability[7]. Therefore, the use of anesthetics and opioids with hemodynamic effects should be carefully managed.

Nakanishi et al.[8] reported that remimazolam maintained hemodynamic stability in patients undergoing transcatheter or surgical aortic valve replacement with appropriate use of vasoconstrictors. However, few reports have compared the hemodynamic effects and intraoperative use of opioids, vasoconstrictors, and vasodilators between patients receiving remimazolam and those receiving midazolam + sevoflurane. We hypothesized that administration of remimazolam for induction and maintenance of anesthesia would maintain hemodynamics as effectively as conventional anesthetics and allow administration of an appropriate dose of opioids. We compared remimazolam with sevoflurane + midazolam and examined hemodynamic stability and opioid dose for patients undergoing TAVI for severe AS, a patient population at risk of hypotension.

## Materials and Methods

### Study Design

This single-center, retrospective cohort study was conducted at Nippon Medical School Hospital in accordance with the Declaration of Helsinki. The protocol was approved by the Ethics Committee of Nippon Medical School Hospital (Bunkyo-ku, Tokyo, Japan; Chairperson, Prof. H. Yamaguchi; approval number: B-2023-660; 28 August 2023). The institutional review board duration of this study was from 28 August 2023 to 31 March 2026. Patients were given the opportunity to refuse participation through an opt-out form on our institution's website[9]. Data were collected from patients' medical records.

### Participants

Data from patients undergoing TAVI at Nippon Medical School Hospital during the study period (from 1 October 2022 to 30 September 2023) were analyzed. The inclusion criteria were age ≥20 years, use of remimazolam only or midazolam + sevoflurane as an anesthetic, and use of a SAPIEN 3 transcatheter heart valve (Edwards Lifesciences, Irvine, CA, USA). There are two types of transcatheter heart valves used in TAVI, but our hospital mainly uses the SAPIEN 3 transcatheter heart valve. Patients undergoing emergency surgery and procedures requiring multiple surgical techniques were excluded.

### Outcomes and Data Collection

Data on the baseline characteristics of the patients were retrospectively extracted from the medical records and included age, sex, height, weight, body mass index, ASA-PS, medical history (myocardial infarction, coronary artery disease, heart failure, hypertension, diabetes, hyperlipidemia, and arrhythmia), preoperative platelet count, prothrombin time-international normalized ratio, serum creatinine, creatinine clearance rate, anesthesia time, and operation time. The primary outcome was intraoperative blood pressure (before induction of anesthesia, at 1, 2, 3, 4, and 5 minutes after induction of anesthesia, at the start of surgery, and at the end of surgery). The secondary outcomes were the doses of vasoconstrictors (dopamine, dobutamine, adrenaline, noradrenaline, and phenylephrine), vasodilators (nicardipine), and opioids (remifentanil and fentanyl) used.

Water balance (mL) was calculated as water balance (mL) = total infusion volume (mL) + blood transfusion volume (mL) − blood loss volume (mL) − urine volume (mL); maximum catecholamine index was calculated as maximum catecholamine index = dopamine (μg/kg/min) + dobutamine (μg/kg/min) + 100 × adrenaline (μg/kg/min) + 100 × noradrenaline (μg/kg/min); and total catecholamine volume was calculated as total catecholamine volume = dopamine (μg/kg/min) × min + dobutamine (μg/kg/min) × min + 100 × adrenaline (μg/kg/min) × min + 100 × noradrenaline (μg/kg/min) × min.

### Statistical Analysis

We did not calculate a sample size for the analysis, as we could not estimate the effect size of remimazolam because of the absence of previous data on mean blood pressure during TAVI.

All statistical analyses were performed using EZR, a graphical user interface for R version 4.2.2 (R open source). EZR is a statistical software package that incorporates R commander, which provides a wide variety of statistical functions necessary for medical statistics[10]. Continuous variables are presented as medians (interquartile ranges). The nonparametric Mann-Whitney U test was used for comparisons between the two groups. Categorical variables are presented as frequency (percentage) and were evaluated using the Fisher exact test. The only missing data were mean blood pressure values, which were judged to be missing completely at random, there-

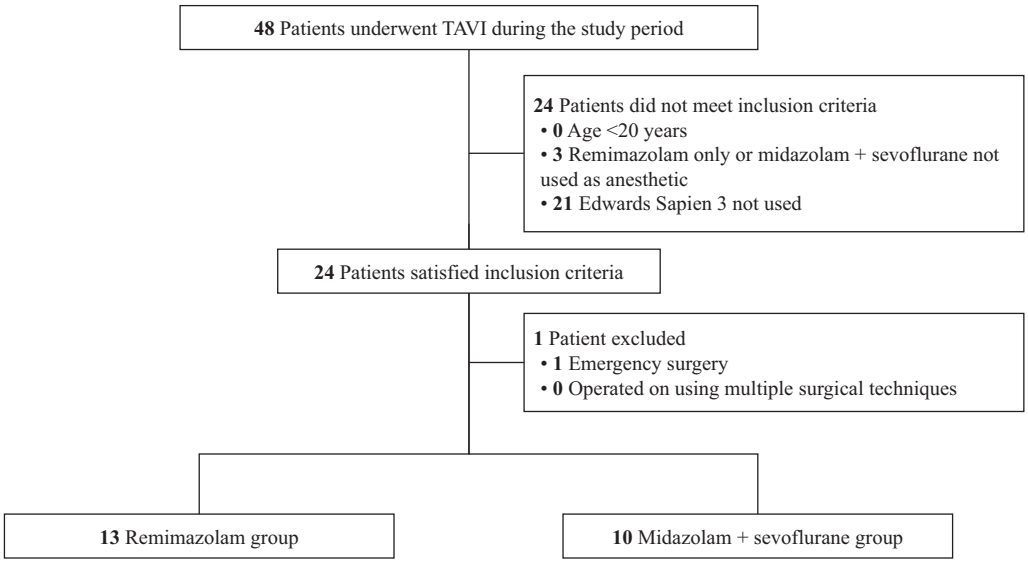


Fig. 1 Flow diagram of study.

fore, analysis was performed after excluding missing data. A *P*-value of <0.05 was considered to indicate statistical significance.

## Results

Of the 48 patients who underwent TAVI during the study period, 23 were included in this study. The remimazolam group comprised 13 patients, and the midazolam + sevoflurane group comprised 10 patients (**Fig. 1**). There was no significant difference in any patient characteristic (except serum creatinine), anesthesia time, operation time, or intraoperative water balance between the two groups. Although there was a significant difference in serum creatinine, no significant difference was found when creatinine clearance was calculated. At the time of anesthesia induction, remimazolam was administered as a bolus or continuous maintenance dose in the remimazolam group, and midazolam was administered intravenously in the midazolam group (**Table 1, 2**).

**Table 3** shows intraoperative use of opioids (remifentanil and fentanyl), vasoconstrictors (dopamine, dobutamine, adrenaline, noradrenaline, and phenylephrine), and vasodilators (nicardipine). There was no significant difference in total fentanyl dose between the groups (1.67 [IQR, 1.06-2.56] vs. 2.40 [IQR, 1.71-2.67] μg/kg, *P*=0.186). By contrast, remifentanil volume (remifentanil administration rate [μg/kg/min] × administration time) was significantly higher in the remimazolam group (9.80 [IQR, 6.00-11.7] vs. 2.67 [IQR, 0.55-5.14] μg/kg, *P*=0.003). Additionally, the maximum rate of remifentanil administration was significantly higher in the remimazolam group (0.10 [IQR, 0.10-0.20] vs. 0.10 [IQR, 0.013-0.10] μg/kg/min, *P*=0.012). Total ephedrine volume, maximum catecholamine index, and total catecholamine volume were lower in the remimazolam group, but the differences were not significant (total ephedrine volume: 8.00 [IQR, 0-12.0] vs. 9.00 [IQR, 4.00-15.0] mg, *P*=0.528; maximum catecholamine index: 5.00 [IQR, 3.00-6.00] vs. 7.00 [IQR, 5.00-8.00], *P*=0.145; total catecholamine volume: 228 [IQR, 128-341] vs. 360 [IQR, 276-439], *P*=0.166). The catecholamines used were noradrenaline and dobutamine. All patients received noradrenaline, and one patient in each group also received dobutamine. The total volume of nicardipine was higher in the remimazolam group, but the difference was not significant (0 [IQR, 0-1.00] vs. 0 [IQR, 0-0.33] mg, *P*=0.607).

**Table 4** shows intraoperative hemodynamics. There was no significant difference in mean blood pressure at any time point (before induction of anesthesia: 92.0 [IQR, 87.0-99.8] vs. 91.0 [IQR, 86.0-107.0] mm Hg, *P*=0.935; after induction of anesthesia—1 minute after: 91.0 [IQR, 83.0-98.5] vs. 90.0 [IQR, 86.3-95.3] mm Hg, *P*=0.843; 2 minutes after: 87.0 [IQR, 79.0-98.0] vs. 91.0 [IQR, 85.3-101.3] mm Hg, *P*=0.709; 3 minutes after: 87.0 [IQR, 79.0-98.0] vs. 88.5 [IQR, 81.3-101.3] mm Hg, *P*=0.710; 4 minutes after: 87.0 [IQR, 77.0-100.0] vs. 88.5 [IQR, 81.3-101.3] mm Hg, *P*=0.556; 5 minutes after: 87.0 [IQR, 77.0-100.0] vs. 88.5 [IQR, 81.3-94.8] mm Hg, *P*=0.832; at the start of surgery: 77.0 [IQR, 70.0-79.0] vs. 82.5 [IQR, 75.5-105.5] mm Hg, *P*=0.072; at the end of surgery: 74.0 [IQR, 71.0-78.0] vs. 82.5 [IQR, 75.5-90.8] mm Hg, *P*=0.082).

Table 1 Baseline characteristics of patients

| | | Remimazolam | Midazolam+sevoflurane | *P* value |
|---|---|---|---|---|
| *n* | | 13 | 10 | |
| Age, median (IQR), years | | 87.0 (85.0-88.0) | 85.5 (81.3-86.8) | 0.382 |
| Sex | Male, n (%) | 4 (30.8) | 6 (60.0) | 0.222 |
| | Female, n (%) | 9 (69.2) | 4 (40.0) | |
| Height, median (IQR), m | | 1.51 (1.42-1.58) | 1.61 (1.51-1.66) | 0.088 |
| Weight, median (IQR), kg | | 47.3 (43.3-59.0) | 59.2 (48.6-74.9) | 0.131 |
| BMI, median (IQR), kg/m$^2$ | | 22.8 (20.8-24.0) | 23.9 (19.9-27.3) | 0.483 |
| PT-INR, median (IQR) | | 1.04 (0.97-1.21) | 1.05 (0.95-1.17) | 0.951 |
| Platelets, median (IQR), $\times 10^3$ μL | | 18.2 (16.1-20.9) | 18.1 (16.7-23.8) | 0.852 |
| Scr, median (IQR), mg/dL | | 0.88 (0.74-0.97) | 1.18 (1.04-1.32) | 0.030 |
| Ccr, median (IQR), mL/min | | 39.3 (32.3-45.0) | 33.9 (31.5-48.7) | 0.927 |
| ASA-PS | 3, n (%) | 3 (23.1) | 0 (0) | 0.229 |
| | 4, n (%) | 10 (76.9) | 10 (100) | |
| Coronary artery disease, n (%) | | 2 (15.4) | 1 (10.0) | 1.000 |
| Myocardial infarction, n (%) | | 0 (0) | 1 (10.0) | 0.435 |
| Heart failure, n (%) | | 7 (53.8) | 6 (60.0) | 1.000 |
| Arrhythmia, n (%) | | 4 (30.8) | 4 (40.0) | 0.685 |
| Hypertension, n (%) | | 11 (84.6) | 6 (60.0) | 0.341 |
| Hyperlipidemia, n (%) | | 7 (53.8) | 5 (50.0) | 1.000 |
| Diabetes mellitus, n (%) | | 5 (38.5) | 3 (30.0) | 1.000 |
| General anesthetics | | | | |
| Remimazolam, median (IQR), mg | | 37.5 (32.2-40.0) | 0 (0-0) | <0.001 |
| Midazolam, median (IQR), mg | | 0 (0-0) | 2.00 (2.00-3.00) | <0.001 |
| Sevoflurane, median (IQR), mL | | 0 (0-0) | 36.1 (31.9-41.3) | <0.001 |
| Dose administered at anesthesia induction | | | | |
| Remimazolam (intravenous injection), median (IQR), mg/kg | | 0.059 (0-0.085) | 0 (0-0) | 0.009 |
| Remimazolam (continuous intravenous infection), median (IQR), mg/kg/h | | 0.51 (0.44-0.56) | 0 (0-0) | <0.001 |
| Midazolam (intravenous injection), median (IQR), mg/kg | | 0 (0-0) | 0.041 (0.036-0.063) | <0.001 |
| Anesthesia time, median (IQR), min | | 117 (111-132) | 124 (104-131) | 1.000 |
| Operation time, median (IQR), min | | 62.0 (55.0-72.0) | 59.5 (51.0-72.8) | 0.852 |

BMI: body mass index, PT-INR: prothrombin time-international normalized ratio, Scr: serum creatinine, Ccr: creatinine clearance (calculated by the Cockcroft Gault formula), ASA-PS: American Society of Anesthesiologists physical status, IQR: interquartile range

Table 2 Intraoperative water balance

| | Remimazolam | Midazolam+sevoflurane | *P* value |
|---|---|---|---|
| Water balance, median (IQR), mL | 1,000 (700-1,200) | 975 (544-1,282) | 1.000 |
| Total infusion volume, median (IQR), mL | 1,100 (1,000-1,300) | 1,025 (900-1,425) | 0.554 |
| Blood transfusion volume, median (IQR), mL | 0 (0-0) | 0 (0-0) | 0.899 |
| Blood loss volume, median (IQR), mL | 0 (0-0) | 0 (0-120) | 0.146 |
| Urine volume, median (IQR), mL | 250 (0-400) | 95.0 (0-259) | 0.725 |

Water balance (mL) was calculated as follows: water balance (mL) = total infusion volume (mL) + blood transfusion volume (mL) − blood loss volume (mL) − urine volume (mL).
IQR: interquartile range

## Discussion

This study investigated the hemodynamic effects and opioid doses used for patients receiving remimazolam during TAVI. The effects of remimazolam on hemodynamics were analyzed by investigating the doses of medications (vasoconstrictors, vasodilators, and opioids) used to maintain stable hemodynamics and comparing these values to those of patients receiving conventional

Table 3 Intraoperative use of opioids, vasoconstrictors, and vasodilators

| | Remimazolam | Midazolam+sevoflurane | *P* value |
|---|---|---|---|
| Opioids | | | |
| Fentanyl, median (IQR), mg | 0.10 (0.050-0.10) | 0.15 (0.10-0.20) | 0.019 |
| Fentanyl, median (IQR), μg/kg | 1.67 (1.06-2.56) | 2.40 (1.71-2.67) | 0.186 |
| Remifentanil maximum, median (IQR), μg/kg/min | 0.10 (0.10-0.20) | 0.10 (0.013-0.10) | 0.012 |
| Remifentanil, median (IQR), (μg/kg/min × administration time [min]) | 9.80 (6.00-11.7) | 2.67 (0.55-5.14) | 0.003 |
| Vasoconstrictors, Vasodilators | | | |
| Ephedrine, median (IQR), mg | 8.00 (0-12.0) | 9.00 (4.00-15.0) | 0.528 |
| phenylephrine, median (IQR), mg | 0 (0-0.050) | 0 (0-0) | 0.446 |
| Nicardipine, median (IQR), mg | 0 (0-1.00) | 0 (0-0.33) | 0.607 |
| Maximum catecholamine index, median (IQR) | 5.00 (3.00-6.00) | 7.00 (5.00-8.00) | 0.145 |
| The total volume of catecholamine, median (IQR) | 228 (128-341) | 360 (276-439) | 0.166 |

Maximum catecholamine index was calculated as maximum catecholamine index = dopamine (μg/kg/min) + dobutamine (μg/kg/min) + 100 × adrenaline (μg/kg/min) + 100 × noradrenaline (μg/kg/min).
Total catecholamine volume was calculated as total catecholamine volume = dopamine (μg/kg/min) × min + dobutamine (μg/kg/min) × min + 100 × adrenaline (μg/kg/min) × min + 100 × noradrenaline (μg/kg/min) × min.
IQR: interquartile range

Table 4 Intraoperative hemodynamics

| | Remimazolam | Midazolam+sevoflurane | *P* value |
|---|---|---|---|
| Before induction of anesthesia, median (IQR), mm Hg | 92.0 (87.0-99.8) | 91.0 (86.0-107.0) | 0.935 |
| 1 minute after induction of anesthesia, median (IQR), mm Hg | 91.0 (83.0-98.5) | 90.0 (86.3-95.3) | 0.843 |
| 2 minutes after induction of anesthesia, median (IQR), mm Hg | 87.0 (79.0-98.0) | 91.0 (85.3-101.3) | 0.709 |
| 3 minutes after induction of anesthesia, median (IQR), mm Hg | 87.0 (79.0-98.0) | 88.5 (81.3-101.3) | 0.710 |
| 4 minutes after induction of anesthesia, median (IQR), mm Hg | 87.0 (77.0-100.0) | 88.5 (81.3-101.3) | 0.556 |
| 5 minutes after induction of anesthesia, median (IQR), mm Hg | 87.0 (77.0-100.0) | 88.5 (81.3-94.8) | 0.832 |
| At start of surgery, median (IQR), mm Hg | 77.0 (70.0-79.0) | 82.5 (75.5-105.5) | 0.072 |
| At end of surgery, median (IQR), mm Hg | 74.0 (71.0-78.0) | 82.5 (75.5-90.8) | 0.082 |

IQR: interquartile range

anesthetics. Maintenance of hemodynamic stability in the remimazolam group was noninferior to midazolam + sevoflurane group, even in patients receiving high doses of remifentanil.

Propofol, with its short elimination half-life, has been widely used in anesthetic induction and maintenance because of its safety. However, propofol suppresses the sympathetic nervous system and thus frequently causes hypotension. Dai et al.[11] reported that propofol was associated with a significantly higher incidence of bradycardia, hypotension, and ventricular premature complexes in patients with coronary heart disease undergoing major noncardiac surgery. By contrast, midazolam was reported to induce only limited hemodynamic changes[12] and thus is generally used in patients for whom hemodynamic stability is a concern, including patients undergoing TAVI. However, remimazolam, which has an elimination half-life approximately one-third that of midazolam, was recently developed and is used for patients with hemodynamic instability[13]. Remimazolam and midazolam are benzodiazepines, but remimazolam is an ultrashort-acting drug with a rapid onset of action and fast awakening time. It is also rapidly metabolized to inactive metabolites by tissue esterases and can be used for induction and maintenance of anesthesia[1,13].

Because patients undergoing TAVI for severe AS were included in this study, intraoperative hemodynamic management and balanced anesthesia with particular attention to analgesia and sedation were important. In such patients, hemodynamics must be carefully monitored because hypotension during TAVI can result in decreased coronary perfusion pressure, development of arrythmias or ischemia, myocardial injury, cardiac failure, and death[14]. Remifentanil has been used for pain control during invasive surgery but decreases blood pressure by 60% to 80%; thus, caution is needed regarding intraoperative hypotension in patients receiving remifentanil.

Remimazolam has been shown to provide better hemo-

dynamic stability than other intravenous anesthetics[15,16]. Liu et al.[17] reported that in patients undergoing valve replacement surgery, hemodynamics were more stable and the incidence of hypotension and dose of vasoconstrictors were lower in a remimazolam induction group than in a propofol induction group. Even in high-risk surgical patients with an ASA-PS of III and older patients, the incidence of hypotension was lower when using remimazolam than when using propofol[18–20].

In the present study, mean blood pressure was slightly lower in the remimazolam group than in the midazolam + sevoflurane group. However, there was no significant difference in mean blood pressure, and mean blood pressure at all time points in this study was >65 mm Hg[21], indicating that remimazolam maintains hemodynamics in patients with an ASA-PS of III and older patients, as reported previously.

In addition, anesthesia time and operation time were shorter in the remimazolam group, but the differences were not significant. There was no significant difference in the catecholamine index or total catecholamine volume. The catecholamines used were noradrenaline and dobutamine. All patients received noradrenaline, and one patient in each group also received dobutamine. Therefore, it is unlikely that the type of catecholamine or the conditions in which it was used affected blood pressure maintenance. Intraoperative water balance was lower in the remimazolam group, but the difference was not significant. Regarding the volume of blood loss, the interquartile range was large in the midazolam + sevoflurane group. However, there was no difference in intraoperative water balance, suggesting that in-out control during surgery was adequate and would not have affected blood pressure. Anesthesia induction was performed with remimazolam at a rate of 0.51 mg/kg/h as a continuous maintenance dose or 0.06 mg/kg as a bolus. In a previous report[22], at the time of induction of anesthesia remimazolam was administered as a continuous maintenance dose or bolus dose, and there was no significant difference in intraoperative blood pressure in any group, which suggests that differences in the method of remimazolam administration during anesthesia induction are unlikely to affect hemodynamics. Thus, we consider it unlikely that anesthesia time, operation time, type of catecholamine and conditions, intraoperative water balance, or method of anesthesia administration affected maintenance of hemodynamic stability.

Therefore, remimazolam appears to be as effective as midazolam + sevoflurane in maintaining intraoperative hemodynamic stability and may be useful in anesthetic management of patients with a high ASA-PS, older patients, and other patients at risk of hypotension.

The remifentanil dose in the remimazolam group was significantly higher than in the midazolam + sevoflurane group, but there was little difference in vasoconstrictor dose (**Table 3**). These results are consistent with previous studies reporting that a remimazolam group had stable hemodynamics, even when receiving a high dose of remifentanil, which has a risk of lowering blood pressure[3,4]. Taken together, the present findings indicate that remimazolam use enables operators to maintain intraoperative hemodynamic stability in surgeries that require careful management of hemodynamics. This allows for aggressive use of remifentanil. Thus, we are able to provide anesthesia with a good balance between analgesia and sedation. Nevertheless, the use and dose of remifentanil will vary in relation to the type of surgery and should be adjusted on an individualized basis.

The total volume of fentanyl administered was slightly lower in the remimazolam group than in the midazolam + sevoflurane group, although the difference was not significant (**Table 3**). Fentanyl and remifentanil are used in combination as anesthesia for pain control during invasive surgery. Since remifentanil may lower blood pressure[23], fentanyl is preferred in conventional midazolam anesthesia to prevent hypotension.

Although both remifentanil and fentanyl have the risk of lowering blood pressure, remifentanil has a stronger effect[23]. Because fentanyl has less of an antihypertensive effect than remifentanil, it is unlikely that the difference in fentanyl dose affected hemodynamics. Therefore, the absence of a significant difference in blood pressure between the two groups suggests that remimazolam maintained hemodynamic stability even when remifentanil was used.

**Study Limitations**

Our study has three limitations. First, it was a retrospective cohort study. Because confounding factors were not available for analysis, prospective studies are needed to investigate the mechanisms by which remimazolam stabilizes hemodynamics. Second, because this was a single-center study, the findings may not be generalizable to other centers, which differ in the annual number of surgeries performed, use of surgical techniques requiring specific medical equipment, and use of opioids. Third, the sample size was small and included only patients undergoing TAVI. However, the baseline characteristics of the two groups were well matched. In future studies, the

sample should be expanded to include other surgeries.

## Conclusions

We compared the hemodynamics of remimazolam to those of midazolam + sevoflurane in patients undergoing TAVI for severe AS. Remimazolam appears to maintain hemodynamics as effectively as midazolam + sevoflurane, even when used with opioids. Our findings suggest that remimazolam is noninferior to midazolam + sevoflurane.

**Availability of data and materials:** The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

**Authors' contributions:** YT, MI designed the concept of this study. YT analyzed the patient data. YT, MI interpreted the patient data. YT drafted the manuscript. YI, MI supervised. All authors made substantial contributions to this work. All authors have reviewed and approved the final manuscript.

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**Conflict of Interest:** The authors declare that they have no competing interests.

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