ORIGINAL RESEARCH

Comparative Study on the Impact of Remifentanil vs. Fentanyl in General Anesthesia for High-Risk Cardiac Patients

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ABSTRACT

Aim: The aim of this study was to compare the impact of remifentanil versus fentanyl in general anesthesia for high-risk cardiac patients undergoing elective cardiac surgery, focusing on their effects on hemodynamic stability, opioid consumption, recovery profiles, and postoperative outcomes.

Materials and Methods: A prospective, randomized, comparative study was conducted with 100 patients undergoing elective cardiac surgery. Patients were randomly assigned to receive either remifentanil (Group R) or fentanyl (Group F) for anesthesia maintenance. The primary outcomes assessed included hemodynamic parameters, opioid consumption, recovery times, postoperative pain, nausea, vomiting, and patient satisfaction.

Results: The baseline characteristics of the two groups were comparable. Both remifentanil and fentanyl provided similar hemodynamic stability, with no significant differences in heart rate, blood pressure, or incidence of intraoperative hypotension. Total opioid consumption was significantly higher in the remifentanil group (380.2 ± 45.3 µg) compared to the fentanyl group (250.5 ± 30.2 µg). The recovery profiles were similar between the groups, with marginally faster extubation and recovery times in the remifentanil group, but no significant differences in additional postoperative analgesia needs. Postoperative pain control was significantly better in the remifentanil group, as indicated by lower VAS scores (2.5 ± 1.1 vs. 3.2 ± 1.4, $p = 0.03$). There were no significant differences in nausea, vomiting, or overall patient satisfaction between the groups.

Conclusion: Both remifentanil and fentanyl provide effective anesthesia for high-risk cardiac patients, with similar hemodynamic stability and recovery profiles. Remifentanil, however, provided superior postoperative pain control but required higher opioid consumption. The choice between these two opioids should be based on the patient's specific needs, including pain management and recovery time considerations.

Keywords: Remifentanil, Fentanyl, High-risk cardiac patients, General anesthesia, Postoperative pain

Introduction

General anesthesia plays a crucial role in the management of high-risk cardiac patients undergoing surgical procedures. The selection of anesthetic agents is particularly important in this population due to their complex medical conditions, which often include coronary artery disease, heart failure, or other comorbidities that make anesthesia management challenging. Among the various anesthetic agents used, opioids are commonly employed to provide analgesia and sedation during surgery. Two such opioids frequently used in general anesthesia are remifentanil and fentanyl. Both drugs belong to the class of synthetic opioids but differ in their pharmacological properties, mechanisms of action, and clinical outcomes.[1]

Remifentanil, a potent ultra-short-acting opioid, and fentanyl, a longer-acting opioid, have been widely used in anesthesiology, particularly for patients undergoing major surgeries. However, despite their widespread use, there remains considerable debate regarding the relative benefits and risks of remifentanil and fentanyl in high-risk cardiac patients. These patients often present with heightened sensitivity to opioids due to their underlying cardiovascular conditions, making it crucial to choose an opioid that not only provides effective analgesia but also ensures cardiovascular stability.[2]

Remifentanil, with its rapid onset and ultra-short duration of action, is often chosen for situations requiring precise control over anesthetic depth and rapid recovery. Its pharmacokinetic properties—

metabolized by nonspecific esterases in the plasma and tissues—allow for quick cessation of effects once the infusion is discontinued. This makes remifentanil especially useful in cases where fast recovery from anesthesia is essential. On the other hand, fentanyl, a more traditional opioid, has a longer half-life and is metabolized primarily in the liver, which may result in prolonged effects, particularly in patients with impaired hepatic function. Fentanyl's extended duration of action, while beneficial in some settings, may present challenges in high-risk cardiac patients, as it could prolong the recovery time and potentially complicate the management of postoperative pain and hemodynamic stability.[3]

The choice between remifentanil and fentanyl for high-risk cardiac patients requires careful consideration of several factors, including their hemodynamic stability, pain management needs, and the potential for opioid-induced side effects. For instance, fentanyl's ability to cause respiratory depression and its potential to accumulate in patients with reduced renal or hepatic function could complicate its use in individuals with compromised organ function. In contrast, the rapid clearance of remifentanil may offer advantages in terms of reducing the likelihood of respiratory depression and improving recovery times, although concerns about its cardiovascular effects, such as hypotension and bradycardia, persist.[4]

Moreover, the impact of these opioids on the cardiovascular system is a significant concern in high-risk cardiac patients. Both remifentanil and fentanyl can affect heart rate, blood pressure, and cardiac output. However, their effects differ in terms of intensity and duration. Fentanyl, as a more potent opioid, may cause significant bradycardia and hypotension, particularly when administered in high doses. Remifentanil, though also capable of inducing bradycardia, may be less likely to cause sustained hypotension due to its shorter duration of action. Nonetheless, both opioids necessitate careful titration, particularly in cardiac patients, where even slight fluctuations in blood pressure and heart rate can have serious consequences.[5]

Another important factor in comparing the two opioids is the management of postoperative analgesia. High-risk cardiac patients often experience significant pain after surgery, which requires effective analgesic management. Both remifentanil and fentanyl can be used for postoperative pain relief; however, the duration of analgesia provided by fentanyl may be more prolonged, potentially requiring the use of additional analgesics or interventions. In contrast, the shorter half-life of remifentanil may necessitate the use of alternative analgesic agents in the postoperative period, which could affect overall pain management strategies.[6-8]

Despite these differences, both remifentanil and fentanyl have been associated with certain risks and benefits in cardiac surgery settings. The pharmacokinetic properties of remifentanil make it an attractive option in surgeries requiring precise and rapid control of anesthesia depth, whereas fentanyl's longer duration of action may be advantageous for maintaining stable analgesia during extended procedures. However, the use of both opioids requires careful monitoring of the patient's hemodynamic status, particularly in high-risk cardiac patients, where sudden changes in blood pressure, heart rate, or respiratory function could lead to significant complications.

Materials and Methods

This was a prospective, randomized, comparative study conducted to evaluate and compare the impact of Remifentanil versus Fentanyl in general anesthesia for high-risk cardiac patients. A total of 100 patients undergoing elective cardiac surgery with general anesthesia were enrolled in the study. The study was conducted in accordance with the Declaration of Helsinki, and all patients provided written informed consent prior to participation. The study received ethical approval from the institutional review board.

Inclusion Criteria

- Adults aged 18 to 75 years.
- ASA (American Society of Anesthesiologists) physical status III or IV.
- Undergoing elective cardiac surgery requiring general anesthesia (e.g., coronary artery bypass grafting, valve replacement).
- Patients with significant cardiovascular disease (e.g., severe coronary artery disease, heart failure).
- Patients who gave written informed consent.

Exclusion Criteria

- Known allergies to opioids or local anesthetics.
- Severe liver or renal dysfunction.
- Patients with a history of adverse reactions to either Remifentanil or Fentanyl.
- Patients undergoing emergency cardiac surgery.
- Pregnancy or lactation.

Randomization and Group Assignment

Patients were randomly assigned to one of two groups using a computer-generated random number table:

1. **Group R (Remifentanil group):** 50 patients received Remifentanil infusion as the primary opioid for anesthesia maintenance.
2. **Group F (Fentanyl group):** 50 patients received Fentanyl as the primary opioid for anesthesia maintenance.

Anesthesia Protocol

All patients underwent a standard preoperative evaluation, which included a comprehensive assessment of their cardiac function. Baseline vital signs were recorded to ensure each patient's suitability for surgery. Premedication was administered in

accordance with the institutional protocol, typically including 1–2 mg of intravenous midazolam to reduce anxiety, before patients were transferred to the operating room.

Induction of Anesthesia

The induction of anesthesia was standardized for all patients, involving the intravenous administration of 2 mg/kg of propofol to achieve a rapid onset of general anesthesia. This was followed by the administration of 0.1 mg/kg of intravenous Rocuronium to facilitate muscle relaxation. In the Remifentanil group (Group R), Remifentanil was administered as a continuous infusion, with a dose ranging from 0.1 to 0.5 µg/kg/min, adjusted based on the patient's clinical needs and tolerance. In the Fentanyl group (Group F), Fentanyl was given as an intravenous bolus at a dose of 3–5 µg/kg during induction.

Maintenance of Anesthesia

Maintenance of anesthesia for both groups was achieved through the administration of inhaled isoflurane, typically ranging between 0.5% and 1.5%, adjusted according to the clinical requirements during surgery. Additional boluses of Remifentanil or Fentanyl were given when necessary to ensure adequate anesthetic depth. The maximum allowed dose of Remifentanil was capped at 1 µg/kg/min, while the maximum dose for Fentanyl was limited to 10 µg/kg to avoid excessive opioid administration.

Monitoring

Intraoperative monitoring followed standard practices and included continuous electrocardiogram (ECG) monitoring, non-invasive blood pressure (NIBP) measurements, pulse oximetry (SpO2), and capnography. Additionally, the depth of anesthesia was closely monitored using a bispectral index (BIS) score, with the target range for anesthesia maintenance being between 40 -60, ensuring a balanced level of sedation and analgesia.

Outcome Measures

The primary outcomes of the study were designed to evaluate the clinical efficacy and safety of Remifentanil versus Fentanyl in the perioperative setting. Hemodynamic stability was closely monitored by tracking the heart rate (HR), mean arterial pressure (MAP), systolic blood pressure and Diastolic blood pressure and any requirement for vasoactive agents to stabilize the patient's hemodynamics during surgery at bases line , after 5 min, 10min, 20min, 30 min and 45 min and et the end of the treatment. Intraoperative hypotension was defined as a decrease in MAP by more than 20% from baseline values. The total opioid consumption for each patient was recorded, representing the total amount of Remifentanil or Fentanyl administered throughout the surgical procedure. The recovery profile was assessed by the time required for extubation, the time to achieve full recovery, and the need for additional postoperative analgesia.

Secondary outcomes included assessments of postoperative pain, measured using the Visual Analog Scale (VAS) at intervals of 0, 1, 6, and 24 hours post-surgery. The incidence of postoperative nausea and vomiting (PONV) was monitored by recording the number of patients who experienced nausea or vomiting within 24 hours following surgery. Finally, patient satisfaction was evaluated using a 5-point Likert scale administered 24 hours postoperatively to gauge overall satisfaction with the anesthesia regimen and recovery experience.

Statistical Analysis

The data collected in this study were analyzed using SPSS version 25.0 (IBM Corp, Armonk, NY, USA). Continuous variables were presented as either mean ± standard deviation (SD) or median with interquartile range (IQR), depending on the distribution of the data. Categorical variables were expressed as frequency and percentage. To compare continuous variables between groups, independent t-tests were performed for normally distributed data, while Mann-Whitney U tests were used when the data were not normally distributed. For categorical variables, comparisons between groups were made using the Chi-square test or Fisher's exact test, depending on the size and distribution of the data. A p-value of less than 0.05 was considered statistically significant for all analyses.

Table 1: Demographic and Baseline Characteristics of Patients

The demographic characteristics of the patients in both groups were similar. The age of patients in Group R (Remifentanil) was 58.4 ± 10.2 years, and in Group F (Fentanyl), it was 59.1 ± 9.8 years, showing no significant difference (p-value = 0.65). The gender distribution was also comparable, with 60% male and 40% female in the Remifentanil group, and 64% male and 36% female in the Fentanyl group (p-value = 0.80). Additionally, the ASA classification was similar, with 60% in ASA III and 40% in ASA IV in both groups (p-value = 0.79). The Body Mass Index (BMI) was almost identical, with a mean of 28.6 ± 4.3 in the Remifentanil group and 29.1 ± 4.5 in the Fentanyl group (p-value = 0.60). Furthermore, the preoperative comorbidities, including diabetes (70% in Group R and 72% in Group F) and hypertension (60% in Group R and 59% in Group F), were distributed similarly between the two groups (p-value = 0.70). These findings suggest that the baseline characteristics of both groups were comparable, which helps ensure that any differences in the outcomes could be attributed to the anesthetic agents used rather than patient characteristics.

Table 2: Comparison of Hemodynamic Parameters between Group R (Remifentanil) and Group F (Fentanyl)

The hemodynamic parameters, including heart rate, systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP), were similar between the two groups throughout the surgery. At baseline, the heart rate was 78.4 ± 5.2 bpm in the Remifentanil group and 79.2 ± 5.5 bpm in the Fentanyl group (p-value = 0.62). Similarly, no significant differences were found at subsequent time points, including 5, 10, 20, 30, 45 minutes, and at the end of surgery (p-values ranged from 0.56 to 0.81). In terms of systolic blood pressure, both groups showed a comparable reduction from baseline to the end of surgery (Remifentanil: 130.5 ± 10.4 mmHg to 116.0 ± 8.0 mmHg, Fentanyl: 131.5 ± 9.8 mmHg to 116.5 ± 8.2 mmHg) with no significant difference (p-value = 0.60 at baseline and p-value = 0.91 at the end). Diastolic blood pressure and MAP followed a similar trend, with no significant differences between the two groups across all time points (p-values ranged from 0.65 to 0.92). These results suggest that both Remifentanil and Fentanyl provided similar hemodynamic stability during the surgical procedure.

Table 3: Intraoperative Hypotension and Use of Vasoactive Agents

The incidence of intraoperative hypotension and the use of vasoactive agents were similar between the two groups. In the Remifentanil group, 32% of patients experienced hypotension, while in the Fentanyl group, 34% had hypotension (p-value = 0.68). Similarly, 24% of patients in the Remifentanil group and 26% in the Fentanyl group required vasoactive agents to maintain hemodynamic stability (p-value = 0.72). These findings indicate that both groups had similar rates of intraoperative hypotension and the use of vasoactive agents, suggesting that neither opioid caused significantly more hemodynamic instability than the other during surgery.

Table 4: Total Opioid Consumption

The total opioid consumption was significantly higher in the Remifentanil group compared to the Fentanyl group. The mean opioid consumption in the Remifentanil group was 380.2 ± 45.3 µg, while in the Fentanyl group, it was 250.5 ± 30.2 µg (p-value = 0.01). This significant difference may be due to the pharmacokinetic properties of the drugs, as Remifentanil is a short-acting opioid that is typically administered continuously during surgery, while Fentanyl is administered in bolus doses. The higher consumption in the Remifentanil group reflects the continuous infusion required to maintain adequate analgesia during the procedure.

Table 5: Recovery Profile and Postoperative Analgesia

The recovery profiles between the two groups were comparable. The time to extubation was slightly shorter in the Remifentanil group (10.2 ± 2.5 min) compared to the Fentanyl group (11.5 ± 3.1 min), but the difference was not statistically significant (p-value = 0.23). Similarly, the time to full recovery was slightly faster in the Remifentanil group (45.6 ± 8.4 min) compared to the Fentanyl group (47.1 ± 9.2 min), with no significant difference (p-value = 0.55). In terms of additional postoperative analgesia, 40% of patients in the Remifentanil group required it, compared to 45% in the Fentanyl group, with no statistically significant difference between the groups (p-value = 0.72). These findings suggest that both groups had similar recovery times and a comparable need for additional postoperative analgesia.

Table 6: Postoperative Outcomes (Pain, Nausea, and Satisfaction)

Postoperative outcomes, including pain, nausea, vomiting, and patient satisfaction, were assessed in both groups. The Visual Analog Scale (VAS) score for pain was significantly lower in the Remifentanil group (2.5 ± 1.1) compared to the Fentanyl group (3.2 ± 1.4), with a p-value of 0.03, indicating that Remifentanil provided better pain control postoperatively. The incidence of postoperative nausea was 18% in the Remifentanil group and 22% in the Fentanyl group, with no significant difference (p-value = 0.56). Postoperative vomiting occurred in 12% of patients in the Remifentanil group and 15% in the Fentanyl group, with no significant difference between the groups (p-value = 0.61). Patient satisfaction, measured on a 5-point Likert scale, was 4.1 ± 0.8 in the Remifentanil group and 4.0 ± 0.7 in the Fentanyl group, with no significant difference (p-value = 0.73). These results indicate that while the Remifentanil group had better pain control, both groups had similar outcomes in terms of nausea, vomiting, and overall satisfaction.

Table 1: Demographic and Baseline Characteristics of Patients

Characteristic	Group R (Remifentanil)	Group F (Fentanyl)	p-value
Age (years)	58.4 ± 10.2	59.1 ± 9.8	0.65
Gender (Male/Female)	30 (60%) / 20 (40%)	32 (64%) / 18 (36%)	0.80
ASA Classification (III/IV)	30 (60%) / 20 (40%)	32 (64%) / 18 (36%)	0.79
BMI (kg/m²)	28.6 ± 4.3	29.1 ± 4.5	0.60
Preoperative Comorbidities (%)	70% Diabetes, 60% HTN	72% Diabetes, 59% HTN	0.70

Table 2: Comparison of Hemodynamic Parameters between Group R (Remifentanil) and Group F (Fentanyl)

Parameter	Group R (Remifentanil)	Group F (Fentanyl)	p-value
Heart Rate (bpm)			
Baseline	78.4 ± 5.2	79.2 ± 5.5	0.62
5 min	75.6 ± 6.4	74.8 ± 5.9	0.67
10 min	74.3 ± 6.1	73.5 ± 5.8	0.72
20 min	73.8 ± 6.0	72.8 ± 5.7	0.56
30 min	72.4 ± 5.5	71.9 ± 5.3	0.81
45 min	70.9 ± 5.1	70.2 ± 5.0	0.78
End of Surgery	69.3 ± 5.0	68.5 ± 4.8	0.75
Systolic BP (mmHg)			
Baseline	130.5 ± 10.4	131.5 ± 9.8	0.60
5 min	128.7 ± 9.9	129.0 ± 9.7	0.75
10 min	125.8 ± 10.1	126.5 ± 10.3	0.72
20 min	121.5 ± 9.7	122.5 ± 9.5	0.63
30 min	119.0 ± 9.3	120.2 ± 9.0	0.77
45 min	118.5 ± 8.9	119.0 ± 8.3	0.85
End of Surgery	116.0 ± 8.0	116.5 ± 8.2	0.91
Diastolic BP (mmHg)			
Baseline	80.3 ± 8.2	81.0 ± 8.0	0.70
5 min	78.4 ± 7.9	79.2 ± 7.5	0.65
10 min	76.2 ± 8.3	76.0 ± 8.1	0.90
20 min	74.5 ± 7.8	75.0 ± 7.6	0.79
30 min	72.8 ± 7.6	73.0 ± 7.2	0.91
45 min	71.9 ± 7.3	72.2 ± 7.1	0.85
End of Surgery	70.0 ± 7.0	70.5 ± 7.3	0.80
MAP (mmHg)			
Baseline	98.2 ± 7.5	98.8 ± 7.4	0.71
5 min	96.1 ± 8.0	96.0 ± 7.8	0.98
10 min	94.0 ± 8.3	94.3 ± 8.0	0.89
20 min	90.3 ± 7.8	90.8 ± 7.4	0.81
30 min	88.0 ± 7.4	88.6 ± 7.2	0.79
45 min	87.3 ± 6.9	87.5 ± 6.8	0.93
End of Surgery	85.0 ± 7.2	85.5 ± 7.0	0.92

Table 3: Intraoperative Hypotension and Use of Vasoactive Agents

Group	Intraoperative Hypotension (%)	Vasoactive Agents Required (%)	p-value
Group R (Remifentanil)	16 (32%)	12 (24%)	0.68
Group F (Fentanyl)	17 (34%)	13 (26%)	0.72

Table 4: Total Opioid Consumption

Group	Total Opioid Consumption (µg)	p-value
Group R (Remifentanil)	380.2 ± 45.3 (µg)	0.01
Group F (Fentanyl)	250.5 ± 30.2 (µg)	

Table 5: Recovery Profile and Postoperative Analgesia

Parameter	Group R (Remifentanil)	Group F (Fentanyl)	p-value
Time to Extubation (min)	10.2 ± 2.5 (min)	11.5 ± 3.1 (min)	0.23
Time to Full Recovery (min)	45.6 ± 8.4 (min)	47.1 ± 9.2 (min)	0.55
Additional Postoperative Analgesia (%)	20 (40%)	22 (45%)	0.72

Table 6: Postoperative Outcomes (Pain, Nausea, and Satisfaction)

Outcome	Group R (Remifentanil)	Group F (Fentanyl)	p-value
VAS Score (0-10)	2.5 ± 1.1	3.2 ± 1.4	0.03
Postoperative Nausea (%)	9 (18%)	11 (22%)	0.56
Postoperative Vomiting (%)	6 (12%)	8 (15%)	0.61
Patient Satisfaction (5-point scale)	4.1 ± 0.8	4.0 ± 0.7	0.73

Discussion

In this study, we compared the impact of remifentanil versus fentanyl on a variety of factors in high-risk cardiac patients undergoing cardiac surgery.

The baseline demographic characteristics of the patients in both groups were comparable. The average age, gender distribution, ASA classification, BMI, and comorbidities such as diabetes and hypertension were almost identical across the remifentanil and fentanyl groups. This ensures that any differences observed in outcomes between the two groups are likely attributable to the anesthetic agents used rather than patient demographics or baseline health status (Miller & Pardo, 2009).[9]

Both remifentanil and fentanyl demonstrated similar hemodynamic stability during the surgical procedures. No significant differences in heart rate, systolic blood pressure (SBP), diastolic blood pressure (DBP), or mean arterial pressure (MAP) were observed at any time point throughout the surgery. These findings align with those of Kallio and Alahuhta (2001), who also reported no significant differences in hemodynamic parameters between remifentanil and fentanyl in high-risk cardiovascular surgery patients.[10] In both groups, the reduction in blood pressure was modest, and there were no major fluctuations that would suggest one opioid had a superior effect on maintaining hemodynamic stability. Similar results were reported by Ferreira and Lira (2008), who found no significant differences in the hemodynamic responses to remifentanil and fentanyl during coronary artery bypass graft surgery.[11]

The incidence of intraoperative hypotension and the requirement for vasoactive agents were similar between the two groups. Specifically, 32% of patients in the remifentanil group and 34% in the fentanyl group experienced hypotension, and 24% and 26% required vasoactive agents, respectively. These findings are consistent with those of Hajjar and Oweiss (2003), who did not observe a significant difference in the cardiovascular responses between remifentanil and fentanyl in cardiac surgery patients. Both opioids appear to have a similar impact on blood pressure regulation, with neither causing a significantly higher rate of hypotension or the need for pharmacological interventions.[12]

There was a significant difference in total opioid consumption between the two groups, with the remifentanil group requiring considerably more opioid (380.2 ± 45.3 µg) than the fentanyl group (250.5 ± 30.2 µg). This finding reflects the pharmacokinetic properties of the drugs, as remifentanil is typically administered via continuous infusion to maintain analgesia, whereas fentanyl is often administered in bolus doses. This result is supported by the literature, where studies have consistently found that remifentanil requires higher doses to maintain its short-acting analgesic effects compared to fentanyl (Zhang & Yu, 2012).[13] The higher opioid consumption in the remifentanil group also supports the understanding that remifentanil's pharmacokinetics necessitate more continuous administration for sustained analgesia, particularly in long surgeries (Fisher & Rodela, 2000).[14]

The recovery profiles in both groups were comparable, with a slight advantage in terms of the time to extubation in the remifentanil group (10.2 ± 2.5 min) compared to the fentanyl group (11.5 ± 3.1 min). Although this difference was not statistically significant, it suggests that remifentanil may offer a faster recovery time, which has been previously reported in the literature (Knott & Tan, 2013).[15] The time to full recovery and the requirement for additional postoperative analgesia were also similar between the two groups, as demonstrated by Gupta and Agarwal (2015), who reported no significant difference in recovery times for patients receiving either remifentanil or fentanyl. In both groups, 40-45% of patients required additional postoperative analgesia, suggesting that both opioids provided adequate pain relief during surgery, but similar supplementary measures were needed postoperatively.[16]

When evaluating postoperative outcomes, remifentanil showed a slight advantage over fentanyl in terms of pain management, with a significantly lower VAS score (2.5 ± 1.1 vs. 3.2 ± 1.4, $p = 0.03$). This finding is consistent with those of Tobias and Rao (2003), who reported that remifentanil provided superior postoperative pain control in pediatric cardiac surgery patients.[17] However, the incidence of postoperative nausea and vomiting was similar between the two groups, with no significant differences in the occurrence of these symptoms. These results are in line with studies by Kothari and Shukla (2012), who found that remifentanil did not lead to higher rates of nausea and vomiting compared to fentanyl in cardiac surgery patients.[18] Moreover, patient satisfaction scores were nearly identical between the two groups, indicating that despite the difference in pain control, both opioids provided comparable overall satisfaction, as also seen in the study by Knott and Tan (2013).[15]

Conclusion

In conclusion, both remifentanil and fentanyl provide effective anesthesia for high-risk cardiac surgery patients, with similar hemodynamic stability and recovery profiles. However, remifentanil was associated with better postoperative pain control but required higher opioid consumption compared to fentanyl. Both agents had comparable rates of intraoperative hypotension and the need for vasoactive agents, as well as similar patient satisfaction scores. These findings suggest that the choice between remifentanil and fentanyl should depend on the specific needs of the patient, such as pain management and recovery speed.

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