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RESEARCH ARTICLE

Remifentanil versus Fentanyl impact on Ejection Fraction and Troponin in Off-Pump Cardiac Surgery

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Abstract

Background: Remifentanil is structurally synthesized from fentanyl. It offers markedly superior analgesic effects compared to fentanyl and reaches peak efficacy within minutes after parenteral dosing (1). This study compared the effects of fentanyl and remifentanil on ejection fraction (EF) and troponin I measurement during elective off-pump coronary artery bypass graft (OPCABG) surgery.

Methods: Seventy-two patients, aged 35-75 years, were included. Parameters recorded include arterial oxygen saturation (SaO_2), heart rate (HR), invasive blood pressure (IBP), and EF. Baseline IBP was recorded before any surgical or anesthetic interventions. In addition, a baseline blood sample was collected for troponin I measurement. Before anesthesia induction, all patients received 100% oxygen for at least 3 minutes, followed by intravenous midazolam 0.06 mg/kg, propofol 1.3 mg/kg, rocuronium 1.2 mg/kg, and sevoflurane 0.5 MAC. Patients were then randomly assigned to one of the two groups (randomization was done using patient numbering: odd-numbered patients were assigned to Group R (remifentanil group), and even-numbered patients to Group F (fentanyl group); Group R received 0.5 µg/kg remifentanil over 1 minute for induction and 0.1–1 µg/kg/hour for maintenance. Meanwhile, Group F received 5 µg/kg fentanyl over 1 minute for induction and 0.1–1 µg/kg/hour for maintenance.

Data were analyzed using SPSS version 23 (IBM Corp., USA). Normality was assessed with the Kolmogorov–Smirnov and Shapiro–Wilk tests. Normally distributed data were expressed as mean ± SD and nonnormally distributed data as median (IQR). EF and serum troponin were analyzed using the Friedman and Wilcoxon signed-rank tests, respectively, and group comparisons were performed using the Mann–Whitney U test. A p-value < 0.05 was considered statistically significant.

Results: Group R showed a median preoperative EF of 55% (IQR 0.110, MR 29.23), while Group F had 58% (IQR 0.113, MR 1.77). The overall median preoperative EF was 56% (IQR 0.100), with no significant difference between groups (p=0.567). Intraoperatively, Group R demonstrated a higher median EF of 60% (IQR 0.12, MR 37.33) compared with 52% (IQR 0.10, MR 23.67) in Group F. The overall intraoperative EF was 52% (IQR 0.10), with a statistically significant difference (p=0.002). The p-value of 0.001 indicates a highly statistically significant difference in serum troponin I levels from preoperative to 24 hours post intensive care unit (ICU) admission for both R and F groups. The p-value of 0.024 indicates a highly statistically significant difference in serum troponin I levels between Group R and Group F, with Group R having a higher median 24 hours post ICU admission troponin.

Conclusion: Both opioids provided safe and effective anesthesia for OPCABG. However, remifentanil was associated with superior intraoperative EF, suggesting greater compatibility with fast-track anesthesia and enhanced postoperative recovery, on the other side, remifentanil demonstrated higher serum troponin levels compared with fentanyl.

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1. Introduction

Cardiac surgery is the final step in the treatment of coronary artery disease, especially for patients with multivessel involvement and those who are not candidates for percutaneous coronary catheterization. Coronary artery bypass graft (CABG) is the most common cardiovascular treatment globally among surgical procedures [1–3]. The conventional on-pump CABG approach has progressively been supplanted, in specific patient cohorts, by OPCABG, a method that circumvents cardiopulmonary bypass and its related consequences, including systemic inflammation, neurological dysfunction, and renal impairment [4, 5]. OPCABG is especially beneficial for high-risk and elderly patients, as it may decrease the likelihood of early mortality, stroke, and extended mechanical ventilation [6, 7].

Ensuring stable intraoperative hemodynamic patient parameters is one of the duties of an anesthesiologist, in addition to achieving a carefully balanced anesthetic and analgesic plan for optimal outcomes in high-stakes procedures [8]. The selection of opioid analgesia has a substantial impact on intraoperative hemodynamic stability, postoperative pain management, and patient recovery outcomes. General anesthesia is usually attained through a combination of hypnotics, neuromuscular blockers, and opioids, ensuring adequate depth while maintaining cardiovascular stability [9].

Fentanyl, a synthetic phenylpiperidine opioid, has been a cornerstone of cardiac anesthetics for decades. It is distinguished by significant potency, swift onset, and modest duration of effect. It provides significant analgesia with minimal myocardial depression, rendering it appropriate for patients with impaired cardiovascular function [1]. Fentanyl is a potent Mu opioid receptor agonist that produces analgesia by binding to receptors within the brain and spinal cord, thereby inhibiting pain transmission. Although its primary action is mediated through Mu opioid receptors, fentanyl may also interact with delta and kappa opioid subtypes, contributing to its broader pharmacological effects [10]. Remifentanil is an ultra-short-acting μ-opioid receptor agonist, metabolized by nonspecific blood and tissue esterases, and functions independently of hepatic or renal function. It demonstrates a swift onset and offset of action, facilitating accurate titration and quick recovery postoperatively, even following extended infusions. The pharmacokinetic properties of remifentanil render it especially suitable for rapid cardiac anesthesia protocols [11].

Consequently, remifentanil's pharmacokinetics are mostly unaffected by renal or hepatic dysfunction, rendering it especially appropriate for critically sick patients who frequently exhibit organ impairment [12]. In comparison to other opioids, remifentanil exhibits fast action, with peak analgesic effects within 1–3 minutes of intravenous injection. This is attributable to its brief blood–brain equilibration half-time (1.2–1.4 minutes), facilitating rapid infiltration into the central nervous system [13].

Opioids such as fentanyl and remifentanil are commonly utilized in cardiac surgeries owing to their strong analgesic effects and favorable cardiovascular safety profiles [14].

This study aimed to compare the effects of fentanyl and remifentanil on EF and troponin I measurement during elective OPCABG surgery.

2. Materials and Methods

2.1. Ethical approval

The current study proposal was approved by the ethics and scientific committee of the Duhok General Director of Health in Duhok City, Iraq, reference number: 30102024-9-19 on 30 October 2024.

2.2. Study design

This clinical study is a prospective randomized comparative convenient sampling trial performed at the Heart Center in Azadi Teaching Hospital, Duhok, Iraq. The cases were collected from 6th November 2024 to 11th May 2025.

2.3. Patients and methods

A total of 72 patients, aged 35-75 years, with American Society of Anesthesiologists (ASA) physical status II or III [15], scheduled for elective OPCABG surgery, were enrolled in the study. The study conducted patient assessments after obtaining written, predesigned informed consent from all participants.

Preoperatively, a baseline blood sample was collected for troponin- I measurement for all patients; they were assessed at baseline using an electrocardiogram (ECG) and SaO_2. Cardiac output (EF) was assessed via transthoracic echocardiography (TTE).

Before anesthesia induction, all 72 patients received 100% oxygen for at least three minutes, followed by intravenous midazolam 0.06 mg/kg, propofol 1.3 mg/kg, rocuronium 1.2 mg/kg, and sevoflurane 0.5 MAC. Patients were then randomly assigned to one of the two groups (randomization was done using patient numbering: odd-numbered patients were assigned to remifentanil group (Group R), and even-numbered patients to fentanyl group (Group F)); Group R received 0.5 μg/kg remifentanil over one 1 for induction and 0.1–1 μg/kg/hour for maintenance; Group F received 5 μg/kg fentanyl over one 1 for induction and 0.1–1 μg/kg/hour for maintenance.

After induction, all patients were ventilated with a gas mixture of 40% oxygen and 60% air. Ventilation was adjusted to maintain end-tidal CO_2 ($EtCO_2$) between 30 and 35 mmHg by manipulating tidal volume and respiratory rate.

Intraoperatively, all patients were monitored using ECG, SaO_2, $EtCO_2$, nasopharyngeal temperature, and ventilatory parameters (peak inspiratory pressure, compliance, resistance, and positive end-expiratory pressure). Blood pressure was also monitored invasively via a left radial arterial line, and central venous pressure was measured using a central line in the right internal jugular vein continuously. Cardiac function, specifically EF, was assessed

via transesophageal echocardiography (TEE) immediately prior to anastomosis.

All patients underwent coronary revascularization using the left internal mammary artery (LIMA). For additional grafts, saphenous vein grafts were used. A single dose of intravenous heparin (150 IU/kg) was administered after LIMA dissection. Postoperatively, IBP, HR, and SaO_2 were documented through arterial line upon ICU admission. EF and serum troponin I levels were measured after 24 hours the first was by TTE while the second was by venous blood sampling.

2.4. Exclusion criteria

Exclusion criteria were the following: any patient with an EF of less than 35%; the preoperative use of inotropic agents and an intra-aortic balloon pump; major organ failure [creatinine >1.5 mg/dL, serum glutamic oxaloacetic transaminase (SGOT) >40 IU/L, serum glutamic pyruvic transaminase (SGPT) >40 IU/L, hematocrit (Hct) <30%]; opioid intolerance; and a history of neurological diseases or a cerebrovascular event.

However, 12 cases were dropped from the assessment due to intraoperative conversion to on-pump CABG (n=6), withdrawal of consent (n=3), and protocol violations such as incomplete data or medication errors (n=3).

2.5. Statistical analysis

The collected data from 60 patients were entered, managed, and analyzed using Microsoft Excel. The raw data were entered into Microsoft Excel spreadsheets, and data validation techniques were applied to check for missing values, duplicates, and inconsistencies. The Excel data sheet was imported into SPSS 23 (IBM).

The descriptive statistics were reported as mean (SD) for normally distributed variables and median (IQR) for nonnormally distributed numerical variables, frequencies and percentages were calculated for categorical variables. The bivariate association between main baseline characteristics and the analgesic groups (remifentanil and fentanyl) were applied using Chi-square test to assess statistical significance. Furthermore, the independent *t*-test used to assess the mean differences for the baseline continuous variables.

The Kolmogorov–Smirnov and Shapiro–Wilk tests (Table 1) were used to assess the normality of continuous variables, including EF, troponin I, and other hemodynamic parameters. A statistical significance was found in these tests for preoperative, intraoperative, and 24 hours post ICU admission EF and preoperative and 24 hours post ICU admission troponin I. So the data considered not normally distributed, then the Mann–Whitney U a nonparametric test as the nonparametric test equivalent of the independent sample *t*-test used to assess for significant differences for the continuous variables with the groups.

Friedman test was conducted to evaluate changes in EF rate across three time points, which illustrates a statistically significant variation in EF overtime ($p < 0.05$). Pairwise comparisons using the Wilcoxon Signed-rank test were applied to troponin I levels between preoperative and 24 hours post ICU measurements, indicating significant differences ($p < 0.05$). All tests were used to assess whether these changes differed between analgesic groups, and a p-value of < 0.05 was considered statistically significant.

3. Results

The study population consisted of two equally sized groups: Group R (n=30, 50%) and Group F (n=30, 50%). The mean age of 60 patients was 59.5 (SD, 7.3) years; 38 (63.3%) were male; and the mean weight was 74.8 (SD, 14.4) kg. There were 35 (58.8%) patients with ASA II and 25 (41.7%) ASA III patients. The median (IQR) for preoperative EF was 56% (0.100), and for S. troponin- I, it was 0.1000 (0.098) (ng/mL).

Only 60 cases were (as illustrated in Table 2) valid and included in the analysis. This indicates a complete dataset for the variables under investigation. The mean (SD) of age distribution for Group R was 59.9 (7.6) years; for Group F, it was 59.0 (7.0); and for the total, it was 59.5 (7.3), with a nonsignificant mean difference of −0.9 (95% CI: −4.65 to 2.88) and a p-value of 0.635. Also, age group, weight, gender, ASA, EF, and troponin baseline distribution for both groups were nonsignificant, as seen in Table 3.

Table 4 examines the effects of remifentanil and fentanyl on preoperative hemodynamic stability and S. troponin release for nonnormally distributed data, utilizing

Table (1): Tests of normality.

	Kolmogorov–Smirnov*			Shapiro–Wilk*		
	Statistic	Df	Sig.	Statistic	Df	Sig.
EF preoperative	0.212	60	0.0000	0.865	60	0.0000
S. troponin (ng/mL) preoperative	0.216	60	0.0000	0.727	60	0.0000
EF intraoperative	0.14	60	0.005	0.925	60	0.001
EF 24 hours post ICU admission	0.133	60	0.01	0.929	60	0.002
S. troponin (ng/mL) 24 hours post ICU admission	0.171	60	0.0000	0.886	60	0.0000

*Tests of normality are significant at the 0.05 level; df, degree of freedom; EF, ejection fraction.

Table (2): Baseline characteristics for the patients (n=60).

	Summary
	(n=60)
Analgesia Group, No. (%)	**60 (100.0)**
Remifentanil	30 (50.0)
Fentanyl	30 (50.0)
Age	(n=60)
Mean (SD)	59.5 (7.3)
Age group, No. (%)	
46–59 Years	30 (50.0)
60–74 Years	30 (50.0)
Weight, Mean (SD), kg	**(n=60)**
Gender, No. (%)	74.8 (14.4)
Male	38 (63.3)
Female	22 (36.7)
ASA, No. (%)	
ASA II	35 (58.3)
ASA III	25 (41.7)
EF Pre, Median (IQR), %	56.0% (1.0%)
S. troponin, Median (IQR) Pre (ng/mL)	0.1000 (0.0948)

SD, Std. Deviation, IQR; Interquartile Range.
EF; Preoperative, ejection fraction by transthoracic echo, %.
S. troponin; Preoperative, serum troponin (ng/mL).

the Mann–Whitney test. Group R had a median preoperative EF of 55% (IQR = 0.110) with a mean rank (MR) of 29.23. Group F had a median preoperative EF of 58% (IQR = 0.113) with an MR of 1.77. The overall median preoperative EF was 56% (IQR = 0.100). The Mann–Whitney U statistic was 412.0, the Z-statistic was –0.573, and the p-value (Sig.) was 0.567. As the p-value (0.567) is greater than 0.05, there is no statistically significant difference in preoperative EF between the two groups.

Table 5 shows that Group R had a median intraoperative EF (ejection fraction by transthoracic echo) of 60% (IQR = 0.12) with an MR of 37.33. Group F had a median intraoperative EF of 52% (IQR = 0.10) with an MR of 23.67. The overall median intraoperative EF was 52% (IQR = 0.10). The Mann–Whitney U statistic was 245.0, the Z-statistic was –3.054, and the p-value (Sig.) was 0.002. The p-value of 0.002, which is less than 0.05, indicates a statistically significant difference in intraoperative EF. Group R had a significantly higher median EF compared to Group F.

Table 6. The Mann–Whitney test presents 24 hours post ICU admission Ejection Fraction (EF) and serum troponin I levels, indicating these variables are nonnormally distributed. The significance level for these tests is $p<0.05$.

Group R had a median 24 hours post ICU admission EF of 60% (IQR = 0.105) with an MR of 37.00. Group F had a median 24 hours post ICU admission EF of 55% (IQR =

Table (3): Baseline characteristics, preoperative ejection fraction (EF) and S troponin I release for the patients and their association with groups that used analgesics.

	Groups that used analgesics			MD or MR	Odds ratio Remifentanil VS Fentanyl	Sig.*	(95% CI)	
	Remifentanil	Fentanyl	Total				Lower	Upper
	(n=30)	(n=30)	(n=60)					
Age, years	(n=30)	(n=30)	(n=60)					
Mean (SD)	59.9 (7.6)	59.0 (7.0)	59.5 (7.3)	–0.9		0.635	–4.68	2.88
Age group, No. (%)								
46–59 Years	15 (50.0)	15 (50.0)	30 (50.0)		1.000	1.000	0.363	2.751
60–74 Years	15 (50.0)	15 (50.0)	30 (50.0)					
Weight, mean (SD), kg	75.1 (13.0)	74.5 (16.0)	74.8 (14.4)	–0.533		0.888	–8.054	6.987
Gender, no. (%)								
Male	19 (63.3)	19 (63.3)	38 (63.3)		1.000	1.000	0.350	2.858
Female	11 (36.7)	11 (36.7)	22 (36.7)					
ASA, no. (%)								
ASA II	20 (66.7)	15 (50.0)	35 (58.3)		2.000	0.190	0.705	5.677
ASA III	10 (33.3)	15 (50.0)	25 (41.7)					
EF Preoperative, Median (IQR), %	55.0% (1.0%)	58.0% (10.0%)	56.0% (10.0%)	29.2/31.8		0.567		
S. troponin, Median (IQR) Preoperative (ng/mL)	10% (10.2%)	2.38% (9.0%)	10.0% (9.45%)	32.3/28.7		0.416		

*Chi-square test, independent *t* test, and Mann–Whitney U test are significant at < 0.05.
SD, std. deviation; IQR, interquartile range; MD, mean difference; MR, mean rank; 95% CI, 95% confidence interval.
ASA refers to the American Society of Anesthesiologists (ASA) Physical Status Classification System; EF, preoperative, ejection fraction by transthoracic echo; %S. troponin, preoperative, serum troponin (ng/mL).

Table (4): Effects of remifentanil and fentanyl on preoperative hemodynamic stability and S. troponin release of nonnormally distributed.

Nar tests	Descriptive statistics								Mann-Whitney test		
Group statistics	Remifentanil (n=30)			Fentanyl (n=30)			Total (n=60)				
	Median	IQR	MR	Median	IQR	MR	Median	IQR	Mann-Whitney U	Z	Sig.
EF Preoperative %	55%	11.0%	29.23	58.0%	11.3%	31.77	56.0%	10.0%	412.0	–0.573	0.567
S. troponin (ng/mL) Preoperative	0.1000	0.1048	32.32	0.0238	0.0913	28.68	0.1000	0.0948	395.5	–0.813	0.416

Npar, nonparametric Mann–Whitney test is significant at < 0.05; Z, Z statistics; IQR, interquartile range; MR, mean rank; preoperative EF, ejection fraction by transthoracic echo %; preoperative S. troponin I, serum troponin ng/mL.

Table (5): The Mann–Whitney test examines intraoperative EF, which is assumed to be nonnormally distributed. The significance level for these tests is p<0.05.

Nar tests	Descriptive statistics								Mann–Whitney test		
Group statistics	Remifentanil (n=30)			Fentanyl (n=30)			Total (n=60)				
	Median	IQR	MR	Median	IQR	MR	Median	IQR	Mann-Whitney U	Z	Sig.
EF Intraoperative %	60.0%	12.0%	37.33	52.0%	10.0%	23.67	55.0%	10.0%	245.0	–3.054	0.002

Npar, nonparametric, Mann–Whitney Test is significant at < 0.05.
Z, Z statistics; IQR, interquartile range; MR, mean rank; intraoperative EF, ejection fraction by transthoracic echo %.

Table (6): Twenty-four hours post ICU admission EF and S. troponin release (nonnormally distributed data).

Nar Tests	Descriptive Statistics								Mann-Whitney Test		
Group statistics	Remifentanil (n=30)			Fentanyl (n=30)			Total (n=60)		Mann-Whitney U	Z	Sig.
	Median	IQR	MR	Median	IQR	MR	Median	IQR			
EF 24 hours post ICU admission %	60.0%	10.5%	37.00	55.0%	10.5%	24.00	56.0%	9.8%	255.0	–2.905	0.004
S. troponin (ng/ml) 24 hours post ICU admission	0.252	0.389	35.58	0.158	0.156	25.42	0.190	0.301	297.5	–2.255	0.024

Npar, nonparametric, Mann–Whitney Test is significant at the 0.05 level; Z, Z statistics; IQR, interquartile range; MR, mean rank.

0.105) with an MR of 24.000. The overall median 24 hours post ICU admission EF was 56% (IQR = 0.098). Group R had a significantly higher median EF compared to group F 24 hours post ICU admission.

In Group R, median preoperative EF was 55.0% (IQR = 11.0%) and rose to 60.0% (IQR= 12%) intraoperatively and remained stable at 60.0% (IQR = 10%) at 24 hours post ICU admission. Conversely, Group F showed a decrease from 58.0% (IQR = 11.0%) preoperatively to 52.0% (IQR=10.0%) intraoperatively, then increased to 55.0% (IQR= 10.0%) at 24 hours post ICU admission. Overall, EF showed a fluctuation in trend from a median of 56.0% (IQR=10.0%) preoperatively, 55.0% (IQR=10.0%) intraoperatively and 56.0% (IQR=10%) at 24 hours post ICU admission, these changes were statistically significant over time (p=0.004) and between groups (p=0.041). As seen in Figure 1.

Table 7 explores the descriptive statistics, percentiles, and results of the Friedman test assessing the effect of time on EF across three time points (preoperative, intraoperative, and 24 hours post ICU admission). The mean ranks were 1.77, 1.93, and 2.31, respectively, with a Chi-square value of 11.005 and a p-value of 0.004. These findings indicate a statistically significant difference in EF across the evaluated time points.

Table 8 shows serum troponin levels (ng/mL) for the preoperative and postoperative periods. Preoperatively, the median troponin level was 0.1000 (IQR=0.0948; MR=22.61), while postoperatively it increased to 0.1900

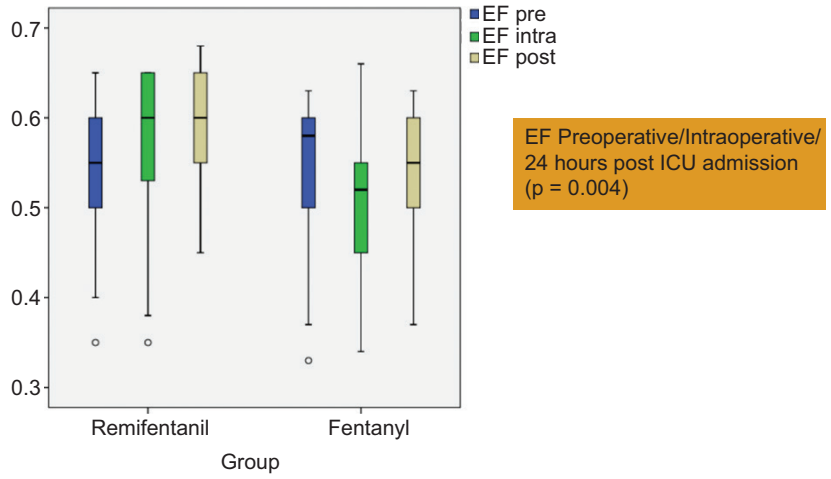

Figure (1): Comparing EF over time by groups.

Table (7): Friedman test for effect of time and differences in EF across three time points.

Descriptive Statistics and Friedman Test								
	N	Percentiles						
		25th	50th (Median)	75th	Mean Rank	Chi-Square	Df	Sig.*
EF % preoperative	60	50.0%	56.0%	60.0%	1.77	11.005	2	0.004
EF % intraoperative	60	50.0%	55.0%	60.0%	1.93			
EF % 24 hours post ICU admission	60	50.3%	56.0%	60.0%	2.31			

* Friedman test is significant at < 0.05; EF, ejection fraction %.

Table (8): Descriptive statistics and Wilcoxon signed ranks test for S. troponin.

	Descriptive statistics			Wilcoxon signed ranks test		
	N	Median	IQR	Mean Rank	Z	Sig.
S. troponin (ng/mL) preoperative	60	0.1000	0.0948	22.61	−5.238	< 0.001
S. troponin (ng/mL) 24 hours post ICU admission	60	0.1900	0.3005	31.89		

The Wilcoxon Signed Ranks Test is significant at the level of 0.05; IQR, interquartile range; Z, Z statistics.

(IQR=0.3005; MR=31.89) in a sample of 60 patients. For comparing preoperative and postoperative values using the Wilcoxon Signed Ranks test demonstrated a statistically significant increase in troponin levels (Z= −5.238, p= 0.001).

The p-value of 0.024 indicates a highly statistically significant difference in serum troponin I levels between Group R and Group F, with Group R having a higher median 24 hours post ICU admission troponin, as seen in Figure 2.

4. Discussion

This research analyzed the intraoperative and early postoperative impacts of remifentanil versus fentanyl during OPCABG surgery. The findings indicate that remifentanil offers superior hemodynamic control. The advantages observed can be attributed to remifentanil's distinct pharmacokinetics, particularly its ultra-short context-sensitive half-life and metabolism by nonspecific esterases. These characteristics facilitate rapid and precise titration during surgical procedures, minimizing the risk of drug accumulation [16]. A Polish prospective observational study indicated that patients administered remifentanil in conjunction with regional blocks exhibited significantly lower troponin-T levels [17]. The current study's findings disagreed with Maruta et al. [18], who reported that the effect of continuous administration and rapid injection of remifentanil was studied and assessed the cause in subgroups of hypertension patients who were treated and those who were not. The studies indicate that remifentanil enhances recovery profiles and may provide myocardial protection, presumably through its modulation of the neuroendocrine stress response and decreased sympathetic activation during surgical procedures [17]. The current study depends on objective parameters (troponin I) while the Maruta study depend on subjective parameters. On the contrary, the Polish study measured troponin T post a baseline analgesia with regional block.The infusion of remifentanil provides superior intraoperative

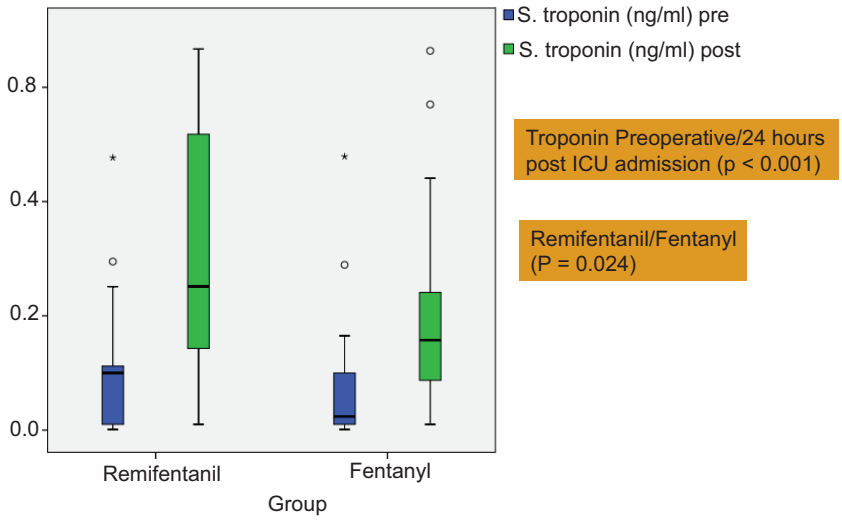

Figure (2): Comparing S. troponin over time by groups.

hemodynamic stability and postoperative recovery; nevertheless, both drugs exhibit comparable effects on myocardial injury during off-pump CABG surgery [19].

The notably reduced troponin I levels in patients receiving remifentanil in ICU suggest potential cardioprotective effect, even in the absence of pain-related stress in the current study. This finding could be explained by attenuation of catecholamine surges and an improved balance between myocardial oxygen supply and demand [20].

5. Strengths and Limitations of the Study

This study possesses multiple strengths: It is one of the first prospective clinical comparisons between remifentanil and fentanyl for OPCABG surgery in Iraq. The randomized design, strict inclusion and exclusion criteria, and standardized anesthesia techniques ensured that the observed outcomes are reliable and replicable. In addition, the use of objective measure, such as troponin I levels strengthens the clinical relevance of the findings.

However, some limitations must be acknowledged: The relatively small sample size (n = 60) limits the statistical power, especially for detecting subtle or rare effects. As a single-center study, generalizability may be limited, particularly to centers with different surgical protocols or anesthesia expertise. Also, no long-term follow-up data were collected.

Despite these limitations, the study provides reliable preliminary data supporting the use of remifentanil in fast-track cardiac anesthesia and lays a strong foundation for future investigations.

6. Conclusion

This research supports the reference that remifentanil in comparison to fentanyl serves as a beneficial opioid analgesic in elective OPCABG surgery depending on enhancing intraoperative hemodynamic stability. Conversely fentanyl compared to remifentanil, exhibited higher myocardial protective effects, indicated by less increase of postoperative troponin I levels.

7. Recommendations

Future research should prioritize large-scale, multicenter randomized controlled trials to confirm the superiority of remifentanil compared to fentanyl in OPCABG surgery across various populations and healthcare environments. A long-term follow-up evaluating outcomes, including 30-day morbidity, postoperative arrhythmias, myocardial infarction, and hospital readmission rates, would yield important insights into the enduring benefits of remifentanil.

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Conflict of Interest

The authors declare that they have no conflict of interest.

Author Contributions

All authors conceived this work and drafted and finalized this study.

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