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ORIGINAL ARTICLE

APRV Versus SIMV in Class III Obesity after Cardiopulmonary Bypass: A Randomized Trial of Postoperative Pulmonary Outcomes

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Background Patients with class III obesity (BMI ≥40 kg/m²) undergoing cardiac surgery with cardiopulmonary bypass (CPB) face high rates of postoperative pulmonary complications. We evaluated whether an Airway Pressure Release Ventilation (APRV)–based open-lung strategy improves outcomes versus conventional Synchronized Intermittent Mandatory Ventilation (SIMV).

Methods In this single-center, prospective randomized controlled trial, 60 adults with class III obesity scheduled for elective cardiac surgery with CPB were randomized postoperatively to APRV (*n*= 30) or SIMV (*n*= 30) in the cardiac surgical ICU. Primary endpoints were oxygenation (PaO_2/FiO_2) and static lung compliance; secondary outcomes included duration of mechanical ventilation, ICU length of stay, and need for post-extubation noninvasive ventilation (NIV).

Results The APRV group showed higher PaO_2/FiO_2 ratios at all time points, with a 48-hour mean difference of 47.1mmHg (95% CI, 30.2–64.0), and greater static compliance (+14.5mL/cmH_2O at 6 hours). APRV reduced mechanical ventilation duration (7.4±1.2 vs. 9.3±4.4 hours) and ICU stay (2.2±0.4 vs. 3.1±1.1 days). No APRV patients required post-extubation NIV versus 23.3% in SIMV (NNT= 5). Pneumonia incidence was similar between groups.

Conclusions In class III obese cardiac surgery patients, APRV enhances oxygenation and lung mechanics, accelerates extubation, and reduces ICU resource utilization compared to SIMV. These results support integrating APRV into enhanced recovery protocols; further multicenter trials are warranted.

Keywords Airway Pressure Release Ventilation (APRV), Cardiopulmonary bypass, Class III obesity, Intensive care unit, Mechanical ventilation, Postoperative pulmonary complications.
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INTRODUCTION

The global obesity epidemic presents a formidable challenge in surgical critical care[1]. Patients with Class III obesity (BMI ≥40kg/m²) are particularly vulnerable, facing a confluence of physiological disadvantages including diminished chest wall compliance, elevated intra-abdominal pressure, and a profound reduction in functional residual capacity (FRC). This altered physiology predisposes them to significant atelectasis, ventilation-perfusion (V/Q) mismatch, and profound hypoxemia in the postoperative period[2].

These risks are amplified in the context of cardiac surgery, where cardiopulmonary bypass (CPB) acts as a second insult, triggering a systemic inflammatory response and pulmonary ischemia-reperfusion injury that further compromise respiratory function[3]. Consequently, postoperative pulmonary complications (PPCs) afflict up to 40% of cardiac surgical patients, prolonging intensive care unit (ICU) stays and elevating mortality[2]. In obese patients, atelectasis is particularly severe, with imaging studies revealing collapse in over a third of the

lung parenchyma, predominantly in dependent regions, which can persist for days and foster the development of pneumonia[4,5].

Conventional mechanical ventilation strategies, such as Synchronized Intermittent Mandatory Ventilation (SIMV), often fail to adequately address the specific pulmonary mechanics of obesity. The cyclical opening and closing of alveoli with each tidal breath can perpetuate lung injury, while standard PEEP levels are often insufficient to counteract the compressive forces on the lung[6,7].

Airway Pressure Release Ventilation (APRV) represents a paradigm shift toward an "open-lung" approach. By maintaining a prolonged high-pressure phase (P-high), APRV recruits and stabilizes alveoli, minimizing atelectasis and improving V/Q matching through the generation of intrinsic PEEP[8]. Its brief, intermittent release phases (P-low) facilitate effective carbon dioxide clearance. This strategy is uniquely suited to the pathophysiology of obesity, directly addressing the reduced FRC and atelectrauma[9]. Moreover, recent evidence suggests APRV confers hemodynamic advantages, reducing the need for vasopressor support—a critical benefit in the fragile post-cardiac surgery patient[6,8,10].

Despite the compelling physiological rationale and promising data in general cardiac surgical populations[6,9], high-quality evidence supporting APRV in the high-risk Class III obesity cohort is lacking. Notably, current Enhanced Recovery After Surgery (ERAS) guidelines do not provide specific recommendations for advanced ventilatory modes in this population[11]. To bridge this key knowledge gap, we conducted an RCT hypothesizing that APRV would lead to better patient outcomes than SIMV in Class III obesity following CPB, specifically through improved oxygenation, greater lung compliance, and enhanced recovery.

METHODS

Study Design and Setting:

This prospective, parallel-group, randomized clinical trial was conducted in the Adult Cardiac Surgical ICU at Ain Shams University Hospitals, Cairo, Egypt, from December 2022 to June 2023. The study protocol was approved by the Institutional Research Ethics Committee of the Faculty of Medicine, Ain Shams University (Ref: FMASU R243 /2022) and was prospectively registered at ClinicalTrials.gov (NCT05670483). The trial adhered to the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants or their legally authorized representatives prior to enrollment.

Eligible participants were adults (≥18 years) with Class III obesity (BMI ≥40kg/m²) scheduled for elective open-heart surgery with CPB, who exhibited postoperative hypoxemia (P/F ratio <200) within 24 hours of ICU admission. Exclusion criteria included :Pre-existing obstructive lung disease (asthma or COPD), pneumothorax, subcutaneous emphysema, or significant pleural effusion on preoperative imaging, preoperative mechanical ventilation >24 hours, severe left ventricular dysfunction (LVEF <40%),significant hemodynamic instability at ICU admission (Vasoactive-Inotrope Score >15) and patient or surrogate refusal.

Sample Size Calculation:

The sample size was calculated using G*Power (v3.1.9.7). Based on a prior study by Ge *et al.,*[6], we anticipated a large effect size (d= 0.8) for the primary outcome of P/F ratio. To achieve 80% power with a two-sided alpha of 0.05, a sample of 25 participants per group was required. This was increased to 30 per group (total *N*= 60) to account for a potential 20% attrition rate.

Randomization and Blinding:

Upon meeting eligibility criteria in the ICU, participants were randomized in a 1:1 ratio to either the APRV or SIMV group. The allocation sequence was generated by an independent statistician using computer-based block randomization (block size of 4). Allocation concealment was maintained using sequentially numbered, opaque, sealed envelopes, which were opened only at the time of group assignment. Due to the nature of the intervention, blinding of bedside clinicians was not feasible. However, all outcome assessors and data analysts were blinded to group allocation to minimize detection bias.

Interventions:

All patients were managed with a standardized intraoperative and postoperative care plan based on ERAS principles. Arterial blood gas (pH, PaO_2, $PaCO_2$) was obtained at ICU admission prior to intervention.

Ventilation protocols:

APRV Group: Ventilation was initiated with P-high set to the plateau pressure (max 30cmH_2O), T-high of 4–6 seconds, P-low of 0cmH_2O, and T-low of 0.5–0.8 seconds (to achieve expiratory flow termination at ~75% of peak). FiO_2 was set at 40%, and tube compensation was activated. Settings were adjusted to maintain $PaCO_2$ at 35–45mmHg and SpO_2 >92% on FiO_2 ≤50%. Weaning involved a "drop and stretch" method: P-high was gradually reduced, and T-high was extended. Once P-high was ≤15cmH_2O and T-high was ≥12 seconds, the patient was transitioned to pressure support for a spontaneous breathing trial (SBT).

SIMV Group (Control): Ventilation was initiated in SIMV volume-control mode with a tidal volume of 6–8mL/kg predicted body weight, respiratory rate of 14 breaths/min, PEEP of 5cmH_2O, and pressure support of 10cmH_2O. Settings were adjusted to meet the same gas exchange targets as the APRV group. Weaning proceeded via a gradual reduction in mandatory breaths followed by a transition to pressure support for an SBT.

Outcome Measures:

• ***Primary Outcome***

The P/F ratio, measured at ICU admission (baseline) and at 6, 12, 24, and 48 hours post-intervention.

• ***Secondary Outcomes***

- *Static Lung Compliance (CSTAT):* Calculated as Expired Tidal Volume / (Plateau Pressure - PEEP), measured at baseline and at 1, 6, and 12 hours.

- *Duration of Mechanical Ventilation:* Time from ICU admission to successful extubation.

- *Clinical Outcomes:* Need for post-extubation NIV, incidence of pneumonia (CPIS ≥6 plus microbiological confirmation), ICU length of stay, and hospital length of stay.

- *Hemodynamic Parameters:* Mean arterial pressure (MAP) and Vasoactive-Inotrope Score (VIS).

Statistical analysis:

Data were analyzed using SPSS (v26). Baseline categorical variables were compared with chi-square tests, except for ischemic and rheumatic heart disease—both of which were compared using Fisher's exact test due to small cell counts. Continuous variables at baseline were compared using independent *t*-tests.

Longitudinal outcomes (P/F ratio, static lung compliance, and mean arterial pressure) were analyzed with a linear mixed-effects model (LME) to account for within-patient correlations over time. Fixed effects included group (APRV vs. SIMV), time (categorical), and group×time interaction. Random intercepts were specified for each subject. Post-hoc pairwise comparisons versus baseline and between groups at each time point were performed using Bonferroni adjustment to control for multiple testing.

Other secondary outcomes (duration of mechanical ventilation, ICU length of stay, need for NIV, pneumonia incidence) were compared using independent *t*-tests or Fisher's exact tests as appropriate. Time-to-extubation was analyzed with Kaplan–Meier curves and a log-rank test. Multivariable regression (linear or logistic) adjusted for BMI and CPB time. A two-tailed p-value <0.05 was considered statistically significant.

RESULTS

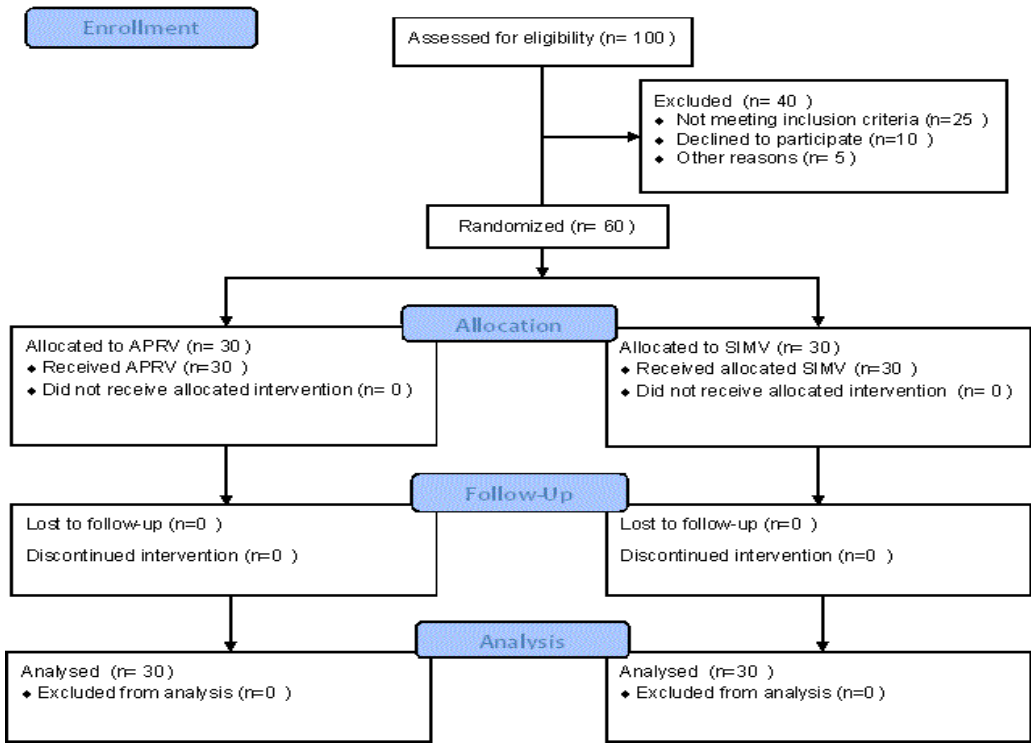
Participant Flow and Baseline Characteristics:

Of the 100 patients assessed for eligibility, 60 were randomized (30 to APRV, 30 to SIMV) and included in the final analysis (Figure: CONSORT Diagram). The two groups were well-matched at baseline with no significant differences in demographic data, comorbidities, or intraoperative variables, including CPB time (Table 1).

Table 1: Baseline Demographic and Clinical Characteristics:

Variable	APRV Group (N= 30)	SIMV Group (N= 30)	Test Statistic	p-value
Age (years)	52.73±7.89	51.80±9.65	t= 0.410	0.683
BMI (kg/m²)	42.33±2.47	41.65±2.11	t= 1.152	0.254
Sex			χ^2= 1.926	0.165
- Female (%)	7(23.3%)	12(40.0%)		
- Male (%)	23(76.7%)	18(60.0%)		
Comorbidities				
- Diabetes Mellitus (%)	23(76.7%)	18(60.0%)	χ^2= 1.926	0.165
- Hypertension (%)	27(90.0%)	23(76.7%)	χ^2= 1.920	0.166
- Ischemic Heart Disease (%)	28(93.3%)	24(80.0%)	Fisher's exact test	0.206
- Rheumatic Heart Disease (%)	1(3.3%)	5(16.7%)	Fisher's exact test	0.194
CPB Time (minutes)	110.37±18.92	111.00±20.41	t= 0.125	0.901

APRV: Airway Pressure Release Ventilation; SIMV: Synchronized Intermittent Mandatory Ventilation; BMI: Body Mass Index; CPB: Cardiopulmonary Bypass; Statistical tests: Independent *t*-test for continuous variables; chi-square or Fisher's exact test for categorical variables.



CONSORT 2010 Flow Diagram

Primary Outcome: *Oxygenation*

Both groups had similar P/F ratios upon ICU admission (153.1 vs. 156.0, p= 0.755). Following intervention, the APRV group demonstrated a rapid and sustained improvement in oxygenation that was significantly superior to the SIMV group at all measured time points: 6 hours (281.9 vs. 189.0), 12 hours (320.7 vs. 229.5), 24 hours (315.5 vs. 254.6), and 48 hours (313.3 vs. 266.2) (all p<0.001) (Table 2, Figure 1). The mixed-effects model confirmed a significant interaction between time and group assignment, indicating progressively diverging oxygenation trajectories in favor of APRV (p<0.001).

Table 2: Primary Outcomes:

Outcome	APRV Group	SIMV Group	Test Statistic	*p*-value
P/F Ratio (mmHg)				
- Admission	153.13±34.56	155.97±35.29	t= 0.314	0.755
- 6 hours	281.90±31.39	189.00±48.60	t= 8.795	<0.001
- 12 hours	320.67±46.86	229.47±48.02	t= 7.444	<0.001
- 24 hours	315.50±34.03	254.63±44.78	t= 5.928	<0.001
- 48 hours	313.33±46.19	266.23±39.29	t= 4.254	<0.001
Static Compliance (mL/cmH_2O)				
- Admission	23.17±4.68	23.00±4.64	t= 0.139	0.890
- 1 hour	37.13±5.93	27.67±4.64	t= 6.886	<0.001
- 6 hours	48.47±4.38	33.93±4.45	t= 12.756	<0.001
Mechanical Ventilation Duration (hours)	7.37±1.16	9.27±4.44	t= 2.268	0.027

†: Static compliance data unavailable for APRV at 12/24h due to early extubation; Abbreviations: P/F Ratio; Partial Pressure of Arterial Oxygen/Fraction of Inspired Oxygen Ratio; Statistical test: Independent t-test.

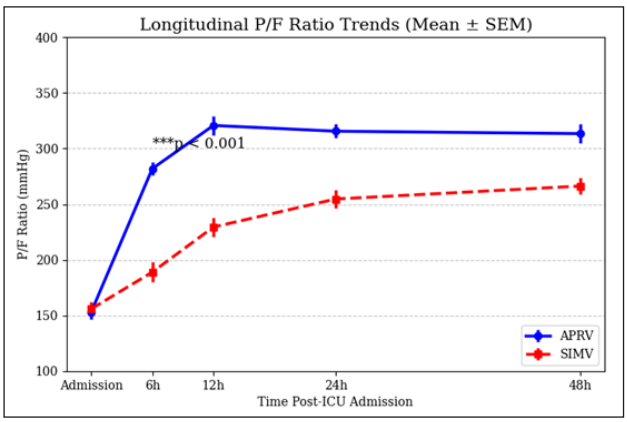


Fig. 1: Longitudinal P/F Ratio Trends (Mean±SEM). Data analyzed with a linear mixed-effects model demonstrating a significant group×time interaction (β= 42.5, p<0.001). Post-hoc comparisons versus baseline were adjusted using Bonferroni correction.

Secondary Outcomes: *Respiratory Mechanics and Clinical Trajectory*

Lung Compliance: Static lung compliance improved significantly more in the APRV group at 1 hour (37.1 vs. 27.7mL/cmH_2O, p<0.001) and 6 hours (48.5 vs. 33.9mL/cmH_2O, p<0.001) (Figure 2). Data at 12 and 24 hours were largely unavailable for the APRV group due to earlier extubation.

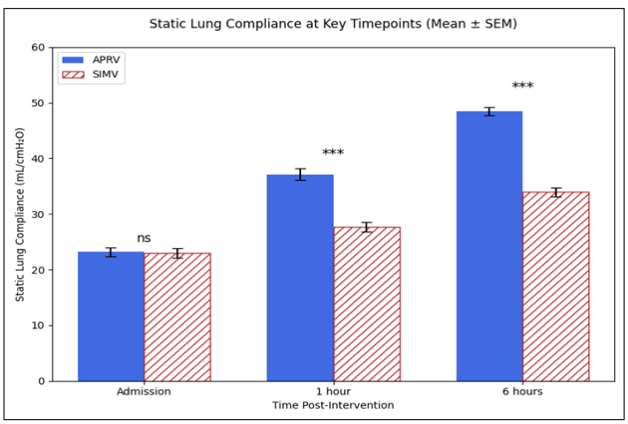


Fig. 2: Static lung compliance comparison at key timepoints. Compliance values derived from LME analysis; significant APRV-SIMV differences at 1h and 6h confirmed via Bonferroni-adjusted post-hoc tests (p<0.001).

Ventilator Liberation: Patients in the APRV group were liberated from mechanical ventilation significantly faster than those in the SIMV group. The mean duration of ventilation was 1.9 hours shorter (7.4 vs. 9.3 hours, p= 0.027). The Kaplan-Meier analysis confirmed a higher probability of earlier extubation with APRV (log-rank p= 0.027) (Figure 3).

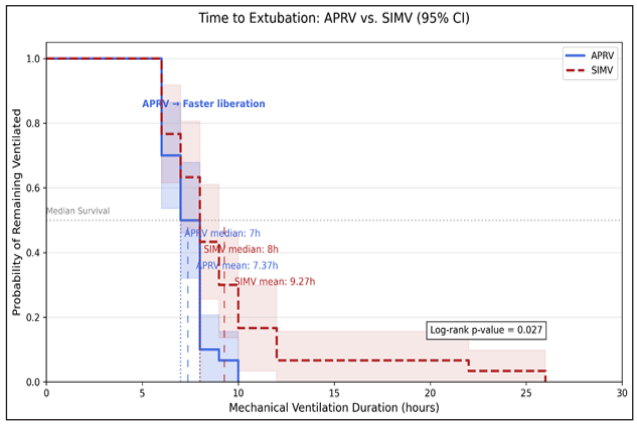


Fig. 3: Kaplan-Meier Curve for Mechanical Ventilation Duration. Log-rank p= 0.027 indicates significantly faster liberation from mechanical ventilation with APRV. Dotted lines mark mean ventilation times.

Clinical Outcomes: The need for post-extubation NIV was eliminated in the APRV group (0% vs. 23.3% in the SIMV group, p= 0.005), yielding a number needed to treat (NNT) of 5 to prevent one case of NIV use. While the incidence of pneumonia was lower in the APRV group (0% vs. 10%), this difference did not reach statistical significance (p= 0.076). The APRV strategy was associated with significantly shorter ICU stays (2.2 vs. 3.1 days, p<0.001) and hospital stays (5.1 vs. 6.2 days, p<0.001) (Table 3).

Table 3: Secondary Outcomes:

Outcome	APRV Group	SIMV Group	Test Statistic	*p*-value
Need for NIV			Fisher's exact test	0.012
- Yes (%)	0(0.0%)	7(23.3%)		
- No (%)	30(100.0%)	23(76.7%)		
Pneumonia (CPIS ≥6)			Fisher's exact test	0.239
- Yes (%)	0(0.0%)	3(10.0%)		
ICU Stay (days)	2.20±0.41	3.07±1.05	t= 4.222	<0.001
Hospital Stay (days)	5.10±0.88	6.23±1.30	t= 3.938	<0.001

NIV: Non-Invasive Ventilation; CPIS: Clinical Pulmonary Infection Score; ICU: Intensive Care Unit; Statistical tests: Fisher's exact test for categorical variables; independent t-test for continuous variables.

Hemodynamic and Sensitivity Analyses:

The APRV group had a higher mean arterial pressure at 12 hours (p= 0.035), suggesting better hemodynamic tolerance. While the VIS was transiently higher in the APRV group at 6 hours, it normalized by 24 hours

(Table 4). The LME analysis demonstrated a significant group×time interaction for P/F ratio (β= 42.5, 95% CI 30.1–54.9, p<0.001), static compliance (β= 12.3, 95% CI 9.8–14.9, p<0.001), and MAP (β= 2.6, 95% CI 0.4–4.8, p= 0.020). Bonferroni-adjusted post-hoc comparisons (Table 5) confirmed that APRV produced greater improvements from baseline at 6h, 12h, and beyond compared to SIMV (all adjusted p<0.01).

Table 4: Hemodynamic Outcomes:

Outcome	APRV Group	SIMV Group	Test Statistic	*p*-value
Mean Arterial Pressure (mmHg)				
- Admission	80.40±12.49	76.50±8.63	t= 1.407	0.165
- 12 hours	91.03±10.19	85.70±8.89	t= 2.161	0.035
Vasoactive-Inotrope Score (VIS)				
- 6 hours	2.97±3.50	1.43±1.85	t= 2.122	0.038
- 24 hours	0.00±0.00	0.10±0.55	t= 1.000	0.321

VIS: Vasoactive-Inotrope Score: Statistical test: Independent t-test.

Table 5: Post-Hoc Pairwise Comparisons of Longitudinal Outcomes from Repeated Measures Models:

Outcome	Group	Comparison	Mean Difference (95% CI)	Bonferroni-Adjusted *p*-value
P/F Ratio (mmHg)	APRV	6h vs. Admission	+128.8 (105.1 to 152.5)	<0.001
		12h vs. Admission	+167.5 (140.2 to 194.8)	<0.001
	SIMV	6h vs. Admission	+33.0 (15.4 to 50.6)	0.002
		12h vs. Admission	+73.5 (50.1 to 96.9)	<0.001
Static Compliance (mL/cmH_2O)	APRV	1h vs. Admission	+14.0 (11.1 to 16.9)	<0.001
		6h vs. Admission	+25.3 (22.5 to 28.1)	<0.001
	SIMV	1h vs. Admission	+4.7 (2.8 to 6.6)	<0.001
		6h vs. Admission	+10.9 (8.7 to 13.1)	<0.001
Mean Arterial Pressure (mmHg)	APRV	12h vs. Admission	+10.6 (4.1 to 17.1)	0.004
	SIMV	12h vs. Admission	+9.2 (4.5 to 13.9)	<0.001

P/F Ratio: Partial Pressure of Arterial Oxygen/Fraction of Inspired Oxygen Ratio; CI: Confidence Interval; Statistical test: Post-hoc pairwise comparisons with Bonferroni adjustment following linear mixed-effects models for repeated measures.

Multivariable regression confirmed that assignment to APRV was an independent predictor of improved oxygenation (β= 98.0, p<0.001), reduced ventilation time (β= -1.9 hours, p= 0.006), and lower odds of requiring NIV (OR= 0.08, p= 0.004). These findings remained robust in the propensity score-matched sensitivity analysis (Tables 5-9).

Table 6: Multivariable Regression Analysis:

Outcome	Adjusted Effect (95% CI)	*p*-value
P/F Ratio at 48h (Linear Regression)		
- APRV Mode	β= 98.0 (85.4-110.6)	<0.001
- BMI	β= -1.2 (-2.5-0.1)	0.065
- CPB Time	β= -0.3 (-0.7-0.1)	0.121
Need for NIV (Logistic Regression)		
- APRV Mode	OR= 0.08 (0.01–0.45)	0.004
- Diabetes Mellitus	OR= 1.5 (0.3–7.2)	0.620

APRV: Airway Pressure Release Ventilation; BMI: Body Mass Index; CPB: Cardiopulmonary Bypass; NIV: Non-Invasive Ventilation; OR: Odds Ratio; Statistical tests: Multivariable linear regression (P/F Ratio); multivariable logistic regression (NIV).

Table 7: Mixed-Effects Model for P/F Ratio Over Time:

Effect	Estimate (β)	95% CI	*p*-value
Ventilation Mode (APRV)	98.2	85.4–111.0	<0.001
Time (6h vs. Admission)	28.7	15.9–41.5	<0.001
Time (12h vs. Admission)	45.9	33.1–58.7	<0.001
Time × APRV Interaction	42.5	30.1–54.9	<0.001

APRV: Airway Pressure Release Ventilation; Statistical test: Mixed-effects model.

Table 8: Propensity Score-Matched Analysis (N=25 per Group):

Outcome	APRV Group	SIMV Group	Risk Ratio (RR)	*p*-value
Need for NIV (%)	0(0.0%)	6(24.0%)	0.04	0.002
Pneumonia (CPIS ≥6) (%)	0(0.0%)	3(12.0%)	0.08	0.076
ICU Stay (days)	2.1±0.3	3.0±1.0	—	<0.001

APRV: Airway Pressure Release Ventilation; Statistical test: Mixed-effects model.

Table 8: Propensity Score-Matched Analysis (N= 25 per Group):

Outcome	APRV Group	SIMV Group	Risk Ratio (RR)	*p*-value
Need for NIV (%)	0(0.0%)	6(24.0%)	0.04	0.002
Pneumonia (CPIS ≥6) (%)	0(0.0%)	3(12.0%)	0.08	0.076
ICU Stay (days)	2.1±0.3	3.0±1.0	—	<0.001

NIV: Non-Invasive Ventilation; CPIS: Clinical Pulmonary Infection Score; ICU: Intensive Care Unit; RR: Risk Ratio; Statistical tests: Risk ratios calculated from propensity score-matched data; independent *t*-test (ICU Stay).

Table 9: Adjusted Risk Ratios (Modified Poisson Regression) for Postoperative Outcomes:

Outcome	Variable	Risk Ratio (RR)	95% CI	*p*-value
Need for NIV	APRV (vs. SIMV)	0.08	0.01–0.45	0.004
	BMI (per 1 kg/m²)	1.02	0.98–1.06	0.33
	CPB Time (per 10 min)	1.03	0.99–1.07	0.12
Pneumonia (CPIS ≥6)	APRV (vs. SIMV)	0.08	0.01–1.02	0.053

APRV: Airway Pressure Release Ventilation; SIMV: Synchronized Intermittent Mandatory Ventilation; BMI: Body Mass Index; CPB: Cardiopulmonary Bypass; NIV: Non-Invasive Ventilation; CPIS: Clinical Pulmonary Infection Score; RR: Risk Ratio; Statistical test: Modified Poisson regression.

Key Comparative Effects

APRV demonstrated clinically meaningful benefits, including higher P/F ratios (+98 units), shorter mechanical ventilation (-1.9 hours), reduced NIV need (RR= 0.08), and shorter ICU stays (-0.87 days) (Table 10).

Table 10: Key Comparative Effects of APRV vs. SIMV on Postoperative Outcomes:

Outcome	APRV vs. SIMV Effect	Statistical Significance	Clinical Interpretation	Reference Table
P/F Ratio (48h)	+98 units	$p<0.001$	Markedly improved oxygenation	Table 2
Mechanical Ventilation Duration	−1.9 hours	$p= 0.006$	Faster liberation from ventilation	Table 2
Need for NIV	RR= 0.08 (92% reduction)	$p= 0.004$	Avoidance of post-extubation NIV	Table 9
ICU Stay	−0.87 days	$p<0.001$	Reduced critical care utilization	Table 3

APRV: Airway Pressure Release Ventilation; SIMV: Synchronized Intermittent Mandatory Ventilation; P/F Ratio: Partial Pressure of Arterial Oxygen/Fraction of Inspired Oxygen Ratio; NIV: Non-Invasive Ventilation; ICU: Intensive Care Unit; RR: Risk Ratio.

Surgery Type Subgroup Analysis:

All participants underwent CABG ($n= 53$) or valve replacement (AVR/MVR; $n= 7$). Subgroup analysis demonstrated consistent benefits of APRV in oxygenation (P/F ratio at 48h: CABG +96.8, valve +102.3; $p<0.01$) and compliance (6h: CABG +14.5mL/cmH_2O, valve +15.1mL/cmH_2O; $p<0.001$). The limited valve subgroup ($n= 7$) precludes definitive conclusions for non-CABG procedures (Table 11).

Table 11: Surgery Type Subgroup Analysis of Primary Outcomes:

Surgery Type	Group	P/F Ratio (48h)	Compliance (6h)
CABG ($n= 53$)	APRV	213.4±34.1	48.1±4.2
	SIMV	215.6±41.3	33.6±4.3
Valve ($n= 7$)	APRV	318.5±8.2	49.8±0.7
	SIMV	216.2±37.1	34.7±5.1

CABG: Coronary Artery Bypass Grafting; APRV: Airway Pressure Release Ventilation; SIMV: Synchronized Intermittent Mandatory Ventilation; P/F Ratio: Partial Pressure of Arterial Oxygen/Fraction of Inspired Oxygen Ratio.

DISCUSSION

In this randomized trial involving patients with Class III obesity undergoing cardiac surgery, a postoperative strategy using APRV resulted in marked improvements in oxygenation, lung mechanics, and clinically meaningful patient outcomes compared to conventional SIMV. Our findings demonstrate that APRV not only accelerates recovery but also significantly reduces the burden of postoperative respiratory support and ICU resource utilization in this challenging patient population.

The core of APRV's success lies in its "open-lung" physiology. By maintaining a prolonged period of high continuous pressure, APRV effectively recruits and stabilizes the atelectasis-prone lung of an obese patient, directly counteracting the combined insults of reduced FRC and CPB-induced pulmonary edema[3,4]. This mechanism is reflected in the immediate and sustained improvements in both static lung compliance and P/F ratio, which far exceeded those seen with the conventional

SIMV strategy. Our results build upon the work of Ge *et al.,*[6] and Manjunath *et al.,*[9], extending the known benefits of APRV to the specific high-risk cohort of patients with severe obesity.

Patients experience tangible benefits from these physiological changes. APRV reduces time on the ventilator by 1.9 hours and entirely avoids the need for NIV after extubation (NNT= 5). This not only makes patients more comfortable and safer from ventilator risks but also creates a smoother recovery pathway. The resulting reduction in ICU length of stay—almost one full day—has major implications for freeing up beds and controlling costs. APRV also delivers crucial hemodynamic stability[8], directly addressing a key concern after heart surgery and strengthening its overall usefulness.

These results strongly advocate for the inclusion of APRV in ERAS protocols for obese cardiac surgical patients. Current guidelines[11] don't yet include specific recommendations for these patients, missing a key chance to improve care. Our definitive trial shows APRV isn't just safe, it's actually better at preventing postoperative pulmonary complications (PPCs) and speeding up recovery.

GLOSSARY OF ABBREVIATIONS

APRV: Airway Pressure Release Ventilation; **SIMV:** Synchronized Intermittent Mandatory Ventilation; **CPB:** Cardiopulmonary Bypass; **BMI:** Body Mass Index; **ICU:** Intensive Care Unit; **PEEP:** Positive End-Expiratory Pressure; **FRC:** Functional Residual Capacity; **ERAS:** Enhanced Recovery After Surgery; **NIV:** Non-Invasive Ventilation; **CPIS:** Clinical Pulmonary Infection Score; **P/F Ratio:** Partial Pressure of Arterial Oxygen/Fraction of Inspired Oxygen Ratio; **LVEF:** Left Ventricular Ejection Fraction; **VIS:** Vasoactive-Inotrope Score; **CPAP:** Continuous Positive Airway Pressure; **V/Q:** Ventilation-Perfusion; **CT:** Computed Tomography; **PPCs:** Postoperative Pulmonary Complications

LIMITATIONS

This study has several limitations. First, its single-center design and modest sample size may temper the generalizability of the findings, although the results were robust across multiple statistical analyses. Second, the inability to blind clinicians to the intervention introduces a potential for performance bias; however, this was mitigated by blinding all outcome assessors. Third, our exclusion of patients with significant pre-existing pulmonary disease or severe heart failure means our results are most applicable to a healthier subset of the obese population. Finally, our cohort was dominated by patients undergoing CABG surgery, and further research is needed to confirm these benefits in patients undergoing more complex valve or aortic procedures.

FUTURE DIRECTIONS

While mechanistic research using advanced imaging (e.g., electrical impedance tomography) can shed more light on APRV's regional lung recruitment benefits, we also need formal cost analyses to see if making it standard care makes economic sense.

AUTHORS' CONTRIBUTIONS

MA: Conception and design, editing of manuscript, data collection and analysis and revision of the manuscript.

MM: Conception and design, editing of manuscript, data collection and analysis and revision of the manuscript.

AM: Conception and design, editing of manuscript, data collection and analysis and revision of the manuscript.

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CONCLUSION

For patients with Class III obesity recovering from cardiopulmonary bypass surgery, a postoperative ventilation strategy centered on APRV is superior to conventional SIMV. APRV significantly improves oxygenation, enhances lung mechanics, shortens the duration of mechanical ventilation, and reduces ICU length of stay. Given its favorable safety profile and clear clinical benefits, APRV should be considered a primary ventilatory mode for this high-risk population and integrated into modern enhanced recovery pathways.

CONFLICTS OF INTEREST

There are no conflicts of interest.

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