

Performance of a Standardized Ultra-Fast-Track ERAS Pathway in Patients with Left Ventricular Outflow Tract Obstruction



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BACKGROUND

Enhanced Recovery After Surgery (ERAS) and ultra-fast-track cardiac anesthesia (UFTCA) have been increasingly adopted in cardiac surgery to improve perioperative efficiency and postoperative recovery.

However, their applicability in hemodynamically vulnerable diseases such as hypertrophic obstructive cardiomyopathy (HOCM) with left ventricular outflow tract obstruction (LVOTO) remains controversial.

These patients are often considered suboptimal candidates for aggressive ultra-fast-track strategies due to:

- Dynamic LVOT obstruction
- Hemodynamic vulnerability during anesthetic transitions
- Risk of SAM exacerbation with catecholamines

Objectives

- To evaluate the scalability, reproducibility, and safety of a standardized UFTCA-based ERAS pathway in consecutive LVOTO patients undergoing minimally invasive septal myectomy.
- To assess whether expansion of the anesthesia team compromises safety

All 671 LVOTO patients were managed using a single, standardized UFTCA-based ERAS pathway at a high-volume tertiary center between 2021 and 2025.

METHODS

Study Design

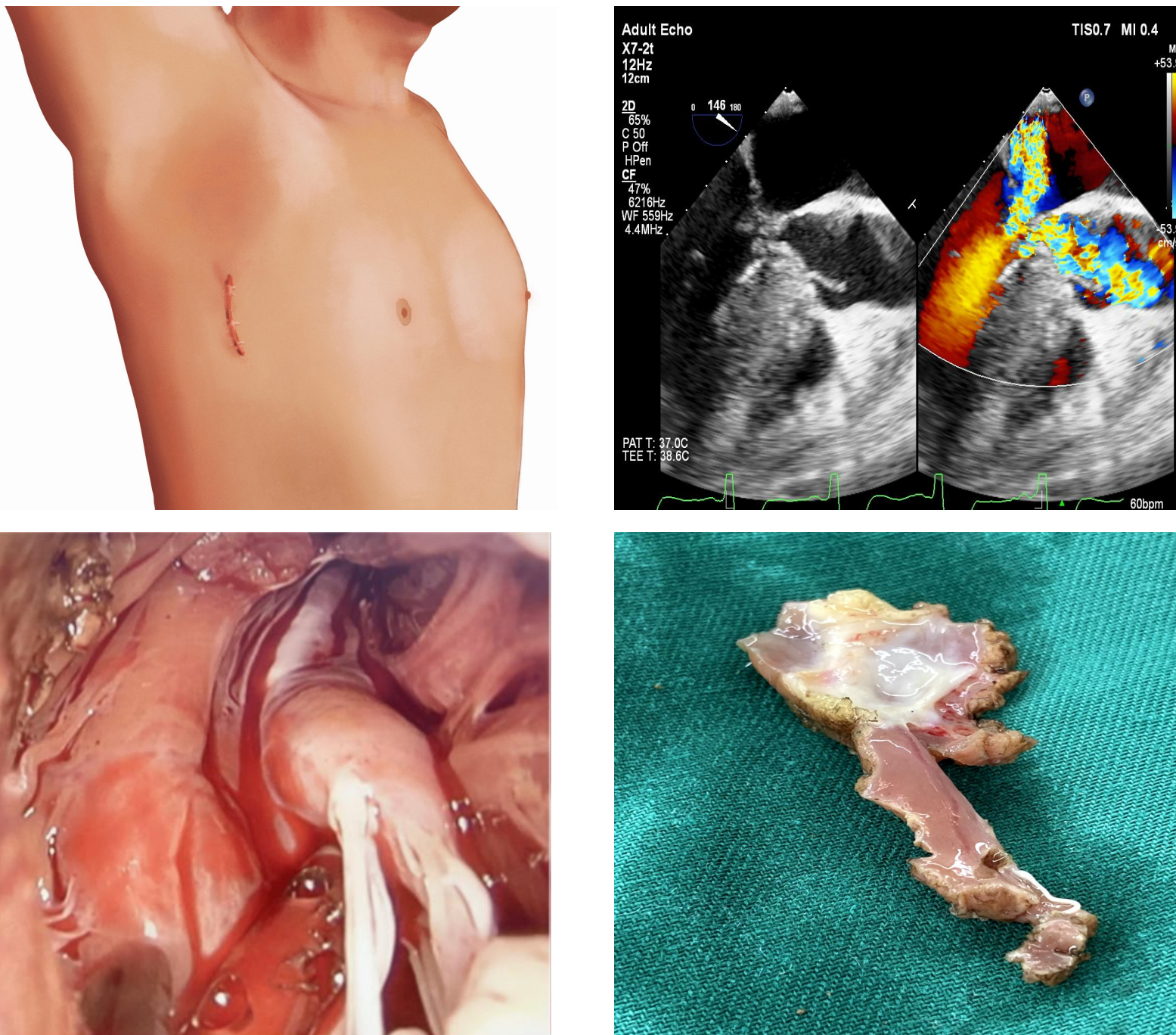
Single-center retrospective observational study of consecutive LVOTO patients.

Population

671 consecutive patients with LVOTO undergoing minimally invasive septal myectomy (2021–2025).

ERAS Protocol Components

- Pre-induction hemodynamic optimization
- Standardized anesthetic induction and maintenance protocols
- LVOTO-specific volume and vasopressor management
- Criteria-based early extubation in the operating room
- Standardized postoperative recovery pathway



Cohort Stratification

Patients stratified into three time-based cohorts to evaluate:

- Pathway maturation over time
- Safety during anesthesia team expansion
- Reproducibility across operators

Outcome Measures

- Perioperative efficiency metrics
- Extubation timing and success rate
- ERAS-related adverse events
- Postoperative atrial fibrillation

RESULTS

671 LVOTO Patients · Standardized ERAS Pathway

>95%

ERAS Success Rate
(Latest Cohort)

0%

ERAS-Related
Adverse Events

Key Findings

- ERAS implementation success increased progressively, exceeding 95% in the most recent cohort
- Early extubation consistently achieved across all cohorts
- Expansion of the anesthesia team did not compromise safety
- Hemodynamic stability maintained without increase in perioperative complications
- No increase in UFTCA-based ERAS-related adverse events
- Postoperative atrial fibrillation rates declined substantially in later cohorts

Table 1 Preoperative Characteristics (excerpt)

Variables	Group ₂₀₂₁₋₂₀₂₃ (n = 231)	Group ₂₀₂₄ (n = 240)	Group ₂₀₂₅ (n = 200)	P value
Sex (male)	134 (33.4%)	144 (35.9%)	123 (30.7%)	0.759
Age	51.00 (22)	50.00 (21)	49.00 (21)	0.122
Diabetes	26 (11.7%)	29 (12.1%)	20 (10.0%)	0.771
Atrial fibrillation (Preoperative)	14 (6.1%)	13 (5.4%)	12 (6%)	0.956
Stroke	7 (3.4%)	7 (3.2%)	15 (7.5%)	0.069
Creatinine	70.85 (21.55)	67.00 (19.80)	71.40 (22.33)	0.040
Coronary artery disease	33 (14.9%)	39 (16.4%)	44 (22.0%)	0.131
Pulmonary hypertension	31 (15.1%)	18 (8.3%)	21 (10.5%)	0.079
LVOT gradient (Preoperative)	78.00 (54.00)	84.50 (51.75)	74.65 (41.75)	0.191
Oxygenation Index (Preoperative)	397.61 (73.80)	400.00 (61.90)	395.23 (66.66)	0.712

Table 2 Intraoperative and Postoperative Characteristics (excerpt)

Variables	Group ₂₀₂₁₋₂₀₂₃ (n = 231)	Group ₂₀₂₄ (n = 240)	Group ₂₀₂₅ (n = 200)	P value
Operation time (min)	270.0 (70.0)	235.0 (54.0)	205.0 (60.0)	<0.001
Aortic Cross-Clamp time (min)	82.0 (29.0)	60.0 (15.0)	53.5 (18.0)	<0.001
CPB Duration (min)	125.0 (40.0)	95.0 (22.0)	88.0 (23.0)	<0.001
LVOT gradient (Postoperative)	8.70 (7.00)	7.00 (5.00)	8.00 (5.98)	<0.001
ICU LOS (h)	25.2 (24.0)	24.9 (20.5)	24.0 (26.0)	0.967
Postoperative LOS (d)	9.0 (4.0)	8.0 (3.0)	7.0 (3.0)	<0.001
Extubation timing (min)	10.0 (15.0)	3.0 (4.0)	5.0 (9.0)	<0.001
UFTCA rate	192 (83.8%)	227 (94.6%)	194 (97.0%)	<0.001
Anesthesia team (Person)	16	27	31	

Table 3 Postoperative complications (excerpt)

Variables	Group ₂₀₂₁₋₂₀₂₃ (n = 231)	Group ₂₀₂₄ (n = 240)	Group ₂₀₂₅ (n = 200)	P value
Atrial fibrillation (Postoperative)	26 (11.3%)	32 (13.3%)	7 (3.5%)	0.001
AKI	1 (0.5%)	1 (0.5%)	4 (2%)	0.294
Pneumonia	38 (16.5%)	26 (10.8%)	22 (11.0%)	0.125
Atelectasis	43 (18.6%)	44 (18.3%)	32 (16.0%)	0.743
Pulmonary Edema	2 (0.9%)	3 (1.3%)	0 (0.0%)	0.385
Oxygenation Index (1h-Postoperative)	205.50 (126.63)	221.95 (114.63)	217.25 (130.92)	0.021

CONCLUSION

A mature ERAS platform supported by ultra-fast-track cardiac anesthesia can be **safely and reproducibly** applied to patients with LVOTO, even in the setting of hemodynamic vulnerability and team expansion.

Disease complexity alone should not preclude ERAS implementation when guided by a standardized, protocol-driven multidisciplinary pathway.

Clinical Implications

- ERAS is feasible in LVOTO despite hemodynamic complexity
- Standardized protocols enable safe team expansion without compromising outcomes
- Protocol-driven approach is scalable and reproducible across different experience levels
- HOCM patients should not be excluded from ERAS programs

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No conflicts of interest to declare.

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