

Integration of Minimal Invasive Extracorporeal Circulation with Minimally Invasive Cardiac Surgery

A Narrative Review of Synergistic Strategies Toward Physiologically Optimized Cardiac Surgery

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BACKGROUND

Conventional cardiac surgery imposes a dual physiological insult:

- Surgical trauma from median sternotomy and extensive tissue dissection
- Systemic inflammatory response triggered by blood–foreign surface contact, air exposure, and shear forces in conventional cardiopulmonary bypass (CPB)

Two innovations address each component independently:

- **MiECC** (Minimal Invasive Extracorporeal Circulation): Closed, biocompatible, air-free circuits that attenuate the inflammatory cascade and reduce hemodilution
- **MICS** (Minimally Invasive Cardiac Surgery): Limited-access approaches (mini-thoracotomy, partial sternotomy) that reduce tissue disruption and wound complications

Central Hypothesis: Combining MiECC + MICS may yield synergistic benefits beyond either strategy alone — targeting a truly “physiologic” cardiac operation.

OBJECTIVES

- Synthesize current evidence on the technical synergy and pathophysiological rationale for integrating MiECC with MICS
- Evaluate reported clinical outcomes of the combined approach in adult CABG and isolated valve surgery
- Identify evidence gaps and define priorities for future investigation

METHODS

Design: Narrative review

Sources: Clinical trials, observational studies, and meta-analyses

Focus Areas:

- Technical compatibility of MiECC circuits with MICS access configurations
- Pathophysiological mechanisms of combined benefit
- Clinical endpoints: transfusion rates, inflammatory biomarkers, AKI, ICU/hospital LOS, atrial fibrillation, extubation time

Procedures Examined:

- Coronary artery bypass grafting (CABG)
- Isolated mitral valve surgery

RESULTS

MiECC Alone vs. Conventional CPB — Established Benefits

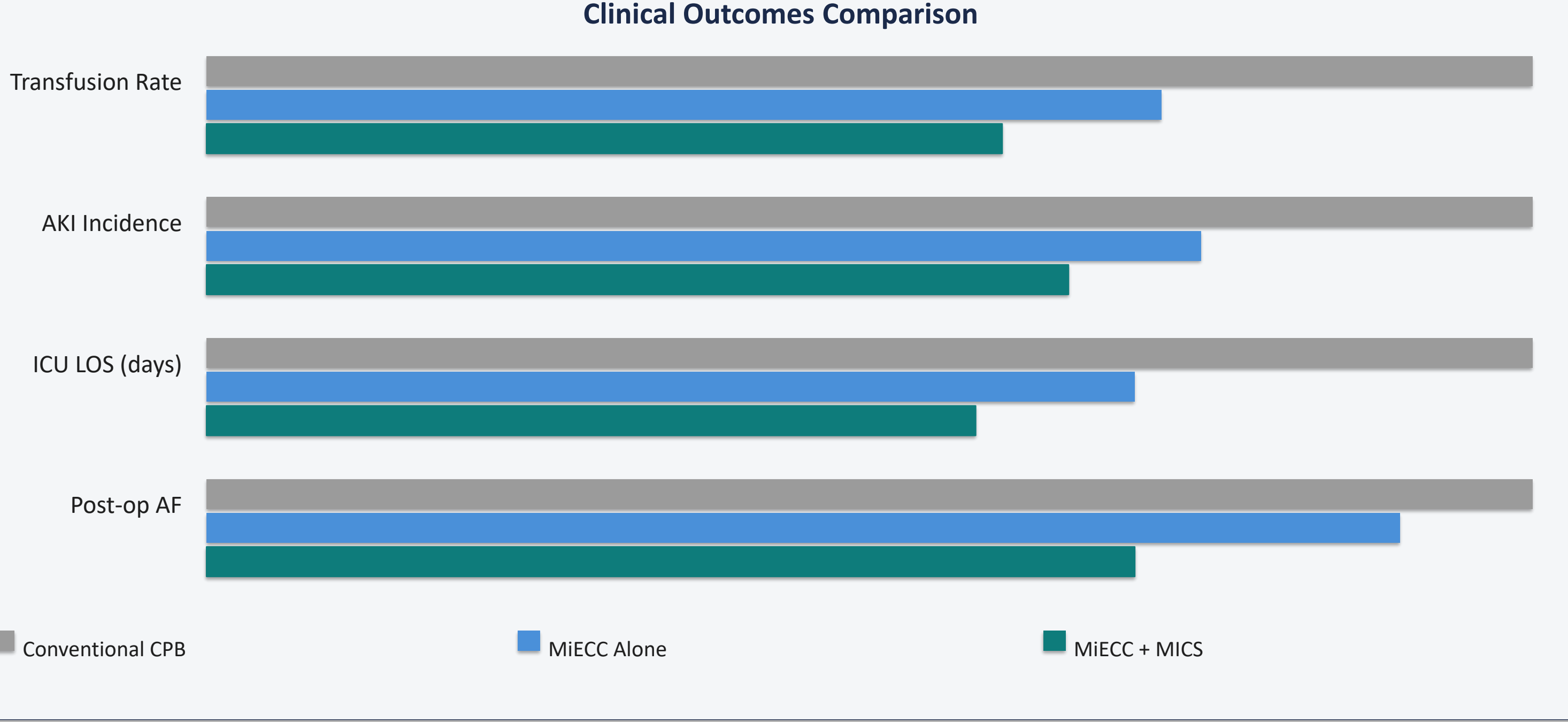
Outcome	Effect with MiECC vs. Conventional CPB
Inflammatory Markers (IL-6, TNF-α)	↓ Significantly Reduced
Transfusion Requirements	↓ ~20–30% Reduction
Acute Kidney Injury (AKI)	↓ ~25% Relative Risk Reduction
ICU Length of Stay	↓ ~1.5 Days Shorter



Combined MiECC + MICS — Emerging Additive Benefits

- Preliminary data from combined MiECC-MICS in CABG and mitral valve surgery demonstrate additive improvements:
- Further reduction in transfusion needs beyond MiECC alone
 - Lower incidence of postoperative atrial fibrillation
 - Shorter time to extubation, supporting fast-track recovery

⚠ **Important:** Large-scale prospective comparative data remain limited. Current evidence derives primarily from single-center experiences and small cohort studies.



CONCLUSIONS

Key Take-Home Messages:

1. **MiECC + MICS** integration represents a compelling multidisciplinary strategy toward physiologically optimized cardiac surgery — addressing both circuit-related and access-related sources of morbidity.
2. Available evidence supports enhanced recovery profiles with the combined approach, including reduced transfusions, less inflammation, and faster ICU throughput.
3. Prospective, procedure-specific comparative studies are now mandated to:
 - Quantify synergistic effects on major clinical endpoints
 - Assess neurocognitive outcomes
 - Evaluate cost-effectiveness

“The convergence of MiECC and MICS moves cardiac surgery from organ-focused repair toward whole-patient physiological optimization.”

KEYWORDS

Minimal Invasive Extracorporeal Circulation · Minimally Invasive Cardiac Surgery · Cardiopulmonary Bypass · Coronary Artery Bypass Grafting · Valve Surgery · Systemic Inflammatory Response Syndrome

REFERENCES

1. Anastasiadis K, et al. Minimal invasive extracorporeal circulation: principles and practice. *Perfusion*. 2015;30(4):245-251.
2. Puehler T, et al. Minimally invasive extracorporeal circulation: impact on blood transfusion. *J Thorac Cardiovasc Surg*. 2020;159(3):926-935.
3. Benedetto U, et al. Miniaturized CPB and acute kidney injury. *Ann Thorac Surg*. 2009;88(5):1426-1433.
4. Biancari F, et al. Meta-analysis of mini vs conventional CPB. *J Cardiothorac Vasc Anesth*. 2009;23(5):637-643.
5. Glauber M, et al. Minimally invasive cardiac surgery: consensus statement. *Eur J Cardiothorac Surg*. 2019;56(S1):i1-i30.
6. Anastasiadis K, et al. MiECC in CABG: a randomized controlled trial. *Interact Cardiovasc Thorac Surg*. 2016;22(4):385-391.
7. Lamelas J, et al. Minimally invasive valve surgery: state of the art. *J Thorac Dis*. 2021;13(3):1986-1995.