A Stepwise Educational Strategy for Training Surgeons in Minimally Invasive Coronary Artery Bypass Grafting

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COI disclosure
The author have no financial conflicts of interest to disclose concerning the presentation.

①Background

Minimally invasive coronary artery bypass grafting (MICS-CABG) offers the benefits of surgical revascularization while reducing surgical invasiveness [1-2]. However, its dissemination remains limited because of technical challenges and learning-curve–related concerns [3].

To address these issues, we developed **a simulation-enhanced, stepwise educational strategy for MICS-CABG** under direct supervision. In this study, we evaluated the feasibility, safety, and early clinical outcomes of this training program in consecutive trainee-performed MICS-CABG cases.

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②Methods

・Study Design and Patients

This was a retrospective observational study of consecutive MICS-CABG procedures performed by two trainee surgeons under direct supervision from **September 2024 to November 2025**. Clinical data and early postoperative outcomes were reviewed.

・Educational Strategy [Figure 1]

A structured, simulation-enhanced, stepwise educational strategy was used for MICS-CABG training. Trainees first developed basic minimally invasive surgical skills using simulation training and learned **internal thoracic artery harvesting with long-shaft instruments and distal coronary anastomosis from the patient's left side during conventional sternotomy off-pump coronary artery bypass grafting (OPCAB)[4]**. Training then progressed stepwise to cardiac exposure and mobilization, proximal anastomosis[5], and performing MICS-CABG under direct supervision.

・Operative Strategy and Outcome Assessment

MICS-CABG was mainly performed using an off-pump strategy[6]. Early postoperative outcomes, including mortality, complications, and length of hospital stay, were evaluated. All grafts were assessed using postoperative computed tomography angiography to evaluate early graft patency.

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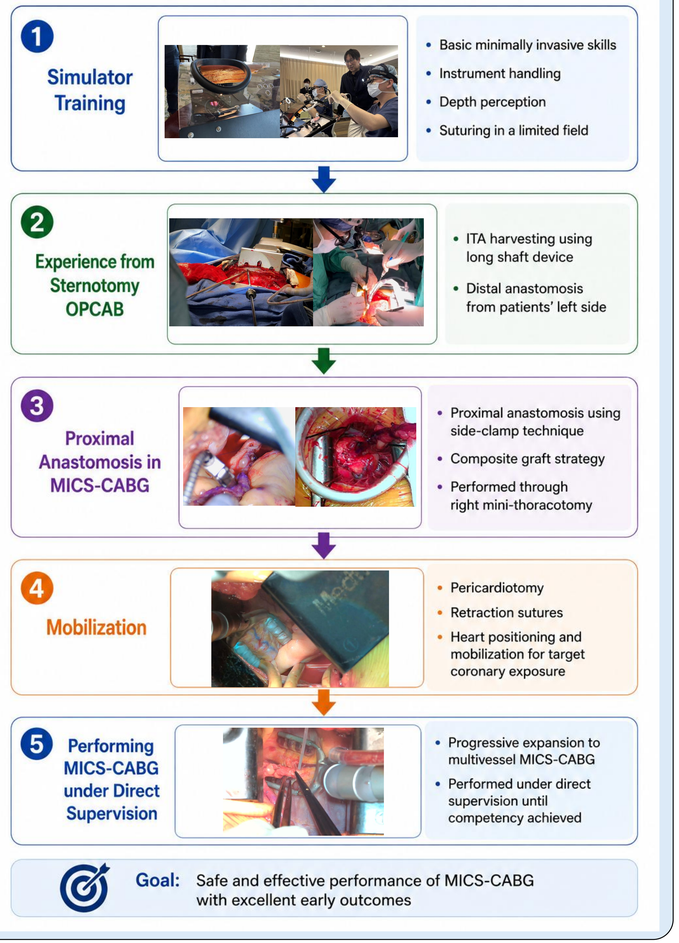
③Educational Strategy

Figure 1. Stepwise Educational Strategy for Training Surgeons in MICS-CABG



④Results

Table 1. Patient Characteristics (n=21)

Variable	Value
Age (years)	73 ± 10
Octogenarians	8 (38%)
Male sex	19 (90%)
Diabetes mellitus	8 (38%)
Chronic kidney disease	5 (24%)
Hemodialysis	2 (10%)
Left ventricular ejection fraction (%)	56 ± 9
EuroSCORE II	1.1 (0.7–2.4)
Left main trunk disease	7 (33%)
Triple-vessel disease	15 (71%)

Table 2. Operative Demographics (n=21)

Variable	Value
Off-pump strategy	20 (95%)
Bilateral internal thoracic artery use	10 (48%)
Gastroepiploic Artery use	4 (20%)
Concomitant procedures	5 (24%)
└Transcatheter aortic valve replacement	4 (19%)
└Left atrial appendage resection	1 (5%)
Operative time (min)	295 ± 89
On-pump conversion	1 (5%)
Conversion to sternotomy	0 (0%)

Table 3. Early Clinical Outcomes (n=21)

Variable	Value
Re-exploration for bleeding	1 (5%)
Surgical site infection	0 (0%)
Cerebrovascular accident	0 (0%)
Early graft patency	49/50 (98%)
Repeat revascularization	0 (0%)
Operative mortality	0 (0%)
Postoperative hospital stay (days)	13 (9–18)

Twenty-one consecutive MICS-CABG procedures performed by two trainee surgeons were analyzed.
Mean age was **73 ± 10 years**, and **71%** had triple-vessel disease [**Table 1**].

An off-pump strategy was used in **95%** of cases, and **BITA** was used in **48%**. Mean operative time was **295 ± 89 min**, with **one on-pump conversion (5%)** and **no conversion to sternotomy [Table 2]**.

Early outcomes were favorable, with **no mortality, cerebrovascular events, surgical site infection, or repeat revascularization**. Postoperative computed tomography angiography demonstrated an **early graft patency of 98% (49/50)**. Median postoperative hospital stay was **13 (9–18) days [Table 3]**.

④Discussion

•A structured stepwise educational strategy enabled safe introduction of MICS-CABG.

•Simulation training and progressive skill acquisition may reduce learning-curve–related risk.

•One patient required conversion to cardiopulmonary bypass; however, prompt conversion was performed without compromising patient safety, emphasizing the importance of supervised training and appropriate intraoperative decision-making.

•Excellent early outcomes and **98% early graft patency** were achieved despite complex patient characteristics.

•This strategy may facilitate broader dissemination of MICS-CABG.