Koşuyolu Heart Journal

Koşuyolu Heart J 2026;29(1):21–25
DOI: 10.51645/khj.2025.568

Original Article

Comparative Analysis of Bilateral Internal Mammary Artery Configurations with a Novel Hemoclip Anchoring Technique

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Abstract

Objective: Bilateral internal mammary artery (BIMA) grafting improves long-term survival in coronary artery bypass grafting (CABG). Although the left internal mammary artery (LIMA) is routinely used for the left anterior descending artery (LAD), in-situ right internal mammary artery (RIMA) grafting is less frequently preferred due to concerns regarding graft tension and insufficient length. This study compared perioperative outcomes of LIMA–LAD and RIMA–LAD grafting and evaluated the feasibility of a novel hemoclip anchoring technique designed to predict RIMA graft stress before LAD anastomosis.

Methods: Between January 2023 and September 2025, 40 patients underwent CABG with BIMA grafting at our center. Twenty-two patients received LIMA–LAD (Group 1), and 18 patients underwent RIMA–LAD using the hemoclip anchoring technique (Group 2). Pre-operative characteristics, intraoperative variables, post-operative hemodynamics, biochemical markers, and early outcomes were analyzed retrospectively.

Results: Baseline demographics and comorbidities were comparable between groups (all $p>0.05$). The number of distal anastomoses, cardiopulmonary bypass times, and cross-clamp durations were similar. Post-operative hemodynamic support requirements (intra-aortic balloon pump 9% vs. 6%; extracorporeal membrane oxygenation 4.5% vs. 6%), myocardial injury markers (troponin 380±110 vs. 365±105 ng/L), and lactate levels showed no significant differences. No graft-related intraoperative complications occurred. Early post-operative outcomes – including atrial fibrillation, re-exploration, sternal wound complications, mortality, and length of stay – were also similar. All patients were asymptomatic at 3-month follow-up.

Conclusion: The hemoclip anchoring technique provides a simple, reproducible, and safe method for pre-anastomotic assessment of RIMA geometry, enabling tension-free in-situ RIMA-to-LAD grafting. Perioperative outcomes were equivalent to conventional LIMA-to-LAD grafting. Larger studies with long-term follow-up are warranted.

Keywords: Coronary artery bypass grafting; internal mammary-coronary artery anastomosis; mammary arteries.

Cite This Article: Kızılyel F, Bayıcı BB, Rabuş MB. Comparative Analysis of Bilateral Internal Mammary Artery Configurations with a Novel Hemoclip Anchoring Technique. Koşuyolu Heart J 2026;29(1):21–25

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Submitted: November 05, 2025
Revised: December 24, 2025
Accepted: December 25, 2025
Available Online: March 18, 2026

Bilateral İnternal Mammarian Arter Konfigürasyonlarının Yeni Bir Hemoklip Tekniği ile Karşılaştırmalı Analizi

Özet

Amaç: Bilateral internal mammarian arter (BIMA) greftlemesi, koroner arter baypas cerrahisinde (CABG) uzun dönem sağkalimi artirmaktadir. Sol internal mammarian arter (LIMA) geleneksel olarak sol ön inen artere (LAD) yönlendirilirken, in-situ sağ internal mammarian arterin (RIMA) kullanimi greft gerilimi ve yetersiz uzunluk endişeleri nedeniyle daha az tercih edilmektedir. Bu çalışma, LIMA–LAD ve RIMA–LAD greftlemesinin perioperatif sonuçlarini karşilaştirmayi ve LAD anastomozu öncesinde RIMA greft stresini öngörmeyi amaçlayan yeni bir hemoklip tekniğinin uygulanabilirliğini değerlendirmeyi amaçladi.

Yöntem: Ocak 2023 – Eylül 2025 arasinda merkezimizde BIMA greftlemesi uygulanan 40 CABG hastasi incelendi. Yirmi iki hastaya LIMA–LAD (Grup 1), 18 hastaya ise hemoklip tekniği kullanilarak RIMA–LAD grefti (Grup

2) uygulandi. Preoperatif özellikler, intraoperatif parametreler, postoperatif hemodinamik veriler, biyokimyasal belirteçler ve erken dönem klinik sonuçlar retrospektif olarak analiz edildi.

Bulgular: Gruplar arasinda başlangiç demografik özellikler ve komorbiditeler benzerdi (p>0.05). Distal anastomoz sayisi, kardiyopulmoner baypas süresi ve kros-klemp süreleri karşilaştirilabilir düzeydeydi. Postoperatif hemodinamik destek gereksinimleri (IABP %9 vs. %6; ECMO %4.5 vs. %6), miyokard hasari belirteçleri (troponin 380±110 vs. 365±105 ng/L) ve laktat düzeyleri anlamli fark göstermedi. Greftle ilişkili intraoperatif komplikasyon izlenmedi. Erken postoperatif sonuçlar—atriyal fibrilasyon, yeniden eksplorasyon, sternal yara enfeksiyonu, mortalite ve hastanede kaliş süresi—benzerdi. Tüm hastalar üç aylik takipte asemptomatikti.

Sonuç: Hemoklip tekniği, RIMA geometrisinin anastomoz öncesi değerlendirilmesinde basit, tekrarlanabilir ve güvenli bir yöntem sunmakta olup gerilimsiz in-situ RIMA-LAD greftlemesini kolaylaştirmaktadir. Perioperatif sonuçlar geleneksel LIMA–LAD greftlemesi ile eşdeğer bulunmuştur. Daha geniş hasta gruplarinda ve uzun dönem izlemlerle doğrulanmasi gerekmektedir.

Anahtar sözcükler: Koroner arter baypas greftleme; internal mammarian–koroner arter anastomozu; mammarian arterler.

Introduction

Coronary artery bypass grafting (CABG) is a fundamental procedure in the treatment of severe coronary artery disease. Arterial grafts, especially the internal mammary arteries, have enhanced long-term patency and clinical results relative to venous grafts.[1] Since its first introduction, left internal mammary artery (LIMA) grafting to the left anterior descending artery (LAD) has emerged as the gold standard owing to its exceptional durability and survival advantages.

Bilateral internal mammary artery (BIMA) grafting provides supplementary long-term benefits, such as enhanced event-free survival and diminished rates of reintervention.[2] Notwithstanding substantial evidence endorsing BIMA, its global application remains limited primarily due to technical issues, the risk of sternal wound complications in high-risk patients, and apprehensions regarding graft length and tension when employing the right internal mammary artery (RIMA) for LAD revascularization.

Graft tension is a crucial factor influencing long-term patency; high tension may result in intimal damage, kinking, twisting, or premature graft failure. Prior methodologies – such as deeper pericardial mobilization, retro-aortic routing, and skeletonization – have attempted to address this issue but require enhancement to provide pre-anastomotic simulation of graft geometry under physiological conditions.[3,4]

To mitigate this deficiency, we utilized a straightforward method of temporarily anchoring the RIMA pedicle to pericoronary adipose tissue using a hemoclip before performing LAD anastomosis. This study sought to compare the outcomes of LIMA–LAD and RIMA–LAD grafting and to assess the efficacy of hemoclip anchoring in mitigating RIMA graft tension.

Materials and Methods

From January 2023 to September 2025, 40 patients who underwent isolated CABG with BIMA grafting were included. Patients were categorized into two groups: Group 1 (n=22): LIMA–LAD; Group 2 (n=18): RIMA–LAD employing the hemoclip anchoring technique. Patients who received free mammary transplants or required simultaneous cardiac surgeries were excluded.

All procedures were conducted through median sternotomy utilizing cardiopulmonary bypass with modest systemic hypothermia. LIMA and RIMA were excised as pedicled grafts utilizing low-current electrocautery and hemoclips for vascular control. Topical papaverine was used to avert spasm. The contralateral mammary artery graft was directed to the circumflex or right coronary artery, and supplementary venous grafts were placed as required.

Hemoclip Anchoring Technique (Group 2)

Before RIMA–LAD anastomosis:

- The RIMA pedicle was fully mobilized and evaluated for length and flow.
- One or two hemoclips were used to temporarily anchor the pedicle to pericoronary adipose tissue adjacent to the LAD (Fig. 1).
- The heart was filled and lungs inflated to replicate normal physiological positioning (Fig. 2).
- Graft alignment was assessed for tension, kinking, or torsion.
- Adjustments were made if necessary before the 7–0 polypropylene LAD anastomosis was completed.

All patients were extubated within 12 h. Aspirin and clopidogrel were initiated on post-operative day 1. Daily electrocardiogram, cardiac enzymes, and echocardiography were performed. Clinical follow-up occurred at 1 and 3 months.

Statistical Analysis

Statistical analyses were performed using the Statistical Package for the Social Sciences software package, version 23 (SPSS Inc., Chicago, Ill., USA). Variables were expressed as numbers (percentages). Continuous variables were analyzed using independent t-tests or Mann–Whitney U tests for group comparisons. Fisher's exact test and χ^2 test were used for categorical data. A $p<0.05$ was considered statistically significant.

Ethical Statement

The Declaration of Helsinki was followed in the study, which was approved by the Non-interventional Clinical Research Ethics Committee of Koşuyolu High Specialization Training and Research Hospital (Date: 18.11.2025, Decision no: 2025/19/1287).

Results

Forty patients underwent BIMA grafting, with 22 receiving LIMA–LAD and 18 RIMA–LAD through the hemoclip anchoring technique. The pre-operative demographic characteristics – such as age, body mass index, EuroSCORE II, left ventricular ejection fraction, diabetes mellitus, hypertension, hyperlipid-

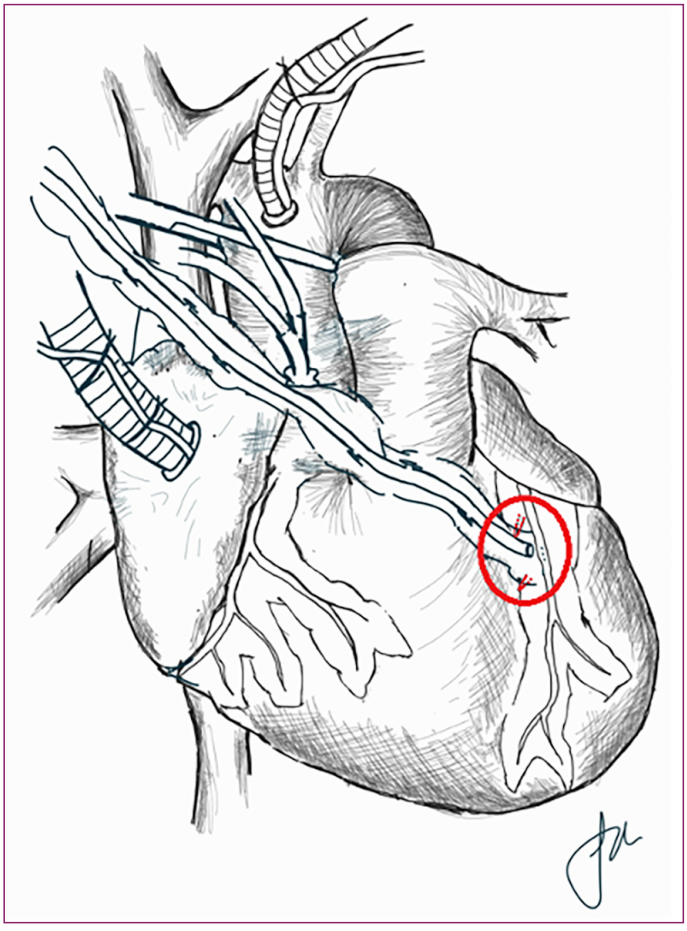

Figure 1. Drawing of the anchored mammary graft to the anastomotic site.

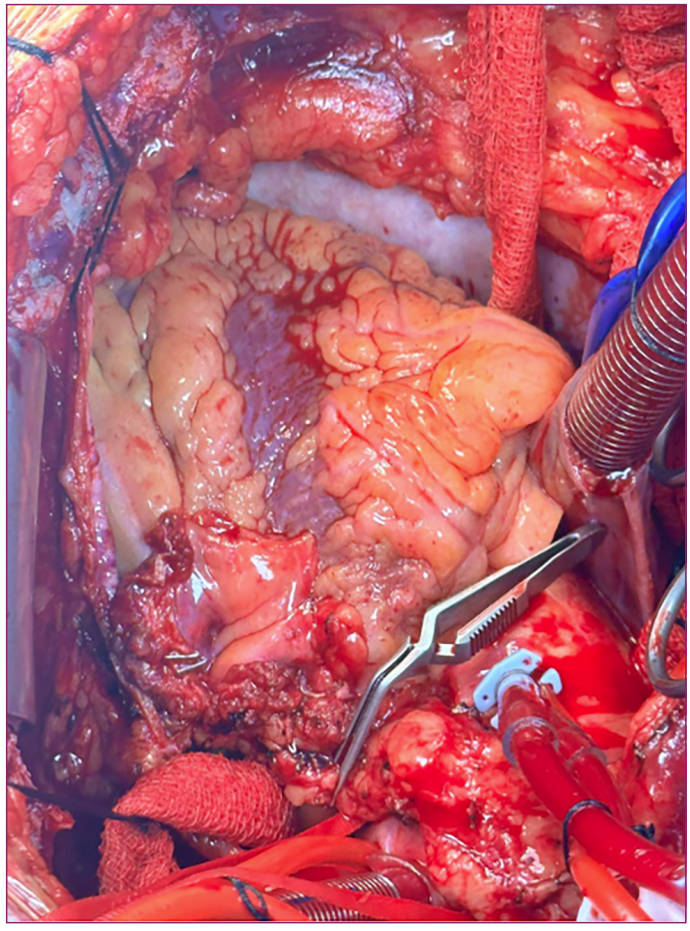

Figure 2. Surgical view of the hemoclip technique before the anastomosis.

emia, carotid disease, and smoking status – were comparable between the two groups, indicating well-balanced baseline risk profiles (Table 1). Intraoperatively, the average durations of cardiopulmonary bypass and cross-clamping were statistically similar, and the number of distal anastomoses was indifferent, indicating that the utilization of RIMA to LAD did not increase operative complexity or necessitate further technical modifications. No intraoperative graft-related problems occurred in either cohort, and no patient required revascularization.

The post-operative hemodynamic outcomes were similarly comparable. The necessity for intra-aortic balloon pump and extracorporeal membrane oxygenation support was minimal in both cohorts and did not exhibit statistically significant disparities. Inotropic support requirements were comparable. Biochemical markers of myocardial damage, such as peak troponin and creatine kinase-MB levels, exhibited no significant differences, suggesting that myocardial protection was equivalent between the two grafting configurations. Post-operative lactate levels were similar, indicating equivalent systemic perfusion and metabolic recovery (Table 2).

As detailed in Table 2, the incidence of early postoperative adverse events—such as atrial fibrillation, re-exploration for bleeding, sternal wound infection, neurological complications, and mortality—was low and did not differ significantly between the groups. One mortality was observed in the LIMA–LAD cohort because of the multi-organ failure postoperatively, whereas the RIMA–LAD group reported no deaths. The median duration of hospitalization was 7 days for both cohorts. At the 3-month follow-up, all surviving patients were asymptomatic, and no significant adverse cardiac events were noted.

The hemoclip anchoring technique successfully simulated secure, tension-free in-situ RIMA-to-LAD grafting before anastomosis, yielding perioperative and early post-operative outcomes comparable to those of traditional LIMA-to-LAD grafting.

Discussion

The internal mammary arteries are the most reliable conduits for coronary revascularization, exhibiting long-term patency rates over 90% and continuous survival advantages evidenced across decades of surgical practice.[5] With the advancement of arterial grafting techniques, multi-arterial and BIMA grafts have demonstrated superiority over venous revascularization, enhancing long-term survival, decreasing the necessity for repeat revascularization, and facilitating event-free recovery.[6,7] Notwithstanding these recognized benefits, the extensive implementation of BIMA is constrained, primarily due to technical issues, sternal wound complications in high-risk groups, and, notably, difficulties associated with graft length and tension when employing the RIMA for left coronary system revascularization.[8]

Table 1. Demographics and comorbidities

	Group 1 (n=22)	Group 2 (n=18)	p
Age (years)	53.5 [47.0–60.8]	54.5 [50.2–59.8]	0.703
Body mass index (kg/m²)	28.3±4.1	27.9±4.4	0.761
EuroSCORE II (%)	0.9 [0.8–1.3]	1.0 [0.8–1.1]	0.724
Left ventricular ejection fraction (%)	65.0 [57.0–65.0]	65.0 [58.0–65.0]	0.585
Diabetes mellitus	9/22 (40.9%)	5/18 (27.8%)	0.386
Hyperlipidemia	17/20 (85.0%)	14/16 (87.5%)	1.000
Hypertension	11/22 (50.0%)	11/18 (61.1%)	0.482
Carotid disease	3/22 (13.6%)	3/18 (16.7%)	1.000
Smoke	17/22 (77.3%)	10/18 (55.6%)	0.145

Table 2. Postoperative hemodynamic and biochemical parameters

	Group 1 (n=22)	Group 2 (n=18)	p
IABP	2/22 (9%)	1/18 (6%)	0.88
ECMO	1/22 (4.5%)	1/18 (6%)	0.74
Inotropic support	2 [1–3]	2 [1–2]	0.41
Troponin (ng/L)	380±110	365±105	0.63
CK-MB (U/L)	21.5±6.0	20.8±5.5	0.71
Lactate (mmol/L)	2.1 [1.6–2.7]	2.0 [1.7–2.6]	0.82
Atrial fibrillation	2/22	0/18	>0.05
Re-exploration	1/22	0/18	>0.05
Sternal wound infection	0	0	-
Mortality	1/22	0/18	>0.05
Hospital stay (days)	7	7	>0.05

IABP: Intra-aortic balloon pump; ECMO: Extracorporeal membrane oxygenation; CK-MB: Creatine kinase-MB.

In conventional practice, the LIMA is favored for LAD grafting due to its advantageous anatomical trajectory and reliable length. However, the RIMA presents considerable anatomical challenges, thereby increasing the potential risk of graft stress, kinking, twisting, or spasm during LAD revascularization. Graft tension may result in intimal damage, hindered anastomotic healing, and premature graft failure – elements that could negate the long-term advantages of multi-arterial grafting. Numerous technical modifications – such as retro-aortic routing, skeletonization, pericardial release maneuvers, and flow-based assessments – have been documented; however, none directly predict pre-anastomotic tension in in situ RIMA–LAD grafting.[9,10]

In this context, we investigated a straightforward intraoperative modification – the hemoclip anchoring technique – intended to evaluate and mitigate graft tension before the construction of the RIMA-to-LAD anastomosis. By temporarily securing the RIMA pedicle to pericoronary adipose tissue and assessing graft shape under physiological settings (cardiac filling and lung inflation), the surgeon obtains real-time input on graft positioning, preventing kinking or excessive tension before finalizing the anastomosis. This technique circumvents substantial dissection or skeletonization and mitigates hazards linked to post-anastomotic modifications, such as graft spasm or hemodynamic instability.

Our comparison investigation revealed that RIMA–LAD grafting utilizing this approach is equally safe and effective as traditional LIMA–LAD grafting during the perioperative period. The pre-operative demographic and comorbidity profiles were evenly matched between groups, with no variations seen in cardiopulmonary bypass duration, cross-clamp time, or the number of distal anastomoses, suggesting that the approach does not elevate surgical complexity. Biochemical indicators of myocardial injury (troponin, CK-MB), hemodynamic support requirements (IABP, ECMO, and inotropes), and early post-operative complications – such as atrial fibrillation, re-exploration, sternal wound issues, or mortality – were similar between the two groups. All patients were asymptomatic during the short-term follow-up, with no significant adverse cardiac events documented.

The findings indicate that the hemoclip anchoring technique efficiently minimizes the primary limitation of RIMA–LAD revascularization – graft tension – while maintaining procedural safety. This technique offers a straightforward, replicable, and low-risk method for simulating graft behavior during surgery, potentially expanding the use of RIMA for LAD grafting and facilitating the broader implementation of complete arterial or BIMA grafting procedures. In light of the robust evidence supporting the long-term benefits of multi-arterial revascularization, even subtle technical strategies that ensure safer arterial graft utilization may yield better long-term outcomes.

Nonetheless, our study possesses limitations, such as its single-center design, limited sample size, and absence of long-term angiographic follow-up. Future prospective studies with bigger patient populations and graft patency evaluations are necessary

to confirm the long-term efficacy of the hemoclip anchoring approach. Notwithstanding these constraints, our first results highlight the viability and safety of this method, advocating for its evaluation as a pragmatic complement in BIMA revascularization.

Conclusion

The hemoclip anchoring technique provides a straightforward and consistent approach for evaluating and alleviating graft tension during in situ RIMA-to-LAD grafting. The perioperative outcomes were analogous to those of LIMA-to-LAD grafting, indicating the feasibility and safety of this alteration. The expanded application of this approach may enhance the acceptance of BIMA grafting and its enduring survival advantages. Comprehensive, prospective trials with long-term angiographic follow-up are necessary.

Disclosures

Ethics Committee Approval: The study was approved by the Koşuyolu High Specialization Training and Research Hospital Non-interventional Clinical Research Ethics Committee (no: 2025/19/1287, date: 18/11/2025).

Informed Consent: Retrospective study.

Conflict of Interest Statement: None declared.

Funding: The author declared that this study has received no financial support.

Use of AI for Writing Assistance: None declared.

Author Contributions: Concept – F.K.; Design – F.K., M.B.R.; Supervision – M.B.R.; Resource – F.K., B.B.B.; Materials – F.K.; Data collection and/or processing – F.K., B.B.B.; Analysis and/or interpretation – F.K.; Literature review – F.K., M.B.R.; Writing – F.K.; Critical review – M.B.R.

Peer-review: Externally peer-reviewed.

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