



Original Article

Internal Mammary Artery Perforator Flap to Cover Sternotomy Wounds:
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ABSTRACT

The issue of sternotomy wounds is a continued challenge in cardiac and thoracic vascular surgery, especially in patients who have various comorbidities and are infected. Functional morbidity is linked to traditional muscle flaps that are effective. IMAP flap provides an alternative to other conventional flaps and the internal mammary perforator (IMAP) flap, which maintains muscle functionality while also producing well-vascularized tissue. **Objectives:** To determine the clinical results of the internal mammary artery perforator flap to reconstruct presternal and mediastinal sternotomy wound defects. **Methods:** This prospective observational study was conducted during the period of August 2024 and February 2025 at the Department of Plastic Surgery, Jinnah Burn Reconstruction Surgery Centre/Allama Iqbal Medical College. Institutional ethical approval was obtained No.6117/ED/JB&RSC. **Results:** In this study, the mean age of the cases was 56.4 ± 10.8 years. There were 21 (70%) males and 9 (30%) females enrolled. Complete reconstructive success was achieved in 10 patients, partial success was achieved in 15 on 29th July 2024 patients, and non-healing wounds were found in 5 patients. Recurrent infection was found in 5 patients (16.7%), and mortality associated with sepsis was observed in 4 patients (13.3%). **Conclusions:** IMAP flap is a secure reconstruction of the defects present on the presternal and mediastinal sternotomy wounds, which has a good healing outcome even in high-risk patients. IMAP flap is a better alternative to the conventional muscle flap for chest wound coverage.

INTRODUCTION

Sternal wound dehiscence during cardiac surgery is a significant complication, affecting 1% of patients having coronary artery bypass grafting [1]. A prevalent cause is wound infection; nonetheless, mechanical dehiscence of the skin may sometimes transpire, especially in situations with heightened chest wall movement (e.g., patients experiencing respiratory crisis) [2]. The primary therapeutic approach is surgical debridement of necrotic tissues, followed by the extraction of sternal cables.

Following wound debridement, negative pressure wound therapy (NPWT) is used until closure by tertiary aim is achieved. At this juncture, soft tissue must be translocated into the incision as a flap to facilitate healing [3]. Conventional reconstructive flaps, including pectoralis flaps, are either ineffective in covering the entire defect or necessitate laparotomy in the case of the omental flap as a sternal wound closure [4]. To repair large incisions, it is necessary to employ several flaps in conjunction, as each



flap is insufficient to cover the entire length of a sternal defect, despite its effectiveness in addressing significant weaknesses [5]. Furthermore, the atrophy of these muscles may result in functional deficits, possible hernias (particularly of the rectus muscle), seromas, and further complications. Moreover, significant dissection of the pectoral muscles at that level may impede chest mobility during the postoperative period owing to discomfort. Alternative therapeutic modalities include topical negative pressure therapy to facilitate wound healing [6]. A recent technique for closing sternal wounds is the deep superior epigastric perforator (DSEP) flap [7, 8]. Using a single perforator from the DSEP and rotating it 90 degrees, this fasciocutaneous perforator flap may successfully repair large defects. Among the documented benefits are the potential for a hidden submammary incision in females, muscle function retention, and less dissection [9]. It is necessary to have an intact internal mammary artery (IMA) axis, as the DSEP flap's maximal harvesting length restricts its application. This article delineates the utilisation of the internal mammary artery perforator (IMAP) flap to reconstruct various presternal and mediastinal lesions under specific circumstances [10]. The primary benefit is that a single fasciocutaneous or musculocutaneous IMAP flap can effectively address any three-dimensional sternotomy wound defect. Previously used for tracheostoma, head and neck reconstruction, and correcting moderate to medium-sized chest wall abnormalities after tumour excision, the IMAP flap is reliable and well-researched. In a selected group of non-infected wounds with a stable sternal wound, Lupon et al. employed the IMAP flap in both fasciocutaneous and musculocutaneous designs to reconstruct sternal wound dehiscence [11]. Likewise, in a case of anterior chest wall defects, the IMAP flap was proven to be a reliable and effective procedure with minimal donor-site morbidity and good healing [12].

Despite advancements in reconstructive techniques for post-sternotomy wound defects, the optimal method that balances effective wound coverage with minimal functional morbidity remains inadequately defined. Traditional muscle flaps, although reliable, are associated with donor-site morbidity and impaired muscle function. Recently, perforator-based flaps such as the IMAP flap have emerged as promising alternatives; however, the available literature is limited, with few prospective studies and insufficient comparative data evaluating their clinical outcomes, reliability, and complication rates, particularly in resource-limited settings. Moreover, there is a lack of regional data assessing the effectiveness of IMAP flaps in diverse patient populations with varying comorbidities. Therefore, further evidence is required to establish the clinical utility and outcomes of IMAP flap reconstruction in

sternotomy wound management. This research will clarify our experience with the internal mammary artery perforator flap for managing sternotomy wounds and provide a novel approach for correcting these issues. This study aimed to evaluate the clinical outcomes associated with the use of the IMAP flap in patients with sternotomy wound defects, particularly with respect to wound healing, infection control, and postoperative complications.

METHODS

This prospective observational study was conducted at the Department of Plastic Surgery, Jinnah Burn and Reconstructive Surgery Centre, Allama Iqbal Medical College, Lahore, after obtaining institutional ethical approval (No. 6117/ED/JB&RSC, dated 29th July 2024). This study was conducted from August of 2024 to February of 2025. A sample size of 30 patients was determined using the single population proportion formula, based on an expected success rate of 70% as determined in previous literature, an 80% confidence level ($Z = 1.96$), and a margin of error of 10% [13]. Patients aged 45–80 years who developed sternotomy wound complications following open heart surgery and required soft tissue reconstruction were included in the study using a consecutive sampling technique. Patients who had wounds on the chest wall that were not associated with post-sternotomy complications, traumatic chest wall defects, malignant wounds, medical contraindications for reconstruction surgery, or who declined to have reconstruction surgery were not included. Informed consent was obtained from all participants in writing before screening. The study population included 22 males and 8 females, that is, 2.75:1. Previous surgical operations performed on the patients included 2 patients who had received a carotico-subclavian bypass, 3 patients who had received a thoracic endoprosthesis after a carotico-subclavian bypass, 5 patients who had undergone combined cardiac valve replacement and coronary artery bypass grafting (CABG), and 20 patients who had received isolated CABG. The majority of patients had several comorbidities such as diabetes mellitus, hypertension, ischemic heart disease, and immunosuppression. Sternal wound dehiscence was evaluated using the Pairolero and Arnold classification scale as part of the pre-operative evaluation. The Type II wounds were intermediate infections that were seen during 2–3 weeks after surgery and included drainage, cellulitis, and mediastinitis, while the Type III wounds were late infections months or years after surgery with chronic sinus tracts or osteomyelitis. Patients were also classified by the American Society of Anesthesiologists (ASA) Physical Status Classification System (PSCS) I–VI [14]. Internal mammary artery perforators were preoperatively located using handheld Doppler ultrasonography, with a dominant perforator

typically found in the second or third intercostal space 1-2 cm from the sternal border. Depending on the nature of the defect, the IMAP flap was raised as a fasciocutaneous flap. The skin paddle was elevated subfascial/subcutaneously from lateral to medial until the perforator was located, with preservation or minimal skeletonization of the perforator, which enabled safe skin paddle rotation. A portion of the pectoralis major muscle was attached to the flap in patients with mediastinal defects and substantial dead space, with the IMAP system maintaining perfusion. The flap was usually turned around 90 degrees, and donor sites were primarily closed in all patients. Each procedure was carried out by the same experienced plastic surgeon. Patients with suspected fungal wound infection based on clinical presentation or non-resolving infection underwent microbiological assessment, including direct microscopy and fungal culture, to guide appropriate antimicrobial management. Postoperative management was performed as per institutional protocols, which included culture-directed antibiotic therapy. Microbiological examination consisted of direct microscopy and KOH preparation (fungal identification). Where necessary, calcofluor white staining was used under ultraviolet light for better visualization of fungal elements. Selected cases were also confirmed by fungal culture, histopathology, serological assays, and molecular diagnostic techniques. The results of the study were classified as success, partial success, non-healing, and recurrent infection. Complete primary wound healing after surgery was deemed a success. Partial success was defined as wounds that became infected but were treated conservatively. Non-healing was considered as having a chronic chest wound that caused infection and osteomyelitis for more than three months. Recurrent infection was defined as when infection returned to a previously healed wound within 3 months.

The data were entered and analyzed in SPSS version 26.0. Data analyzed quantitatively were presented as mean $\pm$ SD, and qualitative data were presented as frequency and percentage. Descriptive analysis was conducted.

RESULTS

A total of 30 patients who were reconstructed using an internal mammary artery perforator flap to treat complicated sternotomy wounds. The average age of the population under study was 56.4 ± 10.8 years, with the largest number of patients falling within the 45-54 years category. The majority of patients were male (70%), and females made up 30% of the patients. The comorbid conditions were very high. The most common risk factors were hypertension and ischemic heart disease (86.7% and 76.7%), and then diabetes mellitus (60%). Fungal infection (36.7%) and immunosuppression (23.3%) had a smaller percentage of patients reported to affect wound healing

outcomes. In this study, the mean age of the cases was 56.4 ± 10.8 years; there were 21 (70%) males and 9 (30%) females enrolled. In this study, there were 18 (60%) diabetic, 26 (86.7%) hypertensive, 23 (76.7%) patients with ischemic heart disease, 7 (23.3%) immunosuppression, 11 (36.7%) patients with fungal infection enrolled (Table 1).

Table 1: Demographic Characteristics and Comorbidities (n=30)

Variables	n (%) / Mean $\pm$ SD
Age (years)	56.4 $\pm$ 10.8
Age Categories	
45-54 Years	13 (43.3%)
55-64 Years	6 (20%)
65-74 Years	7 (23.3%)
≥ 75 Years	4 (13.3%)
Gender	
Male	21 (70%)
Female	9 (30%)
Others	
Diabetes Mellitus	18 (60%)
Hypertension	26 (86.7%)
Ischemic Heart Disease	23 (76.7%)
Immunosuppression	7 (23.3%)
Fungal Infection	11 (36.7%)

As to the main surgical procedure, the most frequent indication was the coronary artery bypass grafting (CABG) with two-thirds (66.7 percent), and the second reason was the combined valve replacement with CABG (20 percent). The patients who had undergone carotico-subclavian bypass or thoracic endoprosthesis were few. Mediastinal defects were a bit more present (53.3%) than presternal defects (46.7%). Most of the patients were ASA grade III (46.7%), which is moderate anesthetic risk, and ASA grade II and IV were 36.7% and 16.7%, respectively (Table 2).

Table 2: Operative and Defect-Related Findings

Variables	n (%)
Original Cardiac / Vascular Procedure	
CABG	20 (66.7%)
Valve Replacement + CABG	6 (20%)
Carotico-Subclavian Bypass	3 (10%)
Thoracic Endoprosthesis Procedure	3 (10%)
Type of Defect	
Presternal	14 (46.7%)
Mediastinal	16 (53.3%)
ASA Grade	
Grade II	11 (36.7%)
Grade III	14 (46.7%)
Grade IV	5 (16.7%)

In the patients who underwent reconstruction, partial success was the most common reconstructive outcome (50%), followed by complete success (33.3%). A lesser number of patients (5, 16.7%) were left with non-healing

wounds after reconstructive surgery, suggesting a lower rate of wound failure. In terms of general clinical results, most patients (21 cases, 70%) had healed wounds, indicating good wound healing in a majority of the participants after surgery. However, there was a small number of patients who developed recurrent infection (5, 16.7%) and several patients who died from sepsis (4, 13.3%), showing that there were serious postoperative complications in a subset of patients (Table 3).

Table 3: Reconstructive Procedure Success and Overall Outcome

Outcomes	n(%)
Reconstructive Outcome	
Success	10 (33.3%)
Partial Success	15 (50%)
Non-Healing Wound	5 (16.7%)
Overall Clinical Outcome	
Healed wound	21 (70%)
Recurrent infection	5 (16.7%)
Death due to sepsis	4 (13.3%)

A chronic post-sternotomy wound four months after coronary artery bypass grafting is shown, followed by surgical debridement and flap planning. The internal mammary artery perforator is identified (arrow) and incorporated into the flap design. The flap is then inset over closed-suction drains to achieve stable coverage of the sternal defect, with a six-month follow-up image demonstrating complete wound healing and durable soft-tissue reconstruction (Figure 1).



Figure 1: A Chronic Post-Sternotomy Wound Four Months After Coronary Artery Bypass Grafting Followed by Surgical Debridement and Flap Planning

A second patient presenting with chronic discharging sinuses over the sternum is shown. Following surgical debridement, flap markings are demonstrated. A combined musculofasciocutaneous flap based on the internal mammary artery perforator is raised and rotated to cover the defect, with the final image showing successful insetting of the flap and restoration of soft-tissue continuity (Figure 2).

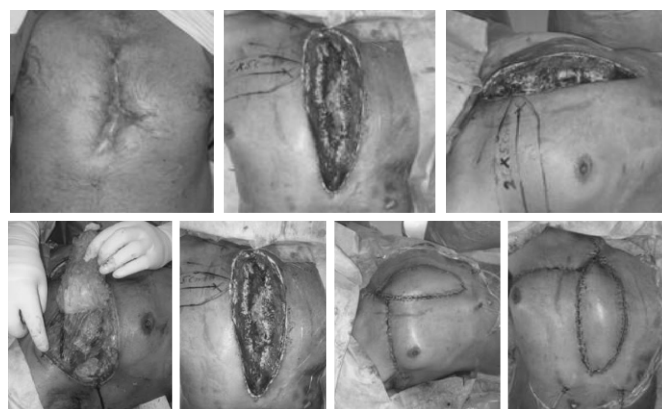


Figure 2: Patient Presenting with Chronic Discharging Sinuses Over the Sternum

DISCUSSION

The IMAP flap has transitioned from its original characterization as a perforator flap using the deltopectoral axis for tracheostomal repair to a multifaceted solution for many anterior chest and neck abnormalities [15]. Subsequent studies have shown its reliability in addressing minor to moderate-sized lesions with little donor-site morbidity. This prospective multicenter research has shown that the IMAP flap is a reliable reconstructive solution for presternal and mediastinal sternotomy wound defects in a high-risk population [16]. The majority of patients finally attained wound healing despite considerable comorbidities and active infection, demonstrating the ability of this flap to provide well-vascularized tissue to impaired surgical areas [17]. The advantageous results seen may be ascribed to many technical and anatomical benefits of the IMAP flap. The perforator-based design facilitates primary closure of the donor site, prevents exposure of deeper holes, and reduces functional loss relative to conventional muscle flaps [18, 19]. In contrast to the pectoralis major, rectus abdominis, or omental flaps, the IMAP flap may rebuild the whole extent of a sternotomy lesion from the suprasternal notch to the xiphisternum with less dissection and decreased morbidity. This characteristic makes it especially appealing for stable patients with infected sternotomy wounds and defect widths of up to 7 cm, a group for which the IMAP flap may be regarded as a primary reconstructive alternative [13]. Nonetheless, its use is restricted in individuals necessitating vasopressor assistance, and the resultant subclavicular scar may be seen as less acceptable by younger female patients. This work broadens the use of the IMAP flap in sternotomy wound restoration by implementing it in both fasciocutaneous and musculocutaneous forms, according to the defect's depth. Fasciocutaneous IMAP flaps offered enhanced shape and skin compatibility for presternal defects but exhibited heightened vulnerability to pedicle torsion and distal venous compromise, notwithstanding

preoperative perforator identification. The delayed elevation of the fasciocutaneous flap appeared to enhance survival, possibly due to gradual expansion of the perforator over time. A direct comparison between fasciocutaneous and musculocutaneous variations was impracticable due to the limited sample size; nonetheless, indirect evidence suggests greater reliability of the musculocutaneous IMAP flap [20]. Anatomical factors help explain the observed disparities among flap forms. The suprafascial width of the internal mammary artery perforator is less than that of its deeper submuscular portion, making it more vulnerable to torsion-related damage when used as a solely fasciocutaneous flap [11]. Finelle and colleagues showed that the length of the second IMAP approximately doubles when traced to its origin, with similar results for the first and third perforators [12]. Extended perforator dissection or the retention of a minor segment of the pectoralis major muscle may therefore decrease torsional stress and improve flap dependability, especially for fasciocutaneous configurations. Despite these advantages, there are inherent weaknesses of the IMAP flap, including a limited range of motion, the need for precise perforator dissection, and the inability to cover large or complicated defects. These restrictions indicate the necessity of careful patient selection and surgical planning [21]. The main strengths of this study are that it has a prospective design as well as multicenter participation, and it has a uniform surgical procedure, whereas the main weaknesses include the small sample size and lack of a comparison control group. To define the best indicators, maximize the technology modifications, and clarify the importance of the IMAP flap in the reconstruction algorithms of sternotomy wound issues, future studies with larger cohorts and comparative designs are needed.

This study was conducted at a single center with a lack of randomization, which may introduce bias and limit the external validity of the results; the relatively small sample size may limit the generalizability of the findings and reduce the statistical power. Short follow-up duration restricts the assessment of long-term outcomes, including flap durability and late complications. No control or comparison group limits the ability to directly compare the effectiveness and complication rates of the IMAP flap with other established reconstructive techniques. Additionally, potential confounding variables such as patient comorbidities (e.g., diabetes, obesity, smoking status) were not fully controlled or stratified. Future studies should include larger, multicenter samples, and randomized controlled trials with longer follow-up periods to improve the generalizability and robustness of the findings. Further comparative studies between IMAP flaps and conventional muscle flaps are warranted to establish standardized guidelines for optimal management of sternotomy wound defects.

CONCLUSIONS

IMAP flap is a secure reconstruction of the defects present on the presternal and mediastinal sternotomy wounds, which has a good healing outcome even in high-risk patients. IMAP flap is a better alternative to the conventional muscle flap for chest wound coverage.

Authors' Contribution

Conceptualization: MB

Methodology: MB, IS, AMM

Formal analysis: KK

Writing and Drafting: MB, KK, FAK, AMM, AS

Review and Editing: MB, IS, KK, FAK, AMM, AS

All authors approved the final manuscript and take responsibility for the integrity of the work

Conflicts of Interest

All the authors declare no conflict of interest.

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