



Post-CABG Deep Sternal Wound Infection: A Retrospective Comparative Analysis of Early versus Late Referral to a Plastic Surgery Unit in a Tertiary Care Center

Parag B. Sahasrabudhe^{1,2} Mugdha D. Pradhan¹ Nikhil Panse² Ranjit Jagtap³

¹Department of Plastic Surgery, Deenanath Mangeshkar Hospital & Research Centre, Pune, Maharashtra, India

²Department of Plastic Surgery, B.J. Medical Govt. College & Sassoon Hospitals, Pune, Maharashtra, India

³Department of Cardiothoracic Surgery, Deenanath Mangeshkar Hospital & Research Centre, Maharashtra, India

Address for correspondence Parag B. Sahasrabudhe, MBBS, MS, MCh, Plot 82, Lane 2, Natraj Society, Karvenagar, Pune 411 052, Maharashtra, India (e-mail: drparags@gmail.com).

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Abstract

Background Deep sternal wound infections (DSWI) following median sternotomy are initially treated by the cardiothoracic surgeons and are referred to a plastic surgical unit late in the course of time.

Methods This is a retrospective review done in a tertiary care teaching institute from January 2005 to June 2018 and the data of 72 patients who had DSWI out of 4,214 patients who underwent median sternotomy for coronary artery bypass grafting (CABG) was collected with respect to the duration between CABG and presentation of DSWI as well as time of referral to a plastic surgery unit. We defined early referral as < or equal to 15 days from presentation and late referral as > 15 days. Both groups were compared with respect to multiple parameters as well as early and late postoperative course, postoperative complications, and mortality.

Results The early group had 33 patients, while the late group had 39 patients. The number of procedures done by the cardiothoracic team before referral to the plastic surgery unit is significant ($p = 0.002$). The average duration from the presentation of DSWI to definitive surgery was found to be 16.58 days in the early group and 89.36 days in the late group. The rest of the variables that were compared in both the groups did not have significant differences.

Conclusion There is no statistical difference between early and late referral to plastic surgery in terms of mortality and morbidity. Yet, early referrals could lead to highly significant reduction in total duration of hospital stay, wound healing, and costs. Early referral of post-CABG DSWIs to Plastic surgeons by the cardiothoracic surgeons is highly recommended.

Keywords

- ▶ deep sternal wound infection (DSWI)
- ▶ negative pressure wound therapy
- ▶ omental flap
- ▶ pectoralis major muscle flaps
- ▶ sternal dehiscence

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Background

Deep sternal wound infection (DSWI) following median sternotomy is a life-threatening complication after this approach for coronary artery bypass grafting (CABG).^{1,2} Most of the patients who undergo CABG have associated morbidities such as diabetes mellitus resulting in delayed wound healing. The incidence of sternal wound infections and dehiscence is reported between 0.2 and 10% among patients who undergo sternotomy and mortality of 5 to 20% following sternal dehiscence.³ The use of bilateral internal mammary arteries (BIMA) for revascularization has been shown to improve graft patency rates and help in reduction of repeated episodes of angina in comparison to the usage of a single internal mammary artery (IMA).⁴⁻⁶ The extensive use of BIMAs precludes a higher incidence of DSWI associated with sternal devascularization.^{7,8} This is of concern in patients with predisposing factors such as diabetes, obesity, chronic pulmonary obstructive disease, or diffuse arteriopathy.⁹⁻¹² When DSWI develops, the cardiac surgeons use conventional methods such as wound debridement, rewiring or plating, and closure with or without negative pressure wound therapy (NPWT). In contrast, when these patients are referred to plastic surgeons they are treated with debridement and closure with various flaps.¹³ A recent review article by Schiraldi et al advocated flap cover in cases of chronic DSWI should not be delayed for more than 2 weeks after NPWT.¹⁴ In this study, we aim to review our cases of DSWI with respect to their time of referral to a plastic surgical unit and study the correlation between the time of referral to the outcomes.

Aims and Objectives

1. To study the outcome of plastic surgical procedures in cases of DSWI in patients of post-CABG and their correlation to time of referral to plastic surgical unit.
2. To find the correlation between the early versus late referral to a plastic surgical unit with the outcome of plastic surgical procedures.
3. To evaluate the indicators of morbidity such as prolonged treatment duration and prolonged hospital stay associated with the delay in referral to plastic surgery unit.

Null Hypothesis

There is no difference between early referral and late referral in terms of decreased postoperative stay, morbidity, and mortality.

Patients and Methods

A retrospective cohort study of all patients of DSWI post-median sternotomy who underwent CABG between January 2005 and June 2018 was performed at a tertiary care center in India. The data was obtained from the electronic medical records of the patients from the hospital database that included demographic data, dates of CABG, dates of presentation of DSWI, and referral to the plastic surgical unit. We defined less than or equal to 15 days from the presentation as an early referral and more than 15 days as a late referral. This was an arbitrary value as there is no mention of cutoff value for time of referral in the literature. Both the groups were compared with respect to the age, gender distribution, classification as per Jones' criteria,¹⁵ delay in wound healing, presence of microorganisms in wound swab culture, number of NPWT changes, duration between presentation to definitive management, duration between definitive surgery and discharge, choice of a flap, number of flaps, duration from plastic surgery referral to discharge, early and late postoperative course, and postoperative complications and mortality. Institutional Ethics Committee permission was obtained before commencing the study. (IHR_2018_SEP_PS_278)

Wounds were classified as per the Jones' classification (► **Table 1**).

Inclusion criteria: All patients who underwent CABG through a median sternotomy approach, who had DSWI (types 2A, 2B, 3A, 3B), and who underwent a plastic surgery procedure.

Exclusion criteria: Patients having superficial sternal wound infections (types 1A and 1B), or who underwent any other cardiac procedure other than CABG, and patients lost to follow-up were not included in the study.

Procedure

All patients with DSWI were assessed with a three-dimensional computed tomography of the thorax, the microbiological culture of the wounds, and routine hematological evaluation and C-reactive protein levels. All patients underwent radical debridement under general anesthesia and specimen of bone and tissue were sent for aerobic, anaerobic, and fungal cultures. Any hardware used for sternal stabilization was removed. Nonadherent dressing with paraffin gauze was applied if the heart was exposed^{16,17} followed by NPWT. The set pressure of -75 mm Hg was used when the cardia was not exposed, and -50 mm Hg in exposed cardia.² The patients underwent repeat debridement under general anesthesia if deemed necessary during the change of NPWT foam.

Table 1 Jones and Jurkiewicz et al classification of sternal wound infections

Type	Depth	Description	Total cases	Early referrals	Late referrals
1A	Superficial	Skin and subcutaneous tissue dehiscence	Not included in the study	Not included in the study	Not included in the study
1B	Superficial	Exposure of sutured deep fascia			
2A	Deep	Exposed bone, stable wired sternotomy	72 cases	33 cases	39 Cases
2B	Deep	Exposed bone, unstable wired sternotomy			
3A	Deep	Exposed necrotic or fractured bone, unstable, heart exposed			
3B	Deep	Types 2 or 3 with septicemia			

Table 2 Correlation of time of referral to the delay in wound healing

	Overall <i>n</i> = 66	Early <i>n</i> = 29	Late <i>n</i> = 37	<i>p</i> -Value 0.29
Delay in wound healing	22 (33%)	12 (41%)	10 (27%)	

Definitive closure was done after all visible necrotic tissue or slough was cleared. In certain cases, the sternum was stable with approximable edges, in which case rewiring was done. As per the wound size, it was decided to do a unilateral pectoralis major muscle advancement flap, bilateral pectoralis major muscle advancement flaps, omental flap, or a combination of both flaps. The pectoralis major muscle advancement flap was done by the technique described previously by the authors.¹⁸ If the defect was large, the omental flap was used as well. After the patient was referred to the plastic surgery unit, our approach was aggressive in terms of radical debridement and early flap cover preferably after one to two sessions of NPWT. The average time between referral to flap was 8 days (range: 5–14).

Statistical Analysis

Data was analyzed using the R statistical software. Both the groups were compared with respect to the demographics. Quantitative data was expressed in median and interquartile range (minimum–maximum). Fisher's exact test was applied to find the association. The *p*-value < 0.05 was considered as statistically significant.

Results

The data of 72 patients who had DSWI out of 4,214 patients who underwent median sternotomy for CABG was collected. Out of them, 68 patients underwent definitive plastic surgery management with flap cover. Two patients died before the definitive closure. Fifty-eight patients required multistage debridement and delayed closure, while only 12 patients could undergo single-stage debridement and immediate closure. We had 59 out of 72 patients, wherein BIMA was used, and 85% (*n* = 50) of these were diabetic. The age distribution was comparable in both the early and late groups with a slight male preponderance in the late group. As per the Jones' classification type 2B was the commonest and the distribution of severity of cases was found to be similar in both the groups. No association was found between the presence or absence of diabetes as a preexisting comorbidity (*p*-value = 0.169). No association was found between the usage of BIMA during CABG (*p*-value = 0.759).

The delay in wound healing was defined as the inability of the wound to heal completely by the end of 2 weeks from the time of definitive closure. The patients who could not undergo definitive closure or who died soon after closure were excluded only from the analysis of delayed wound healing (*n* = 6). Out of the total patients who were referred early, 41% patients had delayed wound healing, and in patients who were referred late, 27% patients had delayed wound healing. There was no difference in outcome of early versus late referral (►Table 2). Both the early and late referral

groups were compared as per the following variables such as presence of microorganisms, duration from definitive surgery to discharge, postoperative complications, number of NPWT changes before definitive closure, mortality, presentation to definitive surgery, duration from plastic referral to discharge, number of flaps, presence of microorganisms in bone culture, postoperative shoulder movement, postoperative scar, and the number of cardiothoracic procedures before plastic surgery referral (►Table 3). But time of referral has affected the total duration of wound healing as average duration of treatment of DSWI in early and late groups were 16.58 and 89.36 days, respectively (excluding the earlier outlier 5,088 days). The number of procedures done by the cardiothoracic team (resuturing, rewiring, and local debridement with NPWT in both the groups before referral to the plastic surgery unit) is significant (*p* = 0.002) and has delayed overall duration of wound healing. The rest of the variables that were compared in both the groups did not show significant differences (►Table 3). In our series, 83% patients reported unrestricted shoulder movement and 85% reported cosmetically acceptable scars. Statistically significant difference was not found in the two groups with respect to the mortality and postoperative complications. However, the odds ratio of 1.39 shows that late referral leads to 30% increased chances of prolonged hospital stay (> 7 days), though statistically not significant (►Table 4).

Discussion

The approach of cardiac surgeons and plastic surgeons to DSWI differs drastically.¹⁹ The traditional approach of cardiac surgeons has been sternal debridement, rewiring, and closed drainage as opposed to the plastic surgeons' approach that is more radical with aggressive debridement and definitive closure with flaps. According to Brandt and Alvarez,¹⁹ the first-line treatment of DSWI showed better outcomes through a plastic surgical strategy than those achieved by the traditional approach of cardiac surgeons. In our study, both the early and late referral groups had similar outcomes with respect to the total treatment duration after their referral to the plastic surgery unit. This is due to the fact that in both groups, the treatment offered by plastic surgeons was radical debridement and early flap cover.

A similar study comparing immediate versus delayed one-stage sternal debridement and pectoralis major muscle flaps was done by Cabbabe and Cabbabe.²⁰ Delayed group consisted of 14.8% patients who underwent multiple procedures by the cardiothoracic team for sternal infection and were referred to plastic surgery for sternal dehiscence and persistent infection after 22 to 63 days of an established DSWI diagnosis. The immediate group had 85.2% patients who were seen by a plastic surgeon within 4 days of the

Table 3 Effect of early versus late referral on various variables

Variable	Overall <i>n</i> = 72	Early <i>n</i> = 33	Late <i>n</i> = 39	<i>p</i> -Value
Presence of organisms				0.19
None	15 (21%)	10 (30%)	5 (13%)	
One	43 (60%)	17 (52%)	26 (67%)	
Multiple	14 (19%)	6 (18%)	8 (21%)	
Number of NPWT changes				0.33
0	16 (23%)	8 (24%)	8 (21%)	
1	25 (35%)	12 (36%)	13 (34%)	
2	23 (32%)	8 (24%)	15 (39%)	
3	5 (7%)	4 (12%)	1 (3%)	
4	0	0	0	
5	1 (1%)	0	1 (3%)	
6	1 (1%)	1 (3%)	0	
Bone C/S				0.63
Bone culture: Negative	43 (60%)	21 (64%)	22 (56%)	
Bone culture: Positive	29 (40%)	12 (36%)	17 (44%)	
Number of flaps				> 0.95
Single	67 (96%)	30 (97%)	37 (95%)	
Multiple	3 (4%)	1 (3%)	2 (5%)	
Post-op complications				0.15
None	44 (61%)	17 (52%)	27 (69%)	
Any complication	28 (39%)	16 (48%)	12 (31%)	
Mortality	5 (7%)	3 (9%)	2 (5%)	0.66
Shoulder movement				0.64
Good	60 (83%)	26 (79%)	34 (87%)	
Restricted	6 (8%)	3 (9%)	3 (8%)	
Death before wound healing/before closure	6 (8%)	4 (12%)	2 (5%)	
Scar problems				0.49
No	61 (85%)	26 (79%)	35 (90%)	
Yes	5 (7%)	3 (9%)	2 (5%)	
Death before wound healing/before closure	6 (8%)	4 (12%)	2 (5%)	
Definitive surgery to discharge (days) Median (IQR)	8 (7–13)	8 (6–14)	9 (7–13)	0.14
Presentation to definitive surgery (days) Median (IQR)	8 (5–14)	9 (4–15)	8 (5–11)	0.61
Plastic referral to discharge (days) Median (IQR)	18 (14–25)	19 (11–24)	17 (14–25)	0.85
Number of CVTS procedures before plastic surgery referral				0.002
Yes	34 (47%)	9 (27%)	25 (64%)	
No	38 (53%)	24 (73%)	14 (36%)	

Abbreviations: CVTS, cardiovascular and thoracic surgery; IQR, interquartile range; NPWT, negative pressure wound therapy.

diagnosis. The plastic surgical management was a one-step debridement and bilateral pectoral muscle flap reconstruction. In our series, it was not possible to close the wound immediately. We had 59 patients wherein BIMA were used and 85% patients ($n = 50$) out of these were diabetic. They had extensive sternal loss due to devascularization of sternum as

both vessels were harvested. So multistage procedures were required in these cases. In our study, the early referral group underwent procedures by the cardiothoracic team in 27% of cases before plastic surgery referral, whereas in the late referral group it was 64%. This was found to be statistically significant ($p = 0.002$). The delay in referral to plastic surgery

Table 4 Effect of early versus late referral on key outcomes

Key outcomes	Odds ratio (95% CI)	p-Value
Death	0.54 (0.08–3.45)	0.52
Post-op complications	0.66 (0.21–2.08)	0.48
Prolonged stay (> 7 days)	1.39 (0.24–8.17)	0.71

Abbreviation: CI, confidence interval.

unit after onset of symptoms increased the total duration of wound healing thereby increasing the treatment duration. The average duration of treatment of DSWI, that is, the onset of symptoms to definitive flap surgery in the early group was 16.58 days and in the late group it was 89.36 days. After referral to plastic surgery, the patients were discharged in a median of 8 days in the early group and 9 days in the late groups, with no statistically significant difference in both the groups. This shows that even after late referral because of aggressive debridement and early definitive flap cover, comparative results could be achieved.

In the series by Ringelman et al,²¹ the pectoralis major was used as either a transposition flap or a reverse turnover flap that needed extensive dissection and caused denervation, leading to cosmetically unacceptable bulges, impairing the normal shoulder functioning and required other modality for complete wound coverage. Fifty-one percent of patients complained of persistent pain, 33% had shoulder weakness, and 25% had unacceptable cosmetic result. Ascherman et al²² and Scully et al²³ have reported great results after usage of pectoralis major flaps and omental flap at 2 and 3 years, respectively. In our series, 83% patients reported unrestricted shoulder movement and 85% reported cosmetically acceptable scars. The striking difference in the study by Ringelman et al and all the other studies including ours was that they have used a transposition or a turnover flap, whereas we have used advancement and double breasting flaps,¹⁸ based on the thoracoacromial pedicle. Since the plane of the muscle is same in the advancement flap, there are no bulges associated, resulting in better functionality and cosmesis in our series.

Two patients in our study had spontaneous right ventricular rupture before they could undergo definitive closure and they succumbed to it despite best efforts. After the first episode, we started using paraffin impregnated gauze dressing as an interface between the NPWT foam and the exposed heart to reduce the negative pressure.²⁴ The reasons that could have caused serious bleeding during NPWT are infectious erosion^{16,25,26} or a displacement of the heart toward or in between the sternal edges²⁷ and fibrous adherence of the right ventricle (RV) to the sternum.²⁸ Both the patients who had RV rupture had extensive bony erosion of sternum and were found to have Klebsiella infection with positive bone cultures.

Even if the patients are referred late to a plastic surgical unit, aggressive and radical debridement, judicious use of NPWT, and early definitive flap cover are the key to managing this life-threatening condition. Hence, we have proposed

aggressive treatment protocol for management of DSWI.²⁹ In patients with positive bone culture, the intravenous antibiotics are continued for 6 weeks.²

The patients who were referred late to us were treated by cardiac team per the traditional conservative approach (resuturing, rewiring and NPWT). This was a significant factor in both the groups in our series. The plastic surgical approach was more aggressive and radical with removal of all the hardware and nonviable bone. Delay in referral to plastic surgery unit after onset of symptoms of DSWI increased the total duration of wound healing, thereby increasing the overall morbidity. With our aggressive approach of early flap cover, we did not find any significant difference in the other variables such as presence of microorganisms, duration from definitive flap surgery to discharge, postoperative complications, number of NPWT changes before definitive closure, mortality, duration from plastic referral to discharge, number of flaps, presence of microorganisms in bone culture, postoperative shoulder movement, and postoperative scars in both early and late referral groups. Late presentation had equally better outcome contrary to general belief that mortality will be higher in late referral group. Hence, we conclude that despite late referral, with good technique and methodological approach, we were able to achieve similar outcomes as early referral. However, early reference could lead to highly significant reduction in total duration of hospital stay and wound healing.

Conclusion

As seen in the study, procedures done by cardiothoracic team for DSWI ($p = 0.002$) only prolonged total recovery time and did not give additional benefits in terms of early wound healing. Although the statistical difference between outcomes of early and late cases managed by plastic surgeons after referral to them is not significant in terms of mortality or post-flap cover functionality, delayed wound healing, and postoperative complications, yet an early reference could lead to highly significant reduction in total duration of hospital stay, wound healing, and costs. Early referral of post-CABG DSWI to plastic surgeons by the cardiothoracic surgeons is highly recommended.

Statement of Institutional Review Board Approval

This study was approved by the Institutional Ethics Committee of Deenanath Mangeshkar Hospital & Research Centre before commencement. (DMHRC Code - IHR_2018_SEP_PS_278)

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None.

Conflicts of Interest

None declared.

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