

Perioperative & Critical Care: Short Report

Optimal Timing of Multidisciplinary Management of Sternal Wound Complications



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ABSTRACT

BACKGROUND Sternal wound complications after median sternotomy increase morbidity and mortality, and plastic and reconstructive surgery is often consulted to provide closure with flap reconstruction. In this study, we investigated how the timing of plastic surgery involvement may influence outcomes in this setting.

METHODS We performed a retrospective review of patients with sternal wound complications cared for at our institution during a 10-year period. Patients were stratified into quartiles based on time from detected complication to plastic surgery consultation. Primary outcome variables included morbidity (postoperative complications and reoperation) and all-cause mortality at 1 year. Univariable followed by multivariable logistic regression was performed to characterize risk factors for these adverse outcomes.

RESULTS A total of 188 patients composed the study population. The time to plastic surgery consultation quartiles were as follows: immediate, 0 to 1 days ($n = 46$); early, 2 to 5 days ($n = 50$); delayed, 6 to 14 days ($n = 42$); and late, >14 days ($n = 50$). Patient demographics, comorbidities, and reconstructive characteristics did not differ across groups. Increased time to plastic surgery consultation was associated with sternal wound reoperations ($P = .026$), 1-year mortality ($P = .008$), hematoma ($P = .044$), and sternal dehiscence recurrence ($P = .019$). Multivariable regression demonstrated that increased time to plastic surgery consultation was associated with increased sternal wound reoperations (odds ratio [OR], 1.1; $P = .041$), sternal wound recurrence (OR, 1.5; $P = .018$), and mortality (OR, 1.3; $P = .037$).

CONCLUSIONS Early involvement of plastic surgery in treating sternal wounds is significantly associated with a reduction in mortality, recurrence of sternal dehiscence, and reoperation. Successful treatment of these challenging complications requires multidisciplinary collaboration, and prompt plastic surgery consultation is recommended.

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Cardiothoracic surgeons perform >2 million median sternotomies annually worldwide, and although postoperative sternal wound complications are relatively uncommon, they can result in increased mortality, additional surgeries, prolonged hospitalizations, and increased medical costs.¹⁻³ Before the development of flap-based plastic and reconstructive surgery (PRS) techniques, sternal wound complications

IN SHORT

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- Successful treatment of these challenging complications requires multidisciplinary collaboration, and prompt plastic surgery consultation is recommended.

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were typically managed with débridement, rewiring, and primary closure, with mortality rates of up to 50%.³ The addition of flap reconstruction to treatment algorithms has led to a reduction in mortality to approximately 20%.⁴ Flaps (such as the pectoralis, rectus abdominis, or omentum) obliterate dead space, cover exposed bone and instrumentation, and provide well-vascularized soft tissue that facilitates antibiotic delivery.

However, there remains considerable uncertainty about the management of these complex wounds and appropriate timing of reconstruction. Some have suggested that delaying definitive reconstruction until the patient's condition is more stable and wound conditions are optimized results in fewer, less severe postsurgical complications.⁵ By contrast, others have suggested that delaying reconstruction after a sternal wound complication diagnosis is associated with greater mortality and resource use.⁶

Given the severe outcomes that can arise from these difficult complications, we sought to characterize modifiable clinical factors for improving the care of

cardiac surgery patients. We hypothesize that earlier plastic surgery involvement may improve the management of sternal wound complications and result in improved outcomes. Therefore, this study sought to characterize the impact of time to PRS involvement on sternal wound complication outcomes.

PATIENTS AND METHODS

A retrospective review was conducted of patients receiving PRS consultation for a sternal wound complication at a single quaternary referral academic medical center between 2008 and 2018. Details of the procedures and patient characteristics were obtained from the electronic medical record. Exclusion criteria were noncardiac procedures, prior flap reconstruction at an outside hospital, and inability to identify the date of the sternal complication. Data on patient demographics, comorbidities, and surgical history were collected. Time from first signs of sternal wound complication (infection or dehiscence) to first PRS involvement (consultation, débridement, or reconstruction) was calculated. Given the wide range of time to PRS involvement (0 to 972 days), the study participants were binned into quartiles based on time from initial sternal wound complication to PRS consultation: 0 to 1 days (immediate), 2 to 5 days (early), 6 to 14 days (delayed), and >14 days (late). Differences between these quartiles were then investigated. The primary outcomes of interest were 90-day readmission and reoperation rates, dehiscence recurrence, and all-cause 1-year mortality. Secondary outcomes included the incidence of seroma and hematoma and length of stay in the intensive care unit.

Shapiro-Wilk tests were performed to determine whether continuous variables were normally distributed. Patient demographics, clinical factors, and outcomes were compared between time quartiles using Student *t*-tests, Kruskal-Wallis tests, and Fisher exact tests as appropriate. To determine the association of time to PRS involvement with the primary outcomes of interest, univariable followed by stepwise multivariable logistic regression (threshold *P* = .1) was performed; collinear variables were automatically eliminated. All demographic and clinical variables, such as cardiac surgery characteristics, wound/infection details, and reconstruction details, were considered for inclusion in the models. To better control for intermediate time points, time to PRS consultation was analyzed as a continuous variable. All statistical analyses were completed using Stata version 15 software (StataCorp LLC).

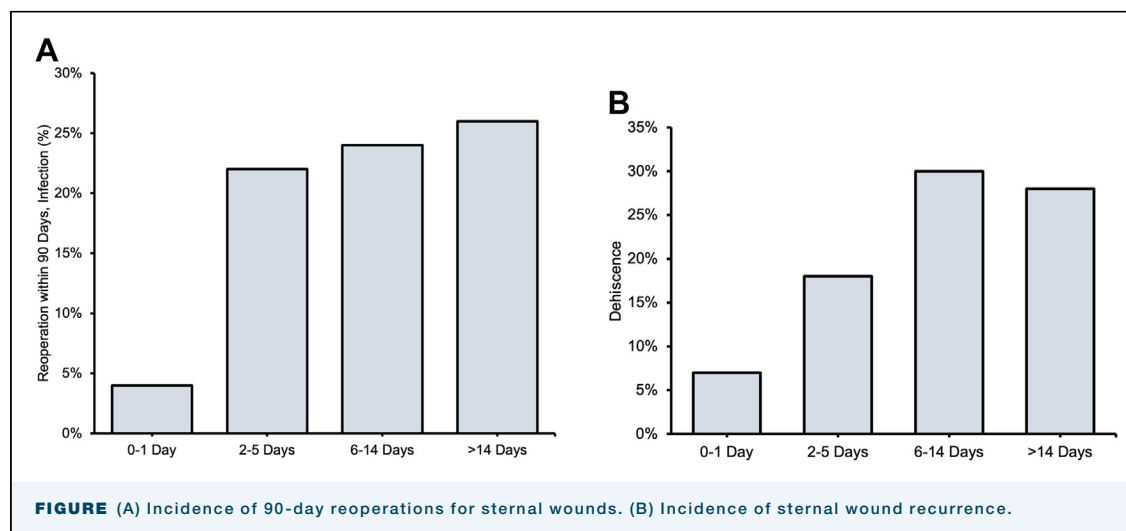
RESULTS

A total of 188 patients met inclusion criteria for PRS consultation after sternotomy within the study period.

TABLE 1 Patient Demographics, Baseline Clinical Characteristics, and Reconstructive Characteristics by Time to Plastic Surgery Involvement Cohort

| Variable | Immediate (0-1 days) | Early (2-5 days) | Delayed (6-14 days) | Late (>14 days) | P Value |
|--|-------------------------|---------------------|------------------------|--------------------|---------|
| Total patients | 46 (24) | 50 (27) | 42 (22) | 50 (27) | ... |
| Demographics and baseline clinical characteristics | | | | | |
| Age, y | 60 (18) | 59 (16) | 63 (20) | 58 (17) | .39 |
| Female sex | 20 (43) | 12 (24) | 12 (29) | 18 (36) | .20 |
| BMI, kg/m ² | 32 (7) | 32 (9) | 32 (11) | 32 (8) | .72 |
| Smoking | 19 (41) | 16 (32) | 18 (43) | 15 (30) | .47 |
| Comorbidities | | | | | |
| COPD | 15 (33) | 11 (22) | 12 (29) | 8 (16) | .25 |
| Diabetes | 22 (48) | 30 (60) | 24 (57) | 23 (46) | .43 |
| Hypertension | 35 (76) | 37 (74) | 32 (76) | 35 (70) | .89 |
| CAD | 28 (61) | 30 (60) | 30 (71) | 30 (60) | .63 |
| CHF | 13 (28) | 23 (46) | 16 (38) | 24 (48) | .19 |
| CKD | 14 (30) | 19 (38) | 19 (45) | 17 (34) | .52 |
| Prior CTS | 13 (28) | 15 (30) | 19 (45) | 27 (54) | .025 |
| Reconstructive surgery characteristics | | | | | |
| Flap type | | | | | .067 |
| Bilateral pectoralis | 25 (54) | 26 (52) | 19 (45) | 14 (28) | |
| Unilateral pectoralis | 4 (9) | 5 (10) | 4 (10) | 7 (14) | |
| Rectus abdominis | 5 (11) | 5 (10) | 5 (12) | 13 (26) | |
| Pectoralis + rectus | 4 (9) | 8 (16) | 6 (14) | 12 (24) | |
| Omentum | 0 (0) | 2 (4) | 3 (7) | 0 (0) | |
| No flap | 8 (17) | 5 (10) | 5 (12) | 4 (8) | |
| NPWT | 14 (30) | 16 (32) | 10 (24) | 9 (18) | .37 |
| No. of drains | 3 (1) | 3 (1) | 3 (1) | 2 (1) | .69 |
| Procedure length, min | 216 (131) | 182 (118) | 213 (131) | 209 (135) | .85 |

Categorical variables are presented as number (percentage). Continuous variables are presented as median (interquartile range) or mean (standard deviation). Boldface *P* values represent statistical significance. BMI, body mass index; CAD, coronary artery disease; CHF, chronic heart failure; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; CTS, cardiothoracic surgery; NPWT, negative pressure wound therapy.



Median time from first signs of sternal wound complication to PRS involvement was 6 days. Cohorts were as follows: immediate in 46 patients (0-1 days), early in 50 patients (2-5 days), delayed in 42 patients (6-14 days), and late (>14 days) in 50 patients. Patient demographics and clinical characteristics did not differ across groups with the exception of redo sternotomy status ($P = .025$; Table 1). Pairwise post hoc Tukey-Kramer testing revealed the immediate (28%) and late (54%) PRS consultation groups to be underrepresented and overrepresented, respectively, in prior cardiothoracic surgery ($P = .038$). Patients had a mean follow-up duration of 2.3 ± 2.9 years, with no significant difference across cohorts ($P = .79$).

Type of flap reconstruction did not differ by cohort, with bilateral pectoralis major flaps being the most common ($n = 84$ [45%]; Table 1). Operative time and other factors, such as use of negative pressure wound therapy and number of drains, were also not significantly different across quartiles.

Following PRS involvement, 70 (37%) patients required readmission within 90 days postoperatively. Of these, 36 (19%) patients required reoperations because of sternal wound recurrence within 90 days postoperatively (Figure). These sternal wound-related reoperations were significantly associated with time of PRS involvement ($P = .026$; Table 2). One-year mortality in our cohort was 12.8%, and was also significantly associated with time to PRS involvement ($P = .008$; Table 2), as were hematoma and sternal wound recurrence.

Multivariable regression modeling also identified that increased time to PRS involvement increased the likelihood of reoperations, sternal wound recurrence, and 1-year mortality (Table 3; Supplemental Table). Odds of mortality increased by 30% with each day's

delay in PRS involvement (odds ratio, 1.3; 95% CI, 1.0-1.5; $P = .04$).

COMMENT

Sternal wound complications after cardiothoracic surgery are a challenging problem for which PRS flap reconstruction has become increasingly common; however, guidelines on appropriate criteria and timing for PRS involvement remain unclear. Here, we identify earlier PRS involvement as a modifiable factor that improves patient outcomes by reducing mortality, sternal wound reoperations, and sternal wound recurrence.

With the significant baseline comorbidity and complexity of those undergoing sternotomy, early multidisciplinary care may be a tool to mitigate complications. Indeed, 52% of the patients included in this study had diabetes and 37% had chronic kidney

TABLE 2 Patient Outcomes by Time to Plastic Surgery Involvement Cohort

| Variable | Immediate (0-1 days) | Early (2-5 days) | Delayed (6-14 days) | Late (>14 days) | P Value |
|------------------|----------------------|------------------|---------------------|-----------------|---------|
| Total patients | 46 (24) | 50 (27) | 42 (22) | 50 (27) | ... |
| Readmission | 15 (33) | 21 (42) | 15 (36) | 19 (38) | .81 |
| Reoperation | 2 (4) | 11 (22) | 10 (24) | 13 (26) | .026 |
| ICU stay, d | 1.8 (4.9) | 7.8 (15.0) | 2.5 (5.3) | 3.6 (8.7) | .09 |
| 1-year mortality | 1 (2) | 11 (22) | 8 (19) | 4 (8) | .008 |
| Complications | | | | | |
| Seroma | 2 (4) | 2 (4) | 3 (7) | 3 (6) | .92 |
| Hematoma | 1 (2) | 4 (8) | 1 (2) | 5 (10) | .044 |
| Wound recurrence | 3 (7) | 9 (18) | 13 (31) | 14 (28) | .019 |

Categorical variables are presented as number (percentage). Continuous variables are presented as median (interquartile range). Boldface P values represent statistical significance. ICU, intensive care unit.

TABLE 3 Multivariable Regression for Primary Outcomes of Interest, Including Time to Plastic Surgery Involvement as a Continuous Variable

| Variable | Odds Ratio | 95% CI | P Value |
|--|------------|---------|-------------|
| 90-day reoperations for sternal wounds | | | |
| Age | 1.0 | 0.9-1.0 | .67 |
| BMI | 0.9 | 0.9-1.1 | .79 |
| Diabetes | 0.9 | 0.4-2.1 | .90 |
| Days to PRS involvement | 1.1 | 1.0-1.2 | .041 |
| Sternal wound recurrence | | | |
| BMI | 1.0 | 0.9-1.1 | .73 |
| Diabetes | 1.7 | 0.8-6.2 | .62 |
| Days to PRS involvement | 1.5 | 1.2-1.6 | .018 |
| 1-year mortality | | | |
| Age | 1.0 | 0.9-1.0 | .82 |
| BMI | 1.0 | 0.9-1.1 | .67 |
| Tobacco use | 0.3 | 0.1-0.9 | .06 |
| Days to PRS involvement | 1.3 | 1.0-1.5 | .037 |

Boldface P values represent statistical significance. BMI, body mass index; PRS, plastic and reconstructive surgery.

disease; both are known independent predictors for mortality.⁵

Prior studies have suggested that early débridement and flap reconstruction for sternal wounds reduce morbidity and mortality compared with delayed débridement and reconstruction.^{6,7} However, reconstructive timing becomes relevant only when PRS involvement is deemed appropriate by the primary surgical service. The results presented here suggest that earlier involvement of PRS is a predictive factor for improved patient outcomes.

Partnering with PRS early may support more aggressive initial débridement and improved clearance of infectious and necrotic tissue, a critical step in combating

infection spread.⁸ Another potential benefit is that earlier consultation may lead to earlier flap reconstruction; however, other factors, such as hemodynamic and respiratory stability, may influence the exact timing of flap surgery.

Given rising diabetes and obesity rates, earlier consultation as demonstrated here will become even more crucial to the process of healing after cardiothoracic surgery.⁹ Patients with significant risk factors for sternal wound complications may benefit from involvement of PRS at the index procedure as there may be a role for prophylactic muscle flaps in preventing sternal wound complications, analogous to prophylactic flap reconstruction for groin coverage in high-risk patients.¹⁰

This study does have limitations. A 10-year study duration may encompass the advent of new technologies with confounding effects on the measured outcomes. The retrospective study design relies on the quality of and access to medical records, and important details, such as wound and infection severity, may not be uniformly documented. Future prospective studies of sternal wound patients are warranted to determine a comprehensive optimal treatment algorithm.

The Supplemental Table can be viewed in the online version of this article [<https://doi.org/10.1016/j.atsr.2022.09.014>] on <http://www.annalsthoracicsurgery.org>.

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DISCLOSURES

The authors have no conflicts of interest to disclose.

PATIENT CONSENT

Institutional review board approval was obtained (IRB#201812121) and need for patient consent was waived.

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