 ● Koşuyolu Heart J 2022;25(1):58-67 • DOI: 10.51645/khj.2022.m215

When Should the Sternum Be Closed After Aortic Surgery?

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ABSTRACT

Introduction: There are many factors affecting postoperative morbidity and mortality in patients managed with delayed sternal closure (DSC) after aortic surgery. This study aimed to examine the postoperative management of patients after DSC and the factors affecting morbidity and mortality.

Patients and Methods: Among 2151 patients who underwent ascending aorta and/or aortic valve surgery between January 2012 and December 2020, 64 patients managed with DSC were included in the study. The records of the patients were obtained from the hospital archive/hospital electronic database. Postoperative day 30 was determined as early mortality.

Results: Uncontrollable bleeding 34.4% (n= 22), LCOS (Low Cardiac Output Syndrome) 31.4% (n= 20) and mediastinal edema 28.1% (n= 18)were the main causes for DSC. In the remaining patients (6.3%, n= 4), DSC was preferred for other non-specific reasons such as uncontrollable arrhythmia. Forty-five patients' chests (70.3%) were closed in the postoperative period, and 19 patients (29.7%) could not be closed due to death (p< 0.001). Early mortality was observed in 27 patients (42.2%), and sepsis was observed in 10 patients (15.6%). Deep sternal wound infection (DSWI) was present in 4.7% of the patients and the rate of sepsis was higher in this patient group (66.7%-13.1%, p< 0.05). There was no statistically significant difference in the probability of sepsis in the culture-positive patient group (p> 0.05). However, the closure time was longer in patients with a previous operation history, postoperative acute renal failure, surgical site infection, and postoperative bleeding revision/surgical revision (p< 0.05).

Conclusion: DSC can be preferred as a life-saving method for various reasons such as bleeding diathesis, mediastinal edema, and malignant arrhythmia after open-heart surgery. Accurate timing and close follow-up are important for sternal closure. In these patients, a multidisciplinary approach is required in the postoperative period.

Key Words: Thoracic surgery; postoperative wound infection; mediastinitis; ascending aorta

Aort Cerrahisi Sonrası Göğüs Açık Çıkılan Hastalarda Sternum Ne Zaman Kapatılmalı?

ÖZET

Giriş: Aort cerrahisi sonrası sternum açık çıkılan hastalarda (DSC) post operatif morbidite ve mortaliteyi etkileyen pek çok faktör mevcuttur. Bu çalışmada DSC sonrası hastaların postoperatif yönetimi, morbidite ve mortaliteyi etkileyen faktörlerin incelenmesi amaçlandı.

Hastalar ve Yöntem: Ocak 2012-Aralık 2020 tarihleri arasında asendan aort ve/veya aort kapak cerrahisi yapılan 2151 hasta arasından DSC prosedürü uygulanan 64 hasta çalışmaya dahil edildi. Kontrol edilemeyen kanama uygulanan hastalar. Hastaların kayıtlarına hastane arşivinden ve hastane bilgi işlem sisteminden ulaşılmıştır. Postop 30. gün erken dönem mortalite olarak belirlendi.

Bulgular: DSC prosedürünün uygulanma nedenleri olarak kontrol edilemeyen kanama %34.4 (n= 22), LCOS %31.4 (n= 20), mediastinal ödem %28.1 (n= 18) oranında görüldü. Kalan %6.3 (n= 4) hasta ise kontrol edilemeyen aritmi gibi diğer non spesifik nedenlerle DSC tercih edildi. Hastaların 45'i (%70.3) postoperatif dönemde kapatılmış, 19 hasta ise (%29.7) exitus nedeni ile kapatılamamıştı (p< 0.001). Erken dönem mortalite 27 hasta (%42.2), sepsis ise 10 hastada (%15.6) görüldü. Hastaların %4.7'sinde deep sternal wound infection (DSWI) mevcut olup sepsis görülme oranı bu hasta grubunda daha yüksekti (%66.7-%13.1, p< 0.05). Kültür pozitif olan hasta grubunda sepsis görülme olasılığı açısından istatistiksel olarak anlamlı fark yoktu (p> 0.05). Ancak geçirilmiş operasyon öyküsü olan, postoperatif akut böbrek yetmezliği gelişen, cerrahi alan enfeksiyonu olan, postoperatif kanama revizyonu veya cerrahi revizyon yapılan hastalarda kapanma süresi daha uzundu (p< 0.05).

Sonuç: DSC prosedürü açık kalp cerrahisi sonrası kanama diatezi , mediastinal ödem, malign aritmi gibi sebeplerle hayat kurtarıcı bir yöntem olarak tercih edilebilir. Sternumun kapatılması açısından doğru zamanlama ve yakın takip önemlidir. Bu hastalarda postoperatif dönemde multidisipliner yaklaşım gerekmektedir.

Anahtar Kelimeler: Göğüs cerrahisi; postoperatif yara yeri enfeksiyonu; mediastinit; asendan aorta

Cite this article as: Başar V, Yiğit F, Jafarov F, Sunar H. When should the sternum be closed after aortic surgery? Koşuyolu Heart J 2022;25(1):58-67.

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Submitted: 14.12.2021
Accepted: 29.01.2022
Available Online Date: 15.04.2022

INTRODUCTION

Closure of the surgical field in open-heart surgery is important in terms of reducing surgical site infection. However, this situation may progress differently in patients requiring long operative time, having comorbid factors, and operated under emergency conditions. Reperfusion can be closed in the late period by leaving the sternum open in patients with secondary myocardial edema, in patients with a high bleeding expectation, in arrhythmogenic cases, and critical patients with left ventricular assist devices. Delayed sternal closure (DSC) after post-cardiotomy is a life-saving approach that reduces early mortality in this patient group. The rate of performing the DSC procedure in adult open-heart surgery is between 1% and 4%[1].

The rate of bleeding in the surgical field is high in patients undergoing aortic surgery, especially in the patient group with high mortality due to aortic dissection in emergency conditions, and in patients undergoing redo surgery with a history of anticoagulant/antiaggregant use. DSC is a frequently used method in these patients[2,3].

Prolonging the operation time in unstable patients admitted under emergency conditions may disrupt the coagulation cascade due to prolonged CPB (cardiopulmonary bypass). The DSC procedure can be considered a transitional period for the control of hemodynamic and cardiac instability in the early postoperative period in this patient group[4,5]. The timing of the sternal closure in this group may vary from patient to patient. For this reason, it is necessary to determine the factors in terms of planning this timing in the intraoperative and early postoperative period[6].

The aim of this study was to examine factors that may affect morbidity and mortality in patients managed with DSC after aortic surgery.

PATIENTS and METHODS

In our study, 64 patients among 2151 patients who underwent aortic and/or aortic valve surgery in our cardiac surgery clinic from January 2012 to December 2020 were retrospectively analyzed. The records of the patients were obtained from the hospital archive/hospital electronic database.

Indications for performing the DSC procedure were uncontrollable bleeding, LCOS/hemodynamically unstable patients, mediastinal edema, and other nonspecific causes such as uncontrollable arrhythmia. Parameters such as diabetes mellitus (DM), smoking, hypertension (HT), chronic obstructive pulmonary disease (COPD), and acute renal failure (creatinine> 2.5 mg/dL or requiring hemodialysis) were recorded in the patients. Albumin level (mg/dL), C-reactive protein (CRP), white blood cell count (WBC), hemoglobin level, CPB, cross-clamp times (minutes), and blood transfusion number (units) were recorded. During cardiac surgery, all surgical procedures were performed with cardiopulmonary bypass. Traditional median sternotomy was performed in all patients. Moderate systemic hypothermia (28-30°C) was used. In CPB, the flow rate was 2.2-2.5 L/min per m^2, the mean perfusion pressure was 50-80 mmHg, and the required hematocrit levels were kept between 20% and 25%. Myocardial protection was applied with hypothermic and hyperkalemic blood cardioplegia with intermittent antegrade and continuous retrograde techniques.

Depending on the profile of the case, arterial cannulation of the patients was aortic, femoral, or axillary, and venous cannulation was unicaval, bicaval, or femoral. It was decided to open the chest in patients who required central venoarterial extracorporeal membrane oxygenator (ECMO) support, had bleeding diathesis, were hemodynamically unstable, and had malignant arrhythmias while closing the sternum. When the decision to open the chest was made, the skin was sutured using 1/0 polydioxanone (PDS) suture material., with the sternum open and the skin fully approximated. In the postoperative intensive care follow-up of the patients, daily chest X-rays and echocardiographic evaluations were made.

This is a retrospective, observational, single-center case series study. Age, gender, weight, diagnosis, previous operations, applied procedure, hospital stay, and laboratory results of the patients were recorded. The period covering postoperative day 30 was taken as a basis in terms of early mortality. The study was approved by the ethics committee on 24/8/2021 (number 2021/10/514) and performed in accordance with the Declaration of Helsinki.

NCSS (Number Cruncher Statistical System) 2007 (Kaysville, Utah, USA) package program was used for statistical analyses. Descriptive statistical methods were used when evaluating the study data: mean, standard deviation, median, frequency, ratio, minimum, maximum. Skewness test, Kolmogorov Smirnov test, and histogram graphs were used as the criterion of fit for normal distribution in numerical data. Chi-square and Fisher's tests were applied with categorical

data. T-test was used to compare the means between two independent groups with normal distribution. The Mann-Whitney U test was used to compare the medians of two independent groups in a distribution that did not show normal distribution. Spearman test was used for correlation analysis in numerical data. Logistic regression analysis was applied while investigating the effect of parameters on exitus. The statistical significance level was taken as $p< 0.05$.

RESULTS

26.6% (n= 17) of the patients were female and 73.4% (n= 47) were male. The mean age was 57.9 ± 13.07 years. We observed that 35.9% (n= 23) of the patients were operated under emergency conditions and 64.1% (n= 41) were operated on elective conditions. Of the patients, 9.4% (n= 6) were intubated and 6.3% (n= 4) had a history of cardiopulmonary resuscitation (CPR) in the preoperative period. The mean length of stay in the intensive care unit was 8.79 ± 10.38 days. The mean hospital stay was 15.73 ± 16.49 days. Sociodemographic data are presented in Table 1.

Twelve patients (18.8%) had a history of cardiac surgery. In their history, RF (renal failure) was observed in nine patients (14.1%), COPD in 10 patients (15.6%), hypertension in 32 patients (50%), and DM in 22 patients (34.4%). At admission, 13 patients (20.3%) had AF (atrial fibrillation) rhythm. The mean operation time was 436.52 ± 115.97 minutes. The mean duration of CPB was 285.27 ± 85.17 minutes. The mean cross-clamp time was 172.95 ± 67.09 minutes.

The mean preoperative WBC level of the patients was 9.6 ± 4.42 /mm^3. CRP level was 12.66 ± 37.78. Three patients

Table 1. Sociodemographic parameters

Variable	Parameter	n	%
Gender	Female	17	26.60
	Male	47	73.40
DM	No	42	65.60
	Yes	22	34.40
Smoker	No	45	70.30
	Yes	19	29.70
PAD	No	60	93.80
	Yes	4	6.30
CVD	No	58	93.50
	Yes	4	6.50
AF	No	51	79.70
	Yes	13	20.30
CAD	No	50	78.10
	Yes	14	21.90
HT	No	32	50.00
	Yes	32	50.00
COPD	No	54	84.40
	Yes	10	15.60
RF	No	55	85.90
	Yes	9	14.10

RF: Chronic renal failure, DM: Diabetes mellitus, CVD: Cerebrovascular disease, AF: Atrial fibrillation, CAD: Coronary artery disease, HT: Hypertension, COPD: Chronic obstructive pulmonary disease, PAD: Peripheric arterial disease.

Table 2. The relationship of preoperative sociodemographic parameters with sepsis

		No Sepsis		Sepsis		
Variable	**Category**	**n**	**%**	**n**	**%**	**p**
DM	No	35	83.30	7	16.70	0.751
	Yes	19	86.40	3	13.60	
HT	No	30	93.80	2	6.30	***0.039***
	Yes	24	75.00	8	25.00	
Gender	Female	17	100.00	0	0.00	***0.038***
	Male	37	78.70	10	21.30	
AF	No	43	84.30	8	15.70	0.979
	Yes	11	84.60	2	15.40	
Intubated	No	48	82.80	10	17.20	0.268
	Yes	6	100.00	0	0.00	
CPR	No	50	83.30	10	16.70	0.374
	Yes	4	100.00	0	0.00	
Late op.	No	46	88.50	6	11.50	***0.061***
	Yes	8	66.70	4	33.30	
Comorbidity	No	54	85.70	9	14.30	***0.019***
	Yes	0	0.00	1	100.00	
COPD	No	45	83.30	9	16.70	0.594
	Yes	9	90.00	1	10.00	
CAD	No	45	90.00	5	10.00	***0.019***
	Yes	9	64.30	5	35.70	
CVD	No	52	86.70	8	13.30	0.051
	Yes	2	50.00	2	50.00	
PAD	No	52	86.70	8	13.30	0.051
	Yes	2	50.00	2	50.00	
Smoker	No	43	95.60	2	4.40	***0.00***
	Yes	11	57.90	8	42.10	
RF	No	46	83.60	9	16.40	0.687
	Yes	8	88.90	1	11.10	

*Pearson Chi-square, RF: Chronic renal failure, DM: Diabetes mellitus, CVD: Cerebrovascular disease, AF: Atrial fibrillation, CAD: Coronary artery disease, HT: Hypertension, COPD: Chronic obstructive pulmonary disease, PAD: Peripheric arterial disease, CPR: Cardiopulmonary resuscitation.

(4.3%) had a history of fever in the pre-op period. H level was statistically significantly higher in the exitus group ($p< 0.05$).

In the postoperative follow-up, 10 patients (15.6%) had sepsis. There was no statistically significant difference in terms of exitus between patients with and without signs of sepsis ($p> 0.05$). When the sociodemographic data (Table 2) were examined in terms of sepsis, the rate of sepsis was higher in patients with hypertension, history of comorbidities, ischemic heart disease, and smoking history and in male patients ($p< 0.05$). There was no statistically significant dif-

Table 3. Distribution of patients by sternal closure

	Open		Closed	
Surgery	**n**	**%**	**n**	**%**
AASGI	8	38.10	13	61.9
AVR	0	0.00	5	100.00
BENTALL	6	75.00	2	25.00
AASGI+CABG	2	22.20	7	77.80
AASGI+AVR	1	11.10	8	88.90
Redo aortic surgery	2	16.70	10	83.30

AASGI: Separating graft interposition of the ascending aorta, AVR: Aortic valve replacement, CABG: Coronary artery by-pass grafting.

ference between the groups with and without sepsis in terms of the history of previous CVD (Cerebrovascular disease), history of peripheral artery disease, chronic kidney disease, COPD, DM, history of intubation, and CPR in the preoperative period, and history of previous operation ($p> 0.05$).

Forty-five (70.3%) of the patients had their chests (Table 3) closed in the post-operative period. The chests of nineteen patients (29.7%) could not be closed and resulted in exitus ($p< 0.001$). The mean closure time of the patients whose sternum was closed was 62.51 ± 76.58 hours. Mean closure time was 144.01 ± 1.77 hours in patients with DSWI. In the patient group without DSWI, the mean duration was 42 ± 2.02 hours. There was a significant difference between closure time and mortality, but the closure time was longer in the exitus group ($p< 0.01$). The closure time was longer in patients who were culture-positive, had previous operation history, postoperative acute renal failure, surgical site infection, and postoperative bleeding revision or surgical revision ($p< 0.05$). However, there was no statistically significant difference in terms of the possibility of sepsis ($p> 0.05$).

In terms of early mortality (Table 4), 27 patients (42.2%) died. In the preoperative period, there was a significant difference in terms of early mortality in emergency cases and patients with a history of intubation and CPR compared to the elective surgery group and those without a history of intubation. The rate of exitus in this patient group was significantly higher ($p< 0.05$). Gender, DM, hypertension, COPD, AF rhythm, previous operation history, presence of ischemic heart disease, previous CVD, history of RF, history of peripheral artery disease, and smoking history did not affect early mortality ($p> 0.05$). When the patients who died and those who did not were compared, there was no statistically significant difference between the two groups in terms of the effect of the length of stay in the intensive care unit ($p> 0.05$). The duration of hospitalization was shorter in the group who died ($p< 0.05$).

There was growth in culture in 28 patients (43.8%). When the effect of culture growth on sepsis and mortality was examined, there was no statistically significant difference between the two groups ($p_1= 0.069$, $p_2= 0.678$, respectively).

When the preoperative data were examined (Table 5), the WBC levels, neutrophil levels, and CRP levels were higher in emergency patients. In this group, the lymphocyte count was lower and cross-clamp time and sternum closure time were longer. Neutrophil/lymphocyte ratio and platelet/lymphocyte ratio were higher ($p< 0.05$). There was no statistically significant difference between emergency and elective patients in terms of age, BMI, EF (ejection fraction), urea/creatinine levels, hemoglobin and hematocrit levels, platelet levels, operation time, and CPB duration ($p> 0.05$).

Redo patients had a higher risk of having wound infection ($p< 0.05$). The early closure rate was lower in redo patients ($p< 0.05$). There was no significant difference in terms of closure and failure to close the sternum in redo patients ($p> 0.05$). There was no significant difference in terms of sepsis and mortality in redo patients ($p> 0.05$).

In our study, uncontrollable bleeding in DSC indication was seen in 22 patients (34.4%). LCOS/hemodynamically unstable patients constituted 31.4% (n= 20) of the patients. The

Table 4. Effects of sociodemographic data on mortality

Variable	Category	Alive		Exitus		
		n	%	n	%	p
Gender	Female	8	47.10	9	52.90	0.295
	Male	29	61.70	18	38.30	
DM	No	26	61.90	16	38.10	0.36
	Yes	11	50.00	11	50.00	
HT	No	19	59.40	13	40.60	0.8
	Yes	18	56.30	14	43.80	
COPD	No	31	57.40	23	42.60	0.879
	Yes	6	60.00	4	40.00	
Elective	Elective	28	68.3	13	31.7	***0.023****
	Emergency	13	39.1	14	60.9	
Intubated	No	36	62.10	22	37.90	***0.032****
	Yes	1	16.70	5	83.30	
CPR	No	37	61.70	23	38.30	***0.016****
	Yes	0	0.00	4	100.00	
AF	No	32	62.70	19	37.30	0.114
	Yes	5	38.50	8	61.50	
Late Op.	No	32	61.50	20	38.50	0.209
	Yes	5	41.70	7	58.30	
Comorbidity	No	36	57.10	27	42.90	0.389
	Yes	1	100.00	0	0.00	
CAD	No	30	60.00	20	40.00	0.503
	Yes	7	50.00	7	50.00	
CVD	No	35	58.30	25	41.70	0.744
	Yes	2	50.00	2	50.00	
RF	No	33	60.00	22	40.00	0.381
	Yes	4	44.40	5	55.60	
PAD	No	34	56.70	26	43.30	0.472
	Yes	3	75.00	1	25.00	
Smoker	No	29	64.40	16	35.60	0.098
	Yes	8	42.10	11	57.90	

*Pearson Chi-square, RF: Chronic renal failure, DM: Diabetes mellitus, CVD: Cerebrovascular disease, AF: Atrial fibrillation, CAD: Coronary artery disease, HT: Hypertension, COPD: Chronic obstructive pulmonary disease, PAD: Peripheric arterial disease, CPR: Cardiopulmonary resuscitation.

Table 5. Preoperative parameters of the cases by elective status

Parameter	Emergency/Elective	n	Mean Rank	p
EF (%)	Elective	41	32.46	0.892*
	Emergency	23	32.57	
Urea (mg/dL)	Elective	41	32.13	0.834*
	Emergency	23	33.15	
Creatinine	Elective	41	30.22	0.191*
	Emergency	23	36.57	
Wbc (/mm^3)	Elective	41	28.22	***0.014****
	Emergency	23	40.13	
Neutrophil (/mm^3)	Elective	41	27.52	***0.004****
	Emergency	23	41.37	
Lymphocyte (/mm^3)	Elective	41	35.91	***0.05****
	Emergency	23	26.41	
Crp (mg/dL)	Elective	41	28.89	***0.038****
	Emergency	23	38.93	
CCT (min)	Elective	41	37.32	***0.005****
	Emergency	23	23.91	
CPB (min)	Elective	41	34.21	0.319*
	Emergency	23	29.46	
Operation time (min)	Elective	41	34.55	0.232*
	Emergency	23	28.85	
Sternum Closure time (h)	Elective	31	19.35	***0.021****
	Emergency	12	28.83	
preNLR	Elective	41	26.13	***0.00****
	Emergency	23	43.85	
prePLR	Elective	41	28.98	***0.043****
	Emergency	23	38.78	
BMI	Elective	41	27.96	0.088**
	Emergency	23	30.36	
Age (year)	Elective	41	57.75	0.904**
	Emergency	23	58.17	
Hb (gr/dL)	Elective	41	12.18	0.764**
	Emergency	23	12.35	
Htc (%)	Elective	41	36.75	0.705**
	Emergency	23	37.36	
Plt (/mm^3)	Elective	41	229.09	0.697**
	Emergency	23	223.17	

*Mann-Whitney U test, **T-test, EF: Ejection fraction CCT: Cross-clamp time, CPB: Cardiopulmonary by-pass time, Wbc: White blood cell count, preNLR: Preoperative neutrophil/lymphocyte rate, prePLR: Preoperative platelet/lymphocyte rate, BMI: Body mass index, CRP: C-reactive protein.

patients who underwent DSC procedure due to mediastinal edema comprised 28.1% (n= 18) of the patients. The remaining 6.3% (n= 4) of the patients preferred DSC for other non-specific reasons such as uncontrollable arrhythmia (Table 6).

Table 6. Distribution of DSC procedure by indications

DSC indication	n	%
Bleeding	22	34.4
Hemodynamic instability	20	31.3
Mediastinal edema	18	28.1
Other	4	6.3
Total	64	100

DSC: Delayed sternal closure.

The effect of postoperative complications on sepsis is shown in Table 7. The rate of sepsis was higher in patients with postoperative complications. In the postoperative period, there was no significant difference between the patients in terms of sepsis, pulmonary infections, SVO, surgical revision, bleeding, and culture positivity (p> 0.05). There was no significant difference in terms of sepsis in patients whose sternum could not be closed in the late period (p> 0.05). Postoperative acute renal failure, wound infection, and ECMO/intraaortic balloon pump (IABP) support use were statistically significantly associated with sepsis (p< 0.05).

The mortality rate was higher in patients with postoperative complications. When the effect of complications on mortality was evaluated, the mortality rate was higher in cases

Table 7. The effect of postoperative complications on sepsis and mortality

Parameter	Category	n	%	p_1	p_2
Pneumonia	No	58	90.60	0.234	0.684
	Yes	6	9.40		
Postop RF	No	37	61.70	**0.03**	0.233
	Yes	23	38.30		
CVD	No	55	85.90	0.14	**0.02**
	Yes	9	14.10		
DSWI	No	61	95.30	**0.013**	0.379
	Yes	3	4.70		
ECMO/IABP	No	54	84.40	**0.021**	**0.001**
	Yes	10	15.60		
Revision	No	51	79.70	0.327	**0.004**
	Yes	13	20.30		
Bleeding	No	45	70.30	0.126	**0.027**
	Yes	19	29.70		
DSC	Open	19	29.70	0.624	**0**
	Closed	45	70.30		
Culture	No	36	56.30	0.07	0.678
	Yes	28	43.80		

DSC: Delayed sternal closure, DSWI: Deep sternal wound infection, RF: Renal failure, ECMO: Extracorporeal membrane oxygenator, IABP: Intra-aortic balloon pump, CVD: Cerebrovascular disease (p_1: Sepsis, p_2: Mortality).

requiring CVD, ECMO, bleeding revision, and surgical revision ($p< 0.05$).

DISCUSSION

Several factors play an important role in the preoperative and intraoperative early period in patients with delayed sternal closure (DSC). It is a frequently used method in critically-ill patients with myocardial edema, unstable hemodynamics, high risk of bleeding, LCOS, and in need of mechanical support with an extracorporeal membrane oxygenator. In patients whose sternum cannot be closed, the DSC procedure may increase the risk of infectious complications, but it is a method that increases cardiac performance by increasing the end-diastolic filling and thus eliminating the pressure effect of the chest wall together with mediastinal edema. There is a compression effect of the chest wall on the heart and a clinical picture similar to cardiac tamponade. On the other hand, it may increase the susceptibility to malignant arrhythmias together with its compression effect[7].

Prolonged operation time, total bypass time, cross-clamp time, and uncontrollable bleeding after grafting are common in patients with aortic dissection[8,9]. Fathi et al. reported that the mortality rate is higher in patients with a history of DM and who received emergency treatment[5]. Wong et al. reported an increase in operative mortality with age, hypertension, cardiogenic shock, preoperative CPR, and in redo patients[6]. In our study, early mortality was higher in patients with a history of intubation, CPR, and emergency admission in the preoperative period. There was no significant difference in terms of sepsis and mortality in redo patients.

While mediastinitis or deep sternal wound infection is seen in 1-2% of patients after all open-heart surgeries, this rate was reported to be 5% in the DSC patient group[10]. Similarly, Wong et al. reported 3% DSWI for the entire group of DSC patients who underwent open-heart surgery in their study of 201 patients[6]. While the DSWI rate was 5.3% in 212 patients involved in the study by Boeken et al.,[1] this rate was 4.7% in our study.

Shimokawa et al. examined the DSC procedure in seven patients who underwent aortic surgery, mostly in cases of aortic dissection as an indication for DSC. They applied the DSC procedure because of bleeding diathesis[9]. In our study, the rate of uncontrollable bleeding was prominent in 34.4% (n= 22) of the patients. The DSC procedure was performed in 31.4% (n= 20) of the LCOS/hemodynamically unstable patients. On the other hand, patients who underwent DSC due to mediastinal edema comprised 28.1% (n= 18) of the patient group. DSC was preferred for the remaining 6.3% (n= 4) of the patients due to hemodynamic instability caused by malignant arrhythmias.

In the DSC patient group, an increase in the rate of blood transfusion due to bleeding in the early postoperative period, prolonged mechanical ventilation and pulmonary infection, acute renal failure, and length of stay in the intensive care unit and hospital are among the factors affecting mortality. Early and long-term results are poor in patients with DSWI-induced mediastinitis. Mediastinitis-induced exitus rates were reported in the range of 10-47%[10]. In our study, early mortality was 42.2%.

Boeken et al. performed the DSC procedure for LCOS, bleeding, arrhythmia, and mediastinal edema in their study involving 212 patients who underwent open-heart surgery and reported a mortality rate of 27.8%. They stated that the mortality rate was lower in patients who did not use IABP[1]. Hashemzadeh et al. also reported increased mortality in patients who needed IABP use[11]. In our study, the mortality rate was higher in patients who needed IABP and ECMO.

Mazzeffi et al. studied postoperative infectious complications in a 57-patient study in which they applied the DSC procedure. They categorized the patients as early closure and late closure according to the postoperative first 48 hours. They showed that there was no significant difference between early and late closure subgroups in terms of mediastinitis, DSWI, and sepsis[12]. In our study, closure time was longer in patients with DSWI. The difference in closure time was not statistically significant in patients with and without sepsis, but closure time was longer in patients with sepsis (20.99 hours versus 27.21 hours). Closure time was longer in patients who were culture positive, in those with a history of redo surgery, and in those who had a surgical revision or a bleeding revision.

Stulak et al. examined the factors affecting postoperative morbidity and mortality in 184 patients who received the DSC procedure with LVAD implantation and revealed that there was no increase in sepsis and mortality in patients who underwent the DSC procedure[13]. In our study, there was no statistically significant difference between sepsis and mortality in the patient group in which we applied the DSC procedure. There was no statistically significant difference between elective or emergency cases and sepsis. The mortality rate was higher in the emergency patient group.

Limitation

This was a retrospective study. It was designed as a descriptive study and no comparison was possible with a control group.

CONCLUSION

In conclusion, the application of the DSC procedure should be considered a life-saving method for severe bleeding diathesis, mediastinal edema, severe arrhythmia, and other reasons after open-heart surgery. Accurate timing and close follow-up are important for sternal closure. In these patients, a multidisciplinary approach is required in the postoperative period.

Ethics Committee Approval: The approval for this study was obtained from Kartal Koşuyolu High Training and Research Hospital Clinical Research Ethics Committee (Decision no: 2021/10/514, Date: 24.08.2021).

Informed Consent: This is retrospective study, we could not obtain written informed consent from the participants.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept/Design - VB; Analysis/Interpretation - VB, FY; Data Collection - FJ; Writing - VB, FY; Critical Revision - HS, VB; Final Approval - HS, VB; Statistical Analysis - FY; Overall Responsibility - HS.

Conflict of Interest: The authors declared that there was no conflict of interest during the preparation and publication of this article.

Financial Disclosure: The authors declared that this study has received no financial support.

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