Pak Heart J

EVALUATION OF OPEN CHEST MANAGEMENT (OCM) WITH DELAYED STERNAL CLOSURE (DSC) AFTER CARDIAC SURGERY

Seyyed Hossein Ahmadi Tafti[1], Abbas Ali Karimi[2], Armita Mahdavi Gorabi[3], Farhad Fathi[4], Mohammad Reza Rezaei[5], Saeid Davoudi[6], Khosro Barkhordari[7]

[1-7]Department of Cardiothoracic Surgery ,Tehran Heart Center, Tehran University of Medical Sciences, Tehran - Iran

Address for Correspondence:

Seyyed Hossein Ahmadi Tafti
Department of Cardiothoracic Surgery ,Tehran Heart Center, Tehran University of Medical Sciences, Tehran - Iran

Emails: hosseinahmaditafti@yahoo.com

Date Received: June 13, 2017
Date Revised: September 02, 2017
Date Accepted: September 22, 2017

Contribution

SHAT conceived the idea and drafted the manuscript. AAK, AMG, FF collected and analyzed the data. MRR, SD and KB critically reviewed the manuscript. All authors contributed significantly to submitted manuscript.

All authors declare no conflict of interest.

This article may be cited as: Tafti SHA, Karimi AA, Gorabi AM, Fathi F, Rezaei MR, Davoudi S, Barkhordari K. Evaluation of open chest management (OCM) with delayed sternal closure (DSC) after cardiac surgery. Pak Heart J 2017; 50 (04): 218-23

ABSTRACT

Objective: In this study, we evaluated the open chest management (OCM) with delayed sternal closure (DSC) after cardiac surgery.

Methodology: In this retrospective cross sectional study we reviewed, the medical records of patients who underwent open-heart operation over a 9- year period between April 2002 and March 2011 at Tehran Heart Center. The indications of DSC, mortality rate and the complications after the procedure were recorded. The characteristics of operations and post-operative status of patients, including duration of ventilator support and Intensive Care Unit (ICU) stay, major complications, need for Intra-Aortic Balloon Pump (IABP) and mortality rate were evaluated. $P \leqslant 0.05$ was considered significant. Data was analyzed using SPSS version 22.0

Results: A total of 22721 patients who underwent open heart operation were included in the study. Delayed sternal closure was performed in 362 (1.5%) patients with mean age of 59.01 ± 12.4 years. Males were 63% (n=229).The rate of DSC was 1.5% and was performed because of the hemodynamic instability, bleeding, arrhythmia, tamponade and aortic dissection. The mortality rate was 28.5%. Diabetes and emergency status of the operation were two predictors of mortality ($p < 0.001$). Moreover, analysis pointed out that diabetes; severe chronic lung disease and postoperative need for hemodialysis were the strongest independent predictors of mortality in patients under going open surgery with DSC. The most prevalent post operation, complications were atrial fibrillation, bleeding, pulmonary embolism and new onset renal failure with incidence rates of 38.4% (139), 26.2% (95), 15.2% (55), and 9.1% (33) respectively.

Conclusion: The hemodynamic instability, bleeding, arrhythmia, tamponade and aortic dissection were the most important factors for the performance of DSC while diabetes and emergency status of the operation were the most important predictors of mortality.

Key Words: Open chest management , Delayed sternal closure , Cardiac surgery, Open sternum.

INTRODUCTION

Median sternotomy is the most frequent approach to access the heart in the heart operation.[1] In some complicated cardiac surgeries including coronary artery bypass graft (CABG), valvular replacement procedures and ventricular assist implantations the delayed sternal closure (DSC) approach has been used.[2-4] The delayed sternal closure was presented in 1975 for the first time and it has been reported in 1.2 -4.2% of cardiac operations in adults.[5,6] Rapid access to control hemorrhage and arrhythmias and the cardiac compression relieve are some of the advantages of prolonged open sternotomy, so some surgeons close the sternum after patient's hemodynamic stability.[7] In spite of these advantages with DSC, some of the studies have announced that the DSC may increase the risk of mediastinal infection, and in rare condition, deep wound infection may occur.[8,9] The indication for DCS are bleeding or hemodynamic instability, obvious pulmonary edema, respiratory compromise, placement of extracorporeal support device and intractable arrhythmias.[10] With evidence for low sternal morbidity and a growing population of patients with the complex cardiac disease, DSC will be an increasingly important management option for the cardiac surgeon. In this regards the heart surgeons have suggested the DSC for major heart operations.[11] In the present study, we retrospectively evaluated the open chest management (OCM) with delayed sternal closure (DSC) procedure after cardiac surgery over a 9-year period.

METHODOLOGY

In this retrospective cross secrtional study, we reviewed, medical records of patients who underwent open-heart operation over a 9-year period between April 2002 and March 2011 at Tehran Heart Center. Demographic data, weight, height, history of diabetes, dyslipidemia, hypertension, chronic lung diseases, renal failure, vascular diseases, congestive heart failure and arrhythmias, laboratory data including serum creatinine before operation and ejection fraction according to angiography report were recorded. We also evaluated the characteristics of operations and post-operative status of these patients, including duration of ventilator support and Intensive Care Unit (ICU) stay, major complications, need for Intra-Aortic Balloon Pump (IABP) and mortality rate. We decided to determine preoperative characteristics, postoperative complications, mortality rate, and predictors of outcome after OCM with DSC by comparison of these variables in surviving not surviving patient groups.

The operation was performed after the induction of anesthesia, median sternotomy incision, cardiopulmonary bypass was established. Then myocardial protection was achieved with intermittent antegrade or retrograde delivery of cold cardioplegic solution and according to the type of the disease, the appropriate operation was done. Prophylactic antibiotic (cephalothin) was administered to all the patients at the induction of anesthesia and continued every 6 hours for 3 days following surgery. In the case of delayed sternal closure antibiotic was continued until 3 days after sternal closure. The priority indicator of surgery was determined elective if the admission of the patient for open heart operation was done electively, Urgent if the patient's condition was unpredictable or the patient had a critical disease and was not discharged from the hospital before undergoing the operation, and emergent if the patient was determined to be transferred to the operation room immediately.

The status of operation (elective, urgent and emergent) and type of surgery (Coronary artery bypass graft, Valve surgery, and others) are shown in Table 2.

Preload and afterload optimization, inotropic support, IABP or ventricular assist device (VAD) insertion were the options to stabilize the patients. The decision for open chest management was made on following parameters: hemodynamic instability, bleeding, arrhythmia, tamponade and aortic dissection. Low cardiac output syndrome was the primary indication for DSC in all patients. It is defined as cardiac index less than 2.0 L/min per m^2, requiring combined pharmacologic inotropic support (dopamine, dobutamine, epinephrine) administered intravenously, with or without additional IABP.

During prolonged sternotomy, sometimes the skin was temporarily closed by a single layer of continuous suture, or in the case of cardiac edema, it was left open and was covered with a sterile spongy dressing. The dressing was changed daily using a strict sterile technique with povidone-iodine. All patients were sedated and ventilated while the sternum was open. The timing for sternal closure was determined by assessing the patients in following days. They were considered suitable for closure if they demonstrate hemodynamic stability, especially when started weaning them from the intra-aortic balloon pump, resolution of coagulation defects, decreased need for pharmacologic support and IABP support, normal urine output, and minimal mediastinal drainage. The Sternal closure was routinely performed in the operating room. After sternum closure with wires, the subcutaneous tissue, and the skin closure were performed in layers. The routine intravenous antibiotic prophylaxis was continued until 3 days after chest closure. The duration of DSC, ICU stay and ventilation was 5.08 days (±9.6 days), 245 hours (±360.9 hours), 110.6 hours (±269.6 hours) respectively.

Statistical analysis was carried out using descriptive statistics, Independent-Samples T-test, Chi-square test, Univariate analysis and Binary Logistic regression analysis. All the statistical analyses were performed using PASW version. Data were analyzed using SPSS version 22.0

Categorical data were presented as numbers (%), and continuous data as Mean ± SD. We used the Chi square test to compare categorical variables and the Student t test to compare continuous variables. $P < 0.05$ was considered significant.

RESULTS

Open Surgery with DSC was performed in 362 (1.5%) of 22721 patients including 66.3% (229) men and 33.7% (133) women. In angiography evaluation we detected that the angiography was normal in 20.1% (73), minimal coronary artery disease in 1.1%(4), single vessel disease in 5.8% (21), two vessels disease in 19.9% (72) and three vessels disease in 53% (192). In addition, in the preoperative angiography evaluation, left main coronary artery was detected in 6.6% (24) of the patients (Table 1). In 57.7% (209) of the patients, IABP was used during operation (Table 2). The most common indication for IABP insertion was hemodynamic instability. After the operation, the most prevalent complications were atrial fibrillation, bleeding, pulmonary embolism and new onset renal failure with incidence rates of 38.4% (139), 26.2% (95), 15.2% (55), and 9.1% (33) respectively. The mortality rate was 28.5% (103).The mortality rate was significantly higher in patients with diabetes ($p<0.001$), carotid vascular disease ($p=0.003$), chronic lung disease ($p < 0.001$), congestive

Table 1: Demographic Variables of Study Population (n=22721)

Variables		Mean	SD
Age (Mean, SD)		**59.01**	**12.42**
Base creatinine(Mean, SD)		1.21	0.75
Ejection Fraction(Mean, SD)		45.72	10.99
Gender	Male	229	66.3
	Female	133	33.7
Smoking	Smoker	92	25.4
	Non-smoker	270	74.6
Diabetes Mellitus	Diabetic	113	31.2
	Non-diabetic	249	68.8
Dyslipidemia	Positive	180	49.7
	Negative	182	50.3
Hypertension	Positive	185	51.1
	Negative	177	48.9
Dialysis	Positive	4	1.1
	Negative	358	98.9
Cerebrovascular accidents	Positive	19	5.2
	Negative	343	94.8
Carotid Vascular disease	Positive	21	5.8
	Negative	341	94.2
Chronic lung disease	Severe	2	0.6
	Moderate	2	0.6
	Mild	12	3.3
	No	346	95.6
Congestive heart failure	Positive	77	21.3
	Negative	346	78.7
Dysrhythmia	Positive	196	54.1
	Negative	166	45.9
Angiography results	Normal	73	20.1
	SVD	21	5.8
	2VD	72	19.9
	3VD	192	53
	Minimal CAD	4	1.1
Angiography results (Left coronary artery involvement)	Positive	24	6.6
	Negative	338	93.4

heart failure (p<0.001), emergency status of operation (p<0.001) and in patients who underwent hemodialysis (p=0.038) (Table 3). Also, in patients with post-operative bleeding (p=0.017),septicemia (p = 0.003), new onset renal failure (p<0.001) and cardiac tamponade (p=0.039). The mortality rate in patients with post-operative complication was higher (Table 3). Additionally, the mortality rate was higher in patients with higher duration of ICU stay and ventilation (Table 4). Predictors of mortality by univariate analysis were diabetes (p<0.001) and emergency status of the operation (p<0.001). Binary Logistic Regression analysis pointed out that diabetes; severe chronic lung disease and postoperative need for hemodialysis were the strongest independent predictors of mortality in patients underwent OS with DSC.

Table 2: Status of Operation and Type of Surgery of Study Population (n=22721)

Status of Operation			Type of Surgery		
	Number (n)	%	Type	Number (n)	Percentage (%)
Emergent	15	4.1	CABG	174	48.1
Urgent	47	13	Valve	68	18.8
Elective	300	82.9	CABG+Valve	42	11.6
			CABG+Valve+Other	19	5.2
			Valve+Other	21	5.8
			Other	16	4.4
			CABG+Other	22	6.1

Table 3: Preoperative Characteristics in Surviving VS Non-Surviving Patients(n=22721)

Variables	Surviving (n=259) %	Dead (n=103) %	p-value
Age (meanSD)	57.9013.95	59.9910.5	0.004
Female	88(32.21%)	45(44%)	0.084
Smoker	65(25%)	27(26.8%)	0.826
History of Diabetes Mellitus	67(25.8%)	46(45.83)	<0.001
History of Hypertension	128(49.2)	57(54.5)	0.309
History of Dyslipidemia	124(37.5%)	56(54.46)	0265
Pre-operative Renal failure	6(2.4%)	6(5.9%)	0.092
History of Hemodialysis	1(0.4)	3(3%)	0.038
History of CVA	10(4%)	9(8.9%)	0.06
History of Carotid vascular disease	9(3.6%)	12(11.6%)	0.003
History of severe chronic lung disease	4(1.6%)	12(11.6%)	<0.001
History of CHF	42(16.8%)	35(34.86%)	<0.001
Emergent operation	7(2.8%)	8(8%)	<0.001
IABP Insertion	152(60.8%)	57(56.8%)	0.561
Post-operation bleeding	77(30.8%)	18(17.95%)	0.017
Post-operation Pulmonary embolism	45(18%)	10(10%)	0.067
New onset renal failure	7(2.8%)	26(25.84%)	<0.001
Post-operation Atrial Fibrillation	109(43.6%)	30(29%)	0.022
Post-operation tamponade	6(2.4%)	7(7%)	0.039

Table 4: Comparison of Means in Surviving VS Non-Surviving Patients (n=22721)

	Surviving patients			Non-surviving patients			p-value
	Number	mean	Standard deviation	Number	Mean	Standard deviation	
DSC duration (days)	259	4.56	8.93	103	6.36	11.05	0.137
ICU stay (hours)	259	207.2	308.3	103	339.9	456	0.007
Duration of ventilation (hours)	259	72.6	169.4	103	206.1	414.4	0.002
Creatinine before surgery	259	1.19	0.82	103	1.24	0.53	0.562
Ejection fraction (%)	259	46.3	10.1	103	44.1	12.8	0.134
BMI (kg/m^{-2})	259	26.4	4.8	103	26	4.8	0.486

DISCUSSION

It is well known that the sternal closure decreases cardiac output and diastolic filling, and it may be lead to complications such as ischemia, reperfusion, and edema.[12-13] To overcome these complications the authors have suggested the open chest technique, and a study by Funray confirmed that open chest improves the cardiac output and systemic blood pressure.[14] In this study we revealed that the rate of open chest procedure during a 9- year interval in Tehran Heart Center was 1.5% and the mortality rate was 28.5% (103 of 362), diabetes and emergency status of the operation were two predictors of mortality ($p < 0.001$). Moreover, binary logistic regression analysis pointed out that diabetes; severe chronic lung disease and postoperative need for hemodialysis were the strongest independent predictors of mortality in patients underwent OS with DSC. The most prevalent post operation complications were atrial fibrillation, bleeding, and pulmonary embolism. The mortality rate in our study was similar to a retrospective study by Shi et al in 2014 on 97 patients, however, in this study, the most post-operation complication and predictor of mortality were the infections.[15] In another retrospective study by Estrera in 2008 the open chest management was performed for 12 patients (1.2%) and the delayed sternal closure for 92%. The mean duration of closure was 3 days, patients were followed for 6 months, and the mortality rate was 16.7%. The significant predictors of open chest management were pump time ($p<0.0001$) and intra-operative blood transfusions ($p<0.002$).[16] In our experience, the hemodynamic instability, bleeding, arrhythmia, tamponade and aortic dissection were the most important factors for the performance of DSC in the patients. In line with us a study by Yasa et al. of 2698 patients who underwent open heart operation, the open chest management was performed for 46 patients (1.7%) including 31 men and 15 women mean age 57 years old. The most important cause of delayed sternal closure performance was bleeding (n=21) followed by hemodynamic instability. Mortality during one month after operation was 23.9 %(11 patients) among the patients with DSC that was higher than our results, however, the mortality rate was 3.6% among patients without DSC. The commonest post- operative complication was renal failure followed by minor wound infection.[17] In another study by Boeken, of 6041 patients underwent cardiac surgery the DSC was considered for 112 cases (3.5%) the most important cause for open chest management was hemodynamic compromise and the most important complication after the procedure was the infection in 5 %. The mortality rate was similar to our practice (28.5% vs 1.5%), including 25.5% because of bleeding and 20.5% due to arrhythmias.[18] Moreover, another study by this author repeated similar results and detected of 5122 cardiac surgeries the OS was performed in 179 patients (3.5%). Indications for OS were the hemodynamic compromise intractable bleeding, arrhythmia, and cardiac edema or tamponade.[14,19] The mortality rate was 29% mortality in patients with low cardiac output syndrome was 34.5%, among patients with bleeding was 26.3%, for arrhythmias 21.4%, and for tamponade, on closure, it was 16.7%. The infection occurred in 4.9%. The commonest predictor of mortality was VAD insertion followed by the new onset of hemodialysis, the other predictors were reoperation, the mean length of duration of OS and longer duration of high-dose inotropic therapy.[19]

In summary, the indication of DSC and mortality rate in our study was similar to previous studies around the world but the post-operative complications were different. For instance, most of the studies that were reviewed in this article pointed out infection as a post-operative complication but we did not detect it in any patients. The exact reason for such discrepancy is not known however, it may be related to the patients' selection and different surgery technique and medication.

LIMITATIONS

This was not a comparative study and we only included patients with DSC, so we could not compare the outcomes of

DSC to other possible approaches, more comparative studies are required to evaluate the outcomes open sternal managements.

CONCLUSION

Hemodynamic instability, bleeding, arrhythmia, tamponade and aortic dissection were the most important indication of DSC, while diabetes and emergency status of the operation were the most important predictors of mortality. The results of previous studies and our practice indicated that delayed closure technique is an important therapeutic option in cases with post-surgery LCOS, hemorrhage, and arrhythmias.

REFERENCES

1. Negri A, Manfredi J, Terrini A, Rodella G, Bisleri G, et al. (2002) Prospective evaluation of a new sternal closure method with thermoreactive clips. Eur J Cardiothorac Surg 22: 571–5.
2. Mestres CA, Pomar JL, Acosta M, Ninot S, Barriuso C, Abad C, Mulet J. Delayed sternal closure for life-threatening complications in cardiac operations: an update. Ann Thorac Surg 1991;51:773-6.
3. Freeman RK, Daily PO, Dembitsky WP, Adamson RM, Moreno-Cabral RJ. The treatment of low cardiac output syndrome following cardiopulmonary bypass using delayed sternal closure. Am Surg 1997;63:882-4.
4. Christenson JT, Maurice J, Simonet F, Velebit V, Schmuziger M. Open chest and delayed sternal closure after cardiac surgery. Eur J Cardiothorac Surg 1996;10:305-11.
5. Riahi M, Tomatis LA, Schlosser RJ, Bertolozzi E, Johnston DW. Cardiac compression due to closure of the median sternotomy in open heart surgery. Chest 1975;67:113-4.
6. Anderson CA, Filsoufi F, Aklog L, Farivar RS, Byrne JG, Adams DH. Liberal use of delayed sternal closure for postcardiotomy hemodynamic instability. Ann Thorac Surg 2002;73:1484-8.
7. Kouchoukos NT, Blackstone EH, Doty DB, et al: Kirklin/Barratt-Boyes, Cardiac Surgery , Vol. 1, 3rd ed. Churchill Livingstone, New York, NY, 2003, p. 112.
8. Anderson CA, Filsoufi F, Aklog L, Farivar RS, Byrne JG, Adams DH. Liberal use of delayed sternal closure for postcardiotomy hemodynamic instability. Ann Thorac Surg 2002;73:1484-8.
9. Ridderstolpe L, Gill H, Granfeldt H, Ahlfeldt H, Rutberg H. Superficial and deep sternal wound complications: incidence, risk factors and mortality. Eur J Cardiothorac Surg. 2001;20:1168-75.
10. Furnary AP, Magovern JA, Simpson KA, et al: Prolonged open sternotomy and delayed sternal closure after cardiac operations. Ann Thorac Surg 1992;54:233-9.
11. Freeman RK, Daily PO, Dembitsky WP, Adamson RM, Moreno-Cabral RJ. The11. treatment of low cardiac output syndrome following cardiopulmonary bypass using delayed sternal closure. Am Surg 1997;63:882-4.
12. Christenson JT, Maurice J, Simonet F, et al: Open chestand delayed sternal closure after cardiac surgery. Eur J Cardiothorac Surg 1996;10:305-11.
13. Gielchinsky I, Parsonnet V, Krishnan B, et al: Delayed sternal closure following open-heart operation. Ann Thorac Surg 1981;32:273-7.
14. Furnary AP, Magovern JA, Simpson KA, et al: Prolonged open sternotomy and delayed sternal closure after cardiac operations. Ann Thorac Surg 1992;54:233-9.
15. Shi YD, Qi FZ, Zhang Y.Treatment of sternal wound infections after open-heart surgery.Asian Journal of Surgery 2014;37:24-9.
16. Estrera AL Porat EE , Miller CC, Meada R, Achouh PE, Irani AD, Safi HJ.Outcomes of delayed sternal closure after complex aortic surgery European Journal of Cardio-thoracic Surgery 2008;33:1039-42.
17. Yasa H, Lafç BB, Y ı l ı k L, Bademci M, Şahin A, Kestelli M, Yeşil M, Gürbüz A.Delayed sternal closure: an effective procedure for life-saving in open-heart surgery. Anadolu Kardiyol Derg 2010; 10: 163-7.
18. Boeken U, Assmann A, Mehdiani A, Akhyari P, Lichtenberg A.Open chest management after cardiac operations: outcome and timing of delayed sternal closure. European Journal of Cardio-thoracic Surgery 2011;40:1146-50.
19. Boeken U, Feindt P, Schurr P, Assmann A, Akhyari P, LichtenbergA.Delayed Sternal Closure (DSC) After Cardiac Surgery: Outcome and Prognostic Markers. J Card Surg 2011;26:22-7