ORIGINAL ARTICLE

Early Outcome of Patients with Poor Hemodynamics Undergoing Open Chest Management after on-Pump Cardiac Surgery

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ABSTRACT
Objective: To evaluate the incidence and early outcome of patients who underwent operative strategy of open chest management (OCM) and delayed sternal closure (DSC) after cardiac surgery because of poor hemodynamics.
Methods: It was a prospective observational descriptivestudy which was conducted at Chaudhary Pervaiz Elahi (CPE) Institute of Cardiology, Multan; from September 2017 to July 2020. All patients who underwent open chest management because of poor hemodynamics were included. In-hospital mortality and surgical site infection were primary end-points of the study.
Results:4,750 patients were operated for cardiac diseases, out of which only 22 (0.46%) patients underwent OCM with DSC. The cause of hemodynamic instability was very low cardiac output state (LCOS) in 19 (86.36%) patients, 2 (9.1%) patients had diffuse mediastinal bleeding and 1 (4.54%) patient had recurrent arrhythmias. 10 (45.5%)patients were survived to discharge. In hospital mortality was 12 (54.5%).One patient (4.54%) developed surgical site wound infection.
Keywords: Open chest management, delayed sternal closure, poor hemodynamics.

INTRODUCTION
Post-pump myocardial dysfunction resulting in hemodynamic instability even after a technically sound cardiac surgery is not an uncommon situation faced by cardiac surgeons.[1, 2] Attempting sternal closure in this situation may lead to further decrease in cardiac output.[3] Open chest management comprises leaving the sternum and subcutaneous tissues open after Procedure followed by delayed sternal closure in ICU (intensive care unit) or operation theatre. This technique of delayed sternal closure was first described by Riahi and associates.[4]

Some of the factors that prevent primary sternal closure after cardiac surgery because of poor hemodynamic indices include myocardial stunning, recurrent arrhythmias, continuous non-surgical bleeding, respiratory compromise and need of transthoracic IABP (intra-aortic balloon pump) and cardiac assist devices.[5] The strategy of OCM with DSCis used in 1.5-4.2% of all adult cardiac procedures.[6, 7] Sternal closure is carried out after the patient is hemodynamically stable.[8] Cardiac surgeons commonly avoid this operative strategy because of their concern that open sternotomy wound would result in increased infectious complications like mediastinitis. Studied have revealed a low incidence of infection after this treatment modality.[7, 9]

Despite valuable benefits of OCM in post-cardiac surgery in patients having LCOS, OCMhas not gained popularity in our country. The target of the current study was to assess the early outcome and complicationsof OCM with DSC in our institute. This study resultsare helpful for young cardiac surgeons regarding awareness and potential benefits of OCM and DSC.

PATIENTS AND METHODS
This prospective descriptive study was arranged indepartment of cardiacsurgery at CPEIC, Multan. The study was conducted from September 2017 to July 2020. Patients who were shifted from operation room to intensive care unit with open chest or patients who became unstable after surgery in intensive care unit (ICU) and after rescue procedure sternum kept opened because of poor hemodynamics were included in the study.

Routine Re-openings because of bleeding or valve dysfunction in which redo surgery was performed but sternum was closed at same time were excluded from the study.

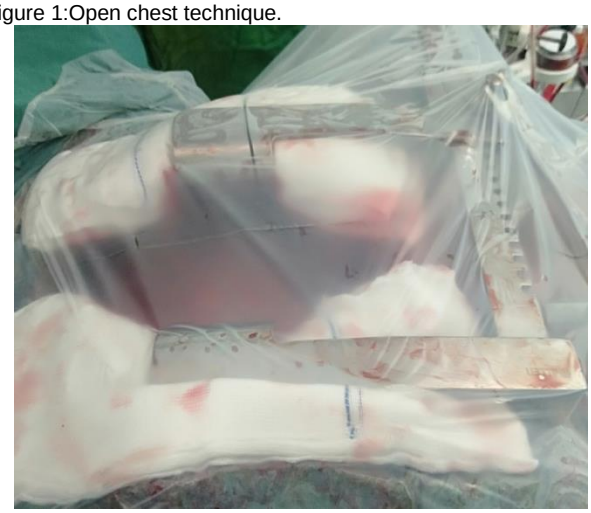
All procedures were accomplished using standard cardiopulmonarybypass technique with moderate hypothermia and cold blood cardioplegia. We routinely used central venous line, arterial line, foley catheter and capnography for perioperative monitoring of patients. Adequate function of native and prosthetic valves was determined by transesophageal echocardiography (TEE). In the absence of transit time flow meter, intraoperative patency of coronary grafts was assessed by subjective evidences by operating surgeon and by analyzing wall motion abnormality on TEE. Both subjective and objective evidences were used to confirm that surgery is technically sound before adopting OCM. TEE was used to monitor cardiac output by calculating Stroke volume by formula (SV=CSA LVOT x VTI). ICON Cardio meter (Osypka Medical 5M-17-011X-B-01/8) was used as non-invasive tool to measure cardiac output.

OCM with DSC as a treatment strategy was adopted in patients who remained in low cardiac output after weaning from bypass (systolic blood pressure less then 80mmHg, mean blood pressure below 55 mmHg and cardiac index below 2.0 L/m2) despite technically sound cardiac surgery and after optimum and judicious management of preload, after load and inotropic support. Adrenaline @ 2.0ug/kg/min, dobutamine20ug/kg/min, milrinone50ug /kg loading then 0.50ug/kg/min were used as their maximum inotropic dose and nor-adrenaline upto 0.2 ug/kg/min was used as maximum vasoconstrictor dose. IABP was used as mechanical inotropic support in patients who underwent isolated or combined CABG. Other

indications to leave the chest open were generalized non-surgical bleeding and recurrent arrhythmias with hemodynamic compromise. Diffuse surgical bleeding was managed with transient mediastinal packing and correction of coagulation disturbances by transfusing platelets and fresh frozen plasma.

Technique of OCM: In all patients, sternal wounds were kept opened by using sternal retractor with sterile gauze on both edges of sternum. Chest drains were placed in the mediastinal and pleural cavities. The wound was covered with sterile and transparent dressing which allowed frequent observation of operative field for presence of any clot or blood and visible improvement in cardiac contractility. The surrounding area of sternal wound was draped with sterile OT sheets (Fig 1).

Figure 1:Open chest technique.



Intensive care unit (ICU) management: In the ICU, OCM patients were maintainedon ventilator support,kept sedated, invasive monitoring of pulmonary and systemic arterial pressures, urine output, end-tidal CO_2 and arterial blood gases were monitored until chest closure was done.

Broad-spectrum intravenous antibiotics such as vancomycin and Imipenem were given as prophylaxis. Antibiotics was continued till patient had invasive monitoring lines or in presence of fever with raised leucocyte count.DSC was done after improvement in hemodynamics of patient such as reduction in needs of inotropes, cessation of IABP support, improvement in coagulation profile and hemodynamic response to temporary approximation of the sternum. Wound was frequently washed with antibiotic enriched warm sterile normal saline at time of suction from mediastinum and at time of chest closure. Chest was closed in ICU when hemodynamics improved (systolic BP above 100, mean BP above 60mmHg, Cardiac index above 2.2 L/m2, patient on mild to moderate inotropes and no active mediastinal bleeding).Sternum was approximated by applying and tightening the sternal wires, followed by closure of the subcutaneoustissue and the skin in layers. The procedure of delayed sternal closure was routinely performed in ICU. Preoperative, operative and postoperative characteristics of the patients were recorded. In-hospital mortality, survival and surgical site infection were noted as primary study end-points.

Data was analyzed in SPSS v25 software. Descriptive and percentages were calculated for quantitative and qualitative variables respectively.Mortality and surgical site infections in OCM group were compared with non OCM group using Independent Student's t-test. P value less than 0.05 were significant.

RESULTS

A total of 4750 patients underwent cardiac surgery at CPE institute of Cardiology, Multan during the study period. Out of these, only 22 (0.46%) patients underwent open chest management and delayed sternal closure. Out of 22, there were 20 (90.9%) patients which were shifted to ICU with open chest after primary surgery, 2 (9.1%) patients became unstable in ICU because of graft failure. In these 2 patients graft revision was done on pump but remained in LCOS, hence OCM and DSC was performed after redo rescue surgery. OCM was adopted as treatment strategy in 19(86.36%) patients because of low cardiac output, and diffuse mediastinal bleeding in 2(9.1%) patients. One (4.54%) patient had recurrent VT with instability. The operative mortality in patients who underwent open chest management was 12(54.5%). Causes of death were major neurological injury in 3 (13.6%) patients, 5 (22.7%) patients died because of persistent low cardiac output state because of cardiac failure, 1(4.54%) patient developed sudden cardiac arrest, 2 (9.1%) died because of respiratory complications and 1(4.54%) died with sepsis. Out of 12 patients who were expired, 4(33.3%) were extubated because of improved hemodynamics, but later re-intubated and ventilated because 2(16.7%) developed major stroke and 2(16.7%) patients had respiratory failure.In hospital mortality in patients who did not require open chest management was 4.2%.

Out of 22 patients, 10(45.4%) were survived to discharge from hospital in satisfactory condition. In survivors, 1(4.5%) patient developed superficial surgical site infection and one patient developed grade II bedsore. Chest was closed in ICU within 1 to 3 days (22.91±13.21 hrs.) Preoperative, operative and postoperative characteristics of patientsare summarized on (Table-I & II) and hemodynamic data at time of adopting open chest management is depicted in table III.

Table 1: Quantitative Baseline and operative characteristics of OCM patients (n=22)

Variable	Mean±S.D.
Age	50.09±14.172
Ejection Fraction	40.91±10.538
ICU stay (Hrs.)	111.636±80.708
Clamp time (minutes)	104.45±31.063
CPB time(minutes)	200.363±96.96
Ventilation Time (Hrs.)	64.50±47.14
Hospital stay(days)	6.772±3.75
Maximum CKMB	179.54±67.227
Time of chest closure (Hrs.)	33.36±16.33

ICU= intensive care unit, CPB=cardio-pulmonarybypass,CK-MB=Creatinineekinase-myocardial band. Hrs.=hours

Table 2: Qualitative variables of OCM Patients

Name of variable	Number (%)
total number of patients	22 (100%)
Gender	
Male	15 (68.2%)
Female	07 (31.8%)
Priority status	
Elective	14 (63.6%)
Urgent	06 (27.3%)
Emergency	02 (9.1%)
IABP	
Yes	14 (63.6%)
No	08 (36.4%)
Outcome	
Death	12 (54.5%)
Discharge	10 (45.5%)
Type of operation	
CABG	10 (45.5%)
CABG+AVR	02 (9.1%)
Redo Surgery	01 (4.5%)
DVR	01 (4.5%)
AVR	03 (13.6%)
MVR+TVR	02 (9.1%)
TOF	01 (4.5%)
CABG+VSR repair	02 (9.1%)
Extubated or not	
Yes	14 (63.6%)
No	08 (36.4%)
Coronary endarterectomy	
Yes	03 (13.6%)
NO	11 (50%)
Not applicable	08 (36.4%)

CABG= Coronary artery bypass grafting, MVR= Mitral valve replacement, AVR=Aortic valve replacement, DVR= Double valve replacement, TVR= Tricuspid valve replacement, TOF= Tetralogy of Fallot

Table 3: Hemodynamic data of patients at time of adopting OCM.

	Mean± S.D
Systolic BP	71.54±6.50
Diastolic BP	38.90±2.81
MAP	49.78±3.78
Cardiac Index	1.67±0.13
CVP	11.77±1.84

BP=blood pressure, MAP=mean arterial pressure, CVP=central venous pressure

Table 4: Comparison of mortality and SSI in OCM and non-OCM group.

Name of Variable	OCM group (n=22)	Non-OCM group (n=4728)	P value
Mortality	12(54.5%)	200(4.2%)	.000
SSI	1(4.5%)	159(3.4%)	.759

SSI: Surgical Site Infection

DISCUSSION

In the early days of cardiac surgery primary chest closure after surgery was mandatory due to the fear of mediastinitis. Recent data in several reports has described that OCM and DSC is a lifesaving procedure in patients with overwhelming diffuse mediastinal bleeding, myocardial stunning and arrhythmias postoperatively.[10, 11] Matsumoto [12]described that restricted diastolic filling is the crucial point at which there is disproportionate cardiac to mediastinal correlation, leading tocompression ore tamponade. Sternal closure after surgery significantly effects the cardiac diastolic filling even in patients having good ejection fraction.[9]

Furnary et al in a study reported significant improvement in low cardiac output (LCO) by opening the sternum.[13]Opening the sternum has been shown to increase cardiacindex (CI) up-to 59.0% and can increase SBP up-to 18% without affecting the filling pressure[13,14]

In our study, delayed sternal closure was used in only 0.46% patients, which is very less as compared to other studies[15,16]

Hospital survival in this series of 22 patients undergoing OCM with DSC was 45.4% less than that in the recent series by Anderson et al. (76%).[17]This might have resulted because we have not used ventricular assist device (VAD) in our patients because of unavailability. In our study patients who required OCM were a higher risk group having low EF, high NYHA class, urgent or emergency priority for surgery and diffuse coronary disease needing coronary endartectomy. These results are comparable to previous studies done by Kennedy and collegues.[9,18]

The in-hospital mortality was 54.5% (n=12). In a study conducted by Furnary et al. that used VADs, mortality rate was 52%.[13] A recent study by Tafti et al. reported lower mortality rate of 28.45% in patients of DSC.[19]Boeken et al. also reported lower mortality rate 29.0% in OCM patients, 11.1% patients died before DSC and 17.9% patients after DSC.[20]Saadat et al. reported mortality rate of 34.2%.[21] While a study by Wong et al. reported 30-day mortality in only 16% patients. They reported emergency surgery, sternal re-exploration and duration of OCM as independent predictors of mortality.[22]

One of the major concerns for not adopting OCM is the risk of wound infections. In present study, incidence of wound infections was only 4.54% that were superficial in nature. This is comparable to the study of Boeken et al., they reported superficial wound infections in 4.7% patients.[20] Jamie et al. also reported similar results.[23] While Saadat et al. reported 0.06% incidence of wound infections in their series of OCM patients.[21] It is interesting to note that in our limited study only one patient developed surgical site infection in OCM group which is not statistically significant as compared to non-OCM group (p =.759).Like majority of cardiac centers in Pakistan our institution also lacks facility of advanced mechanical circulatory assist devices, a more effective solution for post-cardiotomy cardiogenic shock.

The limitation of the study is that it is small and varied group of patients who had open chest management with delayed sternal closure after cardiac surgery.

In summary, OCM with DSC is a useful therapeutic choice in patients who develop LCOS in early post-operativeperiod, significant non-surgical diffuse mediastinal bleeding and arrhythmias. Cardiac institutions with limited resources who lack circulatory assist devices can safely adopt this operative strategy to improve survival in hemodynamic unstable patients after cardiac surgery.

CONCLUSION

We concluded that open chest management provides an opportunity of survival in patients with poor hemodynamics after cardiac surgery without significantly increased risk of major wound infection.

Disclosure and conflict of Interest: None

REFERENCES

1. De Hert S, Moerman A. Myocardial injury and protection related to cardiopulmonary bypass. Best Pract Res Clin Anaesthesiol. 2015;29(2):137-49.
2. Sarkar M, Prabhu V. Basics of cardiopulmonary bypass. Indian J Anaesth. 2017;61(9):760-7.
3. Nelson-McMillan K, Hornik CP, He X, Vricella LA, Jacobs JP, Hill KD,. Delayed sternal closure in infant heart surgery-the importance of where and when: an analysis of the sts congenital heart surgery database. Ann Thorac Surg. 2016;102(5):1565-72.
4. Elassal AA, Eldib OS, Dohain AM, Abdelmohsen GA, Abdalla AH, Al-Radi OO. Delayed sternal closure in congenital heart surgery: a risk-benefit analysis. Heart Surg Forum. 2019;22(5):E325-E30.
5. Calafiore AM, Sheikh AA, Alfonso JJ, Tantawi T, Maklouf B, Shawki A, et al. Elective Primary or Secondary Delayed Sternal Closure Improves Outcome in Severely Compromised Patients. Thorac Cardiovasc Surg. 2018;66(6):500-7.
6. Kundan S, Tailor K, Radhakrishnan HB, Mohanty SR, Bhavsar K, Kadam S, et al. Elective delayed sternal closure portends better outcomes in congenital heart surgery: a retrospective observational study. Indian J Thorac Cardiovasc Surg. 2019;35(4):530-8.
7. 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(5):1484-8.
8. Quader M, LaPar DJ, Wolfe L, Ailawadi G, Rich J, Speir A, et al. Delayed sternal closure after continuous flow left ventricle assist device implantation: analysis of risk factors and impact on outcomes and costs. ASAIO J. 2016;62(4):432-7.
9. Kennedy III JT, DiLeonardo O, Hurtado CG, Nelson JS. A Systematic Review of Antibiotic Prophylaxis for Delayed Sternal Closure in Children. World J Pediatr Congenital Heart Surg. 2020:2150135120947685.
10. Haughey N, Booth K, Parissis H. Post-cardiotomy open chest management. A single-unit experience. Asian Cardiovasc Thorac Ann. 2016;24(6):530-4.
11. Charalambous C, Zipitis CS, Keenan DJ. Outcome of primary chest packing and delayed sternal closure for intractable bleeding following heart surgery: cardiovascular topics. Cardiovasc J S Africa. 2002;13(5):231-4.
12. Bakaeen FG, Haddad O, Ibrahim M, Pasadyn SR, Germano E, Mok S, et al. Advances in managing the noninfected open chest after cardiac surgery: Negative-pressure wound therapy. J Thorac Cardiovasc Surg. 2019;157(5):1891-1903.
13. Furnary AP, Magovern JA, Simpson KA, Magovern GJ. Prolonged open sternotomy and delayed sternal closure after cardiac operations. Ann Thorac Surg. 1992;54(2):233-9.
14. Simonet E, Velebit V, Schmuziger M. Open chest and delayed sternal closure after cardiac surgery. Eur J Cardio-thorac Surg. 1996;10:305-11.
15. Yasa H, Lafci B, Yilik L, Bademci M, Sahin A, Kestelli M, et al. Delayed sternal closure: an effective procedure for life-saving in open-heart surgery. Anadolu Kardiyol Derg. 2010;10(2):163-7.
16. Iyer RS, Jacobs JP, de Leval MR, Stark J, Elliott MJ. Outcomes after delayed sternal closure in pediatric heart operations: a 10-year experience. Ann Thorac Surg. 1997;63(2):489-91.
17. 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(5):1484-8.
18. Donatelli F, Triggiani M, Benussi S, Grossi A. Advantages of delayed sternal closure in cardiac-compromised adult patients. J Card Surg. 1995;10(6):632-6.
19. Ahmadi Tafti SH, Karimi AA, Gorabi AM, Fathi F, Rezaei MR, Davoudi S, et al. Evaluation of open chest management (OCM) with delayed sternal closure (DSC) after cardiac surgery. Pak Heart J. 2018;50(4):218-23.
20. Boeken U, Feindt P, Schurr P, Assmann A, Akhyari P, Lichtenberg A. Delayed sternal closure (DSC) after cardiac surgery: outcome and prognostic markers. J Card Surg. 2011;26(1):22-7.
21. Saadat S, Schultheis M, Romero J, Azzolini A, Odroniec K. Delayed Sternal Closure in Cardiac Surgery. J Clin Exp Cardiol. 2015;6(6):1000375.
22. Wong JK, Joshi DJ, Melvin AL, Aquina CT, Archibald WJ, Lidder AK, et al. Early and late outcomes with prolonged open chest management after cardiac surgery. J Thorac Cardiovasc Surg. 2017;154(3):915-24.
23. Eckardt JL, Wanek MR, Udeh CI, Neuner EA, Fraser TG, Attia T, et al. Evaluation of prophylactic antibiotic use for delayed sternal closure after cardiothoracic operation. Ann Thorac Surg. 2018;105(5):1365-9.