Original Article

Delayed Sternal Closure is a Life Saving Decision

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Nineteen hundred and fifty open heart operations were performed between January 1995 and December 2000 at the cardiac surgery department of Chest Disease Hospital in Kuwait. Sternal closure was delayed in 40 patients (2%), because of hemodynamic instability limiting primary closure in 23 patients and uncontrollable bleeding in 17 patients. Four patients died in the immediate postoperative period while the chest was open, due to persistent low cardiac output secondary to myocardial failure. The sternum was closed in 36 patients on an average of 22±0.3 hours (range, 8 to 48 hours) postoperatively. Two patients died in the late postoperative period prior to hospital discharge after sternal closure. Wound infections occurred in 8 patients. The 34 survivors (85%) were discharged and followed up for a mean of 13.2 months. This study demonstrates that delayed sternal closure is an effective and life saving decision with unstable hemodynamics and uncontrollable hemorrhage. (Ann Thorac Cardiovasc Surg 2002; 8: 220–3)

Key words: sternum, closure, hemorrhage, cardiac output

Introduction

In the early days of cardiac surgery, primary closure of the chest was mandatory because of the fear of fulminant mediastinal infection. Recently, several reports have described delayed sternal closure (DSC) as a lifesaving procedure in patients with uncontrollable hemorrhage, myocardial edema, low cardiac output, arrhythmias, postoperatively.[1-4] Prolonged open sternotomy can relieve cardiac compression and provide rapid access to control hemorrhage and arrhythmias; sternal closure can be carried out after the patient's hemodynamic status has been stabilized.[5,6] Most reports have included either a small group of patients or a single case. The only large series of patients (107) treated with DSC is that of Furnary et al.[1] This report describes our experience of 40 patients with DSC following open heart operations over a period of 5 years, with the aim of identifying the risks and assessing the outcome of this technique.

Patients and Methods

There were 1,950 patients who underwent open heart surgery at our hospital between January 1995 and December 2000. Standard anesthesia, cardiopulmonary bypass, and surgical techniques were employed. For myocardial protection, cold crystalloid hyperkalemic cardioplegia was infused into the aortic root (or directly into the coronary ostia in cases of aortic valve surgery) in addition to topical-hypothermia with ice slush. Some surgeons preferred blood cardioplegia with normothermia and antegrade-retrograde cardioplegia. All patients received prophylactic antibiotics with a combination of cephalosporin and aminoglycosides at induction of anaesthesia and thereafter for one week postoperatively. The sternum was left open in 40 patients (2%), after the initial operation in 16, after the first reexploration in 14 patients, and after a second reexploration in 10 patients.

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Received August 20, 2001; accepted for publication April 4, 2002.
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Table 1. Indications for DSC after 40 cardiac operations

Operation	Bleeding	Hemodynamic instability
MVR	4	2
DVR	2	2
CABG + AVR	1	2
CABG	5	8
CABG + MVR	3	6
CHD	2	3
Total	17	23

MVR: mitral valve replacement, DVR: double valve replacement, CABG: coronary artery bypass grafting, AVR: aortic valve replacement, CHD: congenital heart disease

There were 28 males and 12 females, ranging in age from 6 to 72 years (mean, 58±1 years). The primary operative procedures were coronary artery bypass grafting (CABG) in 13, valve replacement in 10, CABG and valve replacement in 12, congenital heart disease in 5. The operative procedure were classified as elective in 21 (52.5%), urgent in 13 (32.5%), and emergency in 6 (15%) patients.

Indications for DSC are given in Table 1. Twenty-three patients were hemodynamically unstable, despite maximum ionotropic support or intraaortic balloon pump fixation, 17 had markedly edematous ventricles that physically precluded primary sternal closure, and 3 became hemodynamically unstable in the intensive care unit after sternal closure and the sternum was reopened. Ten out of 17 patients who had massive bleeding as a result of prolonged cardiopulmonary bypass and multiple blood transfusion left the operating room without sternal closure. The other 7 underwent reexploration and the sternum was subsequently left open.

During prolonged sternotomy, the skin was closed by heavy merselin stitches and covered with sterile dressing. The dressing was changed frequently using a strictly sterile technique with povidone-iodine. The timing of sternal closure was determined by the level of pharmacological support, correction of coagulation defects, improved hemodynamic parameters, especially when starting weaning from the intraaortic balloon pump, and response to temporary reaproximation of the sternum as a test before deciding to close it. Sternal closure was routinely performed in the intensive care unit, thus avoiding the potential danger in transporting the critically ill patient. Debridement of all nonviable tissue and meticulous cleaning with Betadine solution were performed. Multiple bacterial cultures were taken from the chest wound. The two mediastinal as well as the pleural drains were kept in place when necessary. The sternum was rewired before closure of subcutaneous tissue and skin.

All data for analysis was retrieved from a computerized database. Perioperative death was defined as death for any reason occurring within 30 days after the operation. Sternal, neurological, renal and respiratory morbidity was compared. Sternal morbidity was defined as bacteriologically confirmed superficial wound infection, mediastinitis, and sternal dehiscence necessitating refixation. Statistical analyses were carried out using the chi-square test. A p value of <0.05 was considered significant.

Results

In the DSC group, four patients died in the perioperative period, constituting the overall mortality rate of 10%. Two of these deaths were due to persistent low cardiac output secondary to myocardial failure while the chest was opened. Another two deaths occurred after sternal closure, due to severe uncontrolled bronchopneumonia and neurological complications. The 34 survivors were discharged from the hospital 15 to 35 days after sternal closure. Ten patients got respiratory complications with ventilatory support for more than 24 hours. Two of them had adult respiratory distress syndrome. Renal complications defined as a serum creatinine level above 20 mg/L, occurred in 15 patients, of whom 6 required peritoneal dialysis. Neurological complications were noted in two patients who had undergone intracardiac repair for congenital heart disease, and one patient with mitral valve replacement and CABG. Three patients had upper gastro intestinal hemorrhage that was endoscoped and was controlled by medical treatment. Two patients with multiorgan

failure and four with septicemia subsequently improved. There were eight patients with superficial wound infections after DSC. All were treated successfully with antibiotics and local debridement. Two patients developed mediastinitis requiring mediastinal irrigation. Sternal dehiscence was found in two patients, one of whom required refixation. Sternal wound cultures were present in 10 patients, including staphylococcus aureus in 6, staphylococcus epidermidis in 3, and pseudomonas in 1.

The survivors were followed up for a mean period of 13.2 months. One patient died after 3 months from other causes not related to the sternal closure, one patient developed sternal reinfection after 4 months postoperatively, requiring debridment and rewiring.

Discussion

Prolonged open sternotomy with subsequent DSC has been described as useful in the treatment of severe myocardial dysfunction, uncontrollable hemorrhage, and intractable arrhythmia.[7-10] These effects are magnified in the presence of poor ventricular compliance secondary to ischemia, reperfusion and myocardial edema.[11] Restriction of diastolic filling is the main point at which there is disproportion in the cardiac to mediastinal relationships, leading to compression or tamponade.[12] Sternal closure has been shown to result in a significant decrease in cardiac output and diastolic filling, despite preserved velocity of fiber shortening, even in patients with good cardiac performance.[13] Low cardiac output can be improved by opening the sternum leading to a 59% increase in cardiac index and an 18% increase in systemic blood pressure without a significant change in cardiac filling pressure.[1]

Patients who required DSC were a higher risk group than the general population of patients undergoing open heart surgery, most were in a severely compromised condition during or after the operation, with severe bleeding on termination of cardiopulmonary bypass. Excessive blood transfusion and undue increases in heart size resulting in severe ventricular dysfunction and arrhythmias are often associated with a prolonged perfusion time and poor myocardial preservation.[13] They had an increased frequency of systemic complications such as renal failure, respiratory failure, multiorgan failure, and death. Prolonged cardiopulmonary bypass time, low cardiac output, excessive bleeding, and multiple blood transfusions are known to produce wound infections. The incidence of mediastinal infection after 14 routine cardiac operations is reported to be greater than 1.5%.[14] In this series, no statistically significant difference could be found in sternal morbidity between the DSC group and patients with primary sternal closure. Although not statistically significant, the patients requiring DSC had a higher mortality rate than the patients not requiring DSC. Mortality in this study was similar to that of other published reports.[1,2,7,8]

Many different techniques for the maintenance of an open sternotomy have been described.[11,15-17] In conclusion, our goals in working with this technique are: 1) allowing time for recovery of the heart from the low cardiac output and myocardial edema, 2) releasing it from the risk of tamponade, and 3) easy access to the mediastinum for evacuation of blood clots and/or manual resuscitation. Closure of the skin with heavy merselen stitches and covering the wound with sterile dressing can be applied with an acceptable morbidity and mortality when all attempts to optimize cardiac function have failed.[2,8]

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