Major bleeding complicating deep sternal infection after cardiac surgery

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Objectives: This study was undertaken to determine the incidence and outcome of major bleeding complicating deep sternal infection after cardiac surgery, to identify predisposing factors and means of prevention, and to clarify management options.

Methods: This was a retrospective study of 10,863 consecutive patients, of whom 213 (2.18%) acquired deep sternal infection. With 43 additional referrals, the total number of patients with deep sternal infection was 280. Deep sternal infection was managed by a two-stage scheme. Major bleeding was considered to be bleeding that occurred during or after operation for deep sternal infection from the heart, great vessels, or grafts, or bleeding requiring urgent exploration.

Results: Fifteen patients (5.36%) had major bleeding. The incidences of deep sternal infection and bleeding were highest among patients undergoing coronary artery bypass grafting. Thirteen patients had underlying diseases (type 2 diabetes in 9 cases). Deep sternal infection was diagnosed a median of 15 days after reoperation. Bleeding originated from the right ventricle in 9 patients. In 4 patients bleeding was iatrogenic during surgery for wire removal (n = 2) or reconstruction (n = 2). In 11 it occurred 15 minutes to 15 days (median 2 days) after wire removal, as a result of shearing forces in 7 cases and of infection only in 4 cases. Three patients died immediately. The other 12 were operated on, 6 with complete cardiopulmonary bypass, 2 with femoral cannulation, and 4 without cardiopulmonary bypass. The immediate mortality was 26.7%; the overall mortality was 53.3%. The median length of hospitalization of surviving patients was 38 days.

Conclusions: The probability of development of major bleeding in patients with deep sternal infection was unrelated to the primary operation. The mortality associated with this complication was high. Meticulous technique during wire removal may decrease the risk of major bleeding. The impacts of cardiopulmonary bypass and of the technique and timing of sternal reconstruction remain undetermined.

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Deep sternal infection (DSI, mediastinitis and sternal osteomyelitis) is a dreadful complication of median sternotomy that occurs mainly after cardiac surgery. The rate of DSI after cardiac operations is 1% to 4%, as summarized recently by Francel and Kouchoukus.[1] DSI is associated with high mortality and morbidity, prolonged hospitalization, and increased cost. Although the high mortality has declined considerably as a result of aggressive management

TABLE 1. Incidences of DSI and major bleeding associated with various cardiac operations (1988-2001)

	Operated on		DST				Bleeding		
Operation	No.	Proportion (%)	No.	DSI rate (%)	Total DSI* (No.)	Proportion (%)	No.	%	Proportion (%)
CABG	6994	64.4	180	2.57	215	76.8	12	5.6	80
CABG plus valve	577	5.3	26	4.50	31	11.1	2	6.4	13.3
Valve	1619	14.9	18	1.11	20	7.1	1	5	6.7
Congenital	1230	11.3	2	0.16	2	0.7	0	0	0
Other	358	3.3	9	2.51	10	3.6	0	0	0
Transplantation	85	0.8	2	2.4	2	0.7	0	0	0

*Including referred patients.

schemes, it still remains significant. One of the most frequently fatal sequelae of DSI is major bleeding, usually originating from the right ventricle (RV). In 1995, one of us (A.Y.) reported a single case of RV rupture,[2] corresponding to an article by Cartier and associates.[3] Since then we have encountered this complication more frequently. This study, which is probably the largest in the literature, reports on 15 cases of major bleeding associated with DSI after cardiac surgery in an attempt to identify predisposing factors, means of prevention, treatment options, and outcomes.

Material and Methods

The study was performed retrospectively in a single tertiary referral center. Included are 10,863 consecutive patients who underwent cardiovascular surgery through a median sternotomy from January 1988 to November 2001. Two hundred thirty-seven patients (2.18%) acquired DSI. In addition, 43 patients with DSI were referred from other hospitals. Thus the total number of patients with DSI treated by us was 280. All patients were treated by general thoracic surgeons. Treatment of DSI for most of the patients consisted of wire removal and débridement as the first step (usually without lysis of substernal adhesions), antibiotics, bedside irrigation with tap water and frequent dressing change for a few days, followed by reconstruction with muscle flaps or omental transposition when the wound appeared clean. In 20 patients removal of wires, débridement, and reconstruction were performed simultaneously. Since 1998 we have left the manubrial wires intact, allowing adequate drainage while limiting sternal motion.

Major bleeding was defined as any hemorrhage occurring during or after the first operation for DSI from the heart, major vessels, or grafts, or any other mediastinal bleeding requiring blood transfusion or emergency exploration. Data were obtained from the patients' charts, outpatient notes, and the Israel Central Registration Bureau. All discharged patients were followed up until death or November 30, 2001.

Results

Fifteen of the 280 patients with DSI (5.36%) had major bleeding. Most cases of DSI occurred in patients undergoing myocardial revascularization, which was also the most prevalent type of cardiac procedure in our center (Table 1). The lowest incidence of DSI occurred among patients undergoing surgery for congenital heart disease and the highest occurred among those undergoing combined coronary artery bypass grafting (CABG) and valve surgery. All except 1 case of major bleeding complicated DSIs in patients after CABG (alone or combined with valve surgery). Once DSI had occurred, the probability of bleeding was similar in all groups of patients and unrelated to the primary procedure. Thus although CABG in any combination accounted for 87.9% of all DSIs, it also underlay 93.3% of all major hemorrhages.

The relevant information regarding these patients is summarized in Table 2. There were 11 male and 4 female patients, 49 to 80 years old (median 72 years). Thirteen patients had underlying conditions that could have contributed to the bleeding, with type 2 diabetes mellitus being the most common. The diagnosis of DSI was delayed in most cases, and removal of wires took place 7 to 35 days after the cardiac operation (median 15 days). At that time cultures from only 6 patients grew gram-positive bacteria exclusively from the sternal wound, 3 had a mixture of gram-positive and gram-negative organisms, and 6 had gram-positive bacteria only. Fourteen patients had undergone chest closure with simple wiring, and 1 had undergone closure with longitudinal figure-of-eight wiring coupled with simple transverse wiring. Complex wiring techniques were used in 5% of our patients. Bleeding originated from the right ventricle in 9 patients (involving a vein graft in 1), from a graft anastomosis in 3, from the sternal edges in 2, and from the aortic cannulation site in 1. The bleeding event took place in the operating room in 5 cases: in 2 during wire removal, in 1 during extubation, and in 2 during a reconstructive procedure. Four of these 5 patients left the operating room alive, but 1 died 24 hours later of uncontrollable arrhythmia. In the other 10 cases bleeding occurred in the intensive care unit or in the thoracic surgery unit from 2 hours to 15 days (median 2 days) after wire removal.

Two patients became exsanguinated immediately. Eight were transferred to the operating room after application of local pressure to the wound. One patient died during attempts to repair the RV, despite the use of cardiopulmonary

TABLE 2. Details of 15 patients with major bleeding

Age (y)	Sex	Year	Underlying disease(s)	Operation	Pathogen(s)	Time to exwiring (d)	Time to bleeding (d)
71	M	1994	—	CABG	MRSA, *Acinetobacter*	24	0
69	M	1995	DM, COPD	CABG	*Enterobacter, Klebsiella*	25	30*
60	M	1996	DM	CABG	*Serratia, Pseudomonas aeruginosa*	10	0
49	M	2000	CRF, dialysis	CABG and MVR	MRSA	13	2*
74	M	1994	DM	CABG and AVR	*Streptococcus*, MRSA, *Escherichia coli*	34	2
51	F	1996	DM, HpT	CABG	*P aeruginosa*	29	15
72	M	1996	—	CABG	MRSA, *Streptococcus*	15	15 min†
71	F	1997	DM, HpT	CABG	*Proteus*	11	1
73	M	1997	DM, HpT, OW	CABG	*P aeruginosa, Providentia*	15	2 h
67	M	1997	HpT, mild RF	CABG	*Streptococcus*	17	4
75	M	1999	DM, HpT	CABG	*Staphylococcus*	10	1
80	F	1995	DM, HpT	CABG	MRSA	20	4
73	F	1996	DM, HpT,	CABG	MRSA, *Enterobacter*	32	1
71	M	1998	COPD, HpT, HT	CABG	*Staphylococcus*	14	14
51	M	2000	COPD	MVR and TVR	*Acinetobacter, Citrobacter*	7	2

MRSA, Methicillin-resistant *Staphylococcus aureus*; *DM*, type 2 diabetes mellitus; *COPD*, chronic obstructive pulmonary disease; *CRF*, chronic renal failure; *MVR*, mitral valve replacement; *LITA*, left internal thoracic artery; *AVR*, aortic valve replacement; *HpT*, hypertension; *OW*, overweight; *RF*, renal failure; *S*, standby; *HT*, hypothyroidism; *TVR*, tricuspid valve repair.
*During reconstruction.
†In operating room after extubation.

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TABLE 3. Collective review of the largest series in the literature

Reference	Patients with bleeding	Bleeding rate in DSI (%)	Underlying operations	Mean time to débridement (d)	Bleeding source	Delay to bleeding	Mortality No.	Mortality %
Piwnica and colleagues,[11] 1988	6	14.6	CABG, 1; others, 5	9	RV	3 d	3	50
Cartier and associates,[3] 1993	7	14.6	CABG, 6; valve 1	25	RV	1-7 d	2	29
Arbulu and coworkers,[8] 1996	7	4.8	CABG	15	RV	Median 2d	1	14
Georgiade and coworkers,[10] 1998	7	6.1	CABG	15	RV	0.5 h–4 d	2	29
Szerafin and colleagues,[13] 1999	4	7.1	NA	20	RV	1-5 d	0	0
Current series	15	5.4	CABG, 12; valve, 2; CABG and valve, 1	18	RV, 9; sternum, 2; graft, 3; aorta, 1	0-15 d, median 2 d	7	53

NA, Not available.

bypass (CPB). Thus the immediate death rate was 26.7%. Management of the bleeding was done with complete CPB in 6 cases and with femoral cannulation and CPB standby only in 2 cases. In 4 cases CPB was not used at all. In 8 patients reconstruction was performed at the same session, and in 3 it was delayed for 2 to 5 days. Omentum was used for coverage in most cases. Four of the surviving patients never left the hospital; they died of either uncontrollable arrhythmia (1 patient) or ongoing local and general infection, pneumonia, heart failure, and multiorgan failure (3 patients). Death took place 1 to 65 days after the bleeding event. The overall mortality among patients with major bleeding complicating DSI was therefore 53.3%. Not counting the 2 cases of sternal bleeding, the mortality was 61.5%.

Three groups of patients could be categorized according to the causative mechanisms: iatrogenic, 4 patients whose bleeding occurred during surgery for wire removal or reconstruction; mechanical, 7 patients bleeding from the RV as a result of shearing forces or puncture by the sternal edges; and infectious, 4 patients in whom bleeding was probably related to erosion of vascular structures by the spreading infection. Only 1 of the 7 patients in the mechanical group survived, whereas 6 of the patients in the other two groups survived.

Hospitalizations for the surviving patients were exceedingly long (median 38 days from the bleeding, average 50 days). Six of the 7 discharged patients are still alive and have not had any sequelae related to their bleeding or DSI for periods of 36 to 81 months (mean 62.7 months) after the event.

Bleeding site	Management	CPB	Time to closure (d)	Coverage	Result	Time to result (d)	Current status
RV	Repair and pericardial patch	Y	0	Pectoralis major	Home	65	Alive at 81 mo
RV	Repair	N	0	Omentum	Home	36	Alive at 71 mo
Venous graft	Reanastomosis	Y	2	Omentum	Home	45	Alive at 66 mo
LITA anastomosis	Reanastomosis	Y	0	Omentum	Dead	1	
RV	Attempted repair	Y	—	—	Dead	0	
RV	Dead, surgical unit	—	—	—	Dead	0	
RV	Dead, operating room	—	—		Dead	0	
RV and venous graft	Repair	N	2	Omentum	Dead	32	
RV	Repair	Y	5	Omentum	Dead	110	
RV	Repair and pericardial patch	N	0	Omentum	Home	36	Alive at 49 mo
RV	Repair	N	0	Omentum	Dead	61	
Venous graft	Repair, venous patch	Y	0	Omentum	Home	20	Alive at 48 mo
Sternum	Hemostasis	S	0	Omentum and rectus abdominis	Home	38	Died at 41 mo
Sternum	Hemostasis	S	0	Pectoralis major	Home	110	Alive at 36 mo
Aortic cannulation site	Dead, surgical unit	—	—	—	Dead	0	

Since January 1998, when the policy of retaining the manubrial wires was adopted, there have been 4 major hemorrhages. Only 1 was from the RV.

Discussion

The occurrence of DSI after cardiac surgery remains a serious problem. The incidence of this infection varies from 0.5% to 4%. In a recent study from New England,[4] the rate of mediastinitis after CABG was 1.2%. The incidence for patients operated on in our hospital falls within the accepted rates. The high mortality associated with this complication has somewhat declined as a result of aggressive approaches, including radical débridement and early coverage with viable tissue flaps, but still remains in the range of 15% to 30%.[5]

Major bleeding from the heart or great vessels is a dreadful complication of DSI. The first case, reported in 1976 by Macmanus and Okies,[6] was followed by many case reports or small series.[2,3,7-14] RV rupture is the most common source of major hemorrhage associated with DSI (mechanical group), but bleeding may also originate from the aorta, right atrium, vein grafts, and sternum (infectious group). The typical description is that of a patient who has sternal wires removed and a few hours or days later, usually during coughing or vomiting, begins to bleed profusely from the open and packed wound. Bleeding may also occur spontaneously before débridement[14] (mechanical or infectious group), and during wire removal or reconstructive attempts (iatrogenic group).

Many of the case reports stress only points of management. To achieve better insight regarding the pathogenesis, incidence, management, and prevention of this complication, we summarized previous series that contained detailed information (Table 3). The 46 cases encountered represent a 6.56% rate of major bleeding among patients with DSI. The incidence of DSI in these series was 0.5% to 2.13%. Thirty-three cases (73%) occurred after CABG. Most of the DSIs were delayed, with a mean of 17.4 days (range 6-30 days) to débridement. The RV was the most common source of bleeding (41 cases), with most bleeding occurring within 5 days after wire removal (range 15 minutes to 15 days). Most bleedings occurred in the intensive care unit or in the thoracic surgery unit. Surviving patients were managed with manual pressure and transferred to the operating room. In about half of the cases CPB was used, but its impact on survival is difficult to evaluate. Various techniques were used to close and buttress the bleeding site. The wound was closed with tissue flaps immediately, or after a delay of a few days. Again, the techniques used and the timing of reconstruction are so variable that it is impossible to determine their significance. The mortality associated with this dreadful event remains high, 33% overall. One may speculate that many additional fatal cases have never been reported.

We agree with others that the main cause of bleeding, and certainly of RV rupture, is adherence of the sternal edges to the anterior heart surface, caused by the relatively long period from cardiac surgery to diagnosis of DSI and

wire removal. Thus most patients belong to the mechanical group, with infection being a contributing factor. In addition infection may spread to involve the epicardium, cannulation sites, and anastomoses. In this infectious group, mechanical forces play only a minor role if any.

It has not been clear from previous reports why most cases occur after CABG, and several theories have emerged to explain this. Conversely, this association may merely represent the popularity of CABG and the fact that this operation is associated with a higher incidence of DSI than are other cardiac operations. The higher occurrence after CABG thus may simply represent this higher risk of infection. From our own material, it clearly emerged that although the incidences of DSI were different for the various cardiac operations, the incidences of bleeding were similar once DSI had occurred. CABG alone or combined with valve surgery accounted for 87.9% of all DSIs and for 93.3% of all major hemorrhages.

Although rare, major bleeding associated with DSI should always be kept in mind. With a DSI incidence of 0.5% and bleeding incidence of 5%, DSI-associated hemorrhage might occur in 0.025% of patients undergoing cardiac surgery, and with a DSI incidence of 4% and bleeding rate of 14.6%, it might occur in 0.58% of all patients. Prevention of this complication is therefore a major task. Certainly lowering the rate of DSI is mandatory. When DSI occurs, wire removal and débridement should be undertaken as early as possible. This procedure should always be done in the operating room with general anesthesia and CPB capability, and not as a bedside procedure. Meticulous techniques may prevent most of the iatrogenic cases, and the appropriate operating room setting would aid successful management of those that do occur. It is interesting to note that only 1 case of bleeding (delayed) was associated with a complex wiring technique. Thus in our experience a closure technique other than simple wiring did not predispose the patient toward bleeding associated with DSI. One may consider leaving the manubrial wires in place, as we have practiced for the last 4 years. Although the incidence of bleeding has not dropped considerably in our experience, RV rupture has almost disappeared. Alternatively, the undersurface of the sternum could be freed completely from the heart and grafts. Both maneuvers could help to lower the incidence of mechanical causes (RV rupture). Whether to reconstruct the gap immediately with tissue flaps is a dilemma. This may prevent bleeding and hasten recovery, thus lowering the rate of bleeding in the infectious group, but on the other hand it may allow ongoing sternal infection, necessitating additional operations in the future. We are now changing our policy to immediate reconstruction whenever the infection is not overwhelming and the patient is in stable condition. Repairs should preferably avoid foreign material. The best method of reconstruction has yet to be determined. We prefer omentum, but it seems that muscle flaps are as effective.

In conclusion, major bleeding associated with DSI after cardiac surgery is not very rare. The best means of management are preventive measures. Treatment consists of surgical repair with or without CPB. Final sternal reconstruction may be done immediately or delayed for a few days.

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