

Re-exploration for bleeding or tamponade after cardiac operation

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Abstract

The aim of this study was to determine the outcome of patients who had a chest re-sternotomy and to identify risk factors for higher in-hospital mortality after re-exploration for bleeding and/or tamponade after cardiac operations. We present our experience of an acceptably low re-exploration rate after cardiac surgery, and the outcomes of those re-explored. This was a retrospective analysis of medical records of all patients who had a chest re-exploration for the control of bleeding and cardiac tamponade over a 7-year period (2000–06), at the Cardiothoracic Centre of the Hospital České Budějovice, Czech Republic. Between 2000 and 2006, 152 patients (3.4% of the total heart operations) underwent re-exploration after heart surgery. One hundred and seven (70.4%) were re-explored for bleeding, 36 (23.7%) for possible tamponade and nine (5.9%) for both. An identifiable source of bleeding was found in 72.4% patients. Risk factors associated with higher in-hospital mortality after re-exploration for bleeding and tamponade include delayed re-sternotomy, higher levels of lactate and lower levels of haematocrit before revision and other well-known risk factors such as older age, more complex cardiac procedures, redo operations, longer cardiopulmonary bypass, renal failure and diabetes mellitus. Patients who need re-exploration are at a higher risk of complications, morbidity and mortality if the time until re-exploration is prolonged.

Keywords: Haemorrhage • Cardiac surgical procedures • Cardiac tamponade • Surgical revision

INTRODUCTION

Postoperative cardiac surgical bleeding is still a problematic complication, particularly in cases of complex cardiac surgical procedures. It may cause haemodynamic instability and necessitate aggressive therapy. Re-exploration for bleeding and/or tamponade significantly affects in-hospital mortality and the length of stay in the intensive care unit (ICU).

This study was performed to examine the significance, incidence, cause and outcome of early or delayed re-exploration for excessive bleeding and/or tamponade after a cardiac operation in our unit. Additionally, we sought to identify patients at high risk of perioperative bleeding and re-exploration.

PATIENTS AND METHODS

Between May 2000 and May 2006, 4493 open-heart operations were performed at the Cardiothoracic Centre in České Budějovice, Czech Republic, including routine coronary surgery (on-pump and off-pump) and valve procedures, complex aortic procedures and reoperations except cardiac transplantations. One hundred and fifty-two patients (3.4% of the total heart operations) underwent re-exploration for excessive bleeding or clinical suspicion and echo diagnosis of cardiac tamponade. Demographic data, operation characteristics, indication for re-exploration, blood loss, timing and findings at re-sternotomy were recorded. The patients who needed re-exploration for the

control of bleeding and cardiac tamponade were divided into two groups: patients who died and patients who survived. We also recorded the clinical outcome of patients, the length of stay in the ICU and survival rates. Follow-up period was during the hospitalization in our ward and it was the same for both groups. The loading dose of sodium heparin (Heparin, Zentiva, Czech Republic) prior to cardiopulmonary bypass was 3 mg/kg. During bypass, anticoagulation was adjusted to maintain the activated clotting time at >480 s. The protamine dose was based on the initial heparin concentration. Sodium heparin was reversed after decannulation with protamine hydrochloride (Protamine, ICN Switzerland AG, Biersfelden, Switzerland).

The decision to perform re-sternotomy was made by the surgeon responsible and was based on conventional guidelines: the amount of blood loss—we adhered to Barratt-Boyes criteria for re-exploration (Table 1)—haemodynamic status of the patient, laboratory parameters and findings on transoesophageal echocardiography examinations. All patients were in sinus rhythm except one who was reopened for tamponade at the 32nd day after primary surgery and had cardiac arrest. The suspicion of the tamponade was made on the basis of rapid haemodynamic deterioration of the patients (increase of central venous pressure, decrease of arterial blood pressure, tachycardia) with an increase of inotropic support and was confirmed by echocardiographic examination. Emergency re-sternotomy was performed in haemodynamically unstable patients and was performed in the ICU. Urgent re-sternotomy was performed in haemodynamically stable patients who were transported to the operating theatre. The volume of bleeding in the postoperative period was

Table 1: Kirklin and Barratt-Boyes criteria for re-exploration for bleeding

1. Drainage of:
 - More than 500 ml during the first hour
 - More than 400 ml during each of the first 2 h
 - More than 300 ml during each of the first 3 h
 - More than 1000 ml in total during the first 4 h
 - More than 1200 ml in total during the first 5 h
2. Excessive bleeding that restarts (indicating a possible surgical cause)
3. Sudden massive bleeding

Table 2: Characteristics of primary heart operation in all patients

Characteristics	Total (n = 4493)	Revision (n = 152)
Urgency of operation		
Elective	3329 (74.1%)	84 (55.2%)
Urgent	858 (19.1%)	42 (27.3%)
Emergency	265 (5.9%)	23 (15.7%)
Unknown	41 (0.9%)	3 (1.8%)
Type of operation		
CABG	2824 (62.8%)	59 (38.8%)
Valve operation	598 (13.3%)	56 (36.8%)
CABG + valve	484 (10.4%)	25 (16.4%)
Other	587 (13.1%)	12 (7.9%)

calculated through the sum of losses through all thoracic drains from the time of chest closure until the decision to perform re-sternotomy on the patient because of excessive bleeding or sudden massive bleeding and was based on the Kirklin and Barratt-Boyes criteria (Table 1).

Statistical methods

Descriptive data are given as mean \pm standard deviation and comparisons between continuous variables were performed with Student's *t*-test and Mann-Whitney tests. In all cases, a *P*-value of 0.05 or less was considered to be significant.

RESULTS

In our institute, we conducted 3329 elective procedures, representing 74.1% of all patients. 2824 (62.8%) patients underwent coronary artery bypass graft surgery (CABG), 598 (13.3%) valve surgery, 484 (10.8%) underwent combined (CABG + valve surgery) procedures. 74.1% of the original operations were done electively, 19.1% were done urgently, 5.9% as emergency. (The characteristics of the heart operations are shown in Tables 2 and 3.) One hundred and fifty-two patients underwent re-sternotomy for the control of bleeding and/or cardiac tamponade. This was equivalent to 3.4% of the total cardiac open-heart operations. (The demographic data are shown in Table 4.) One hundred and seven (70.4%) of the reopened patients were male and forty-five

Table 3: Characteristics of primary heart operation in re-sternotomy patients

Characteristics	Survived (n = 95)	Died (n = 57)
Type of operation		
CABG	49 (51.6%)	10 (17.5%)
Valve operation	32 (33.7%)	24 (42.1%)
CABG+valve	10 (10.5%)	15 (26.3%)
Other Total	4 (4.2%)	8 (14.1%)
Reoperation	6 (6.3%)	9 (15.8%)

Table 4: Demographic data of re-sternotomy patients

Characteristics	Total	Survived	Died	<i>P</i> -value
Number of patients	152	95 (62.5%)	57 (37.5%)	<0.001
Number of male patients	107 (70.4%)	76 (80%)	31 (54.4%)	0.003
Age (median)	70	64.9	70.3	0.003
BMI	27.3	27.8	26.6	NS
Diabetes mellitus	39 (25.6%)	20 (21.05%)	19 (33.3%)	<0.001
Hypertension	116 (76.3%)	73 (76.8%)	43 (75.4%)	NS
Renal failure	36 (23.7%)	17 (17.9%)	19 (33.3%)	<0.001

(29.6%) were female. The age of the patients ranged from 26 to 85 years (median 70). Specifically, the deceased re-sternotomy patients were older—70.3 vs. 64.9 years ($P = 0.003$), underwent a higher percentage of procedures other than isolated CABG and contained more patients undergoing a reoperation. 15.8% of the re-sternotomy patients who died had undergone redo cardiac procedures, compared with 6.3% in the surviving group of patients ($P < 0.001$). Additional differences included a higher prevalence of female gender ($P = 0.003$), diabetes mellitus ($P < 0.001$) and chronic renal insufficiency ($P < 0.001$). Also, deceased patients after re-sternotomy had a longer cardiopulmonary bypass time (75 vs. 122 min.) and aortic cross-clamp time (44 vs. 86 min) during the primary cardiac operation. One hundred and seven patients (70.4%) were re-explored for bleeding, 36 (23.7%) because there was a clinical suspicion and echo diagnosis of cardiac tamponade and 9 (5.9%) for both. The median blood loss before re-sternotomy was 1190 ml in surviving patients and 1440 ml in patients who died (statistically not significant). Before being returned to the operating room, all re-sternotomy patients received blood units and other haemostatic therapy (frozen plasma, thrombocytes and others). Surviving patients received a median of 8 units of blood, and those who did not survive received a median of 11 units of blood. The mean consumption of units of blood was significantly higher in re-sternotomy patients, 27.5 units, compared with 5 units of blood in patients who did not undergo re-exploration. The median time to re-exploration was 300 min in surviving patients, but 780 min in those who died ($P < 0.001$). (The distribution of the timing of re-exploration is shown Fig. 1.) 78% of surviving patients were reopened up to 12 h after their primary operation. 21% of surviving patients were reopened after 12 h. The re-exploration of

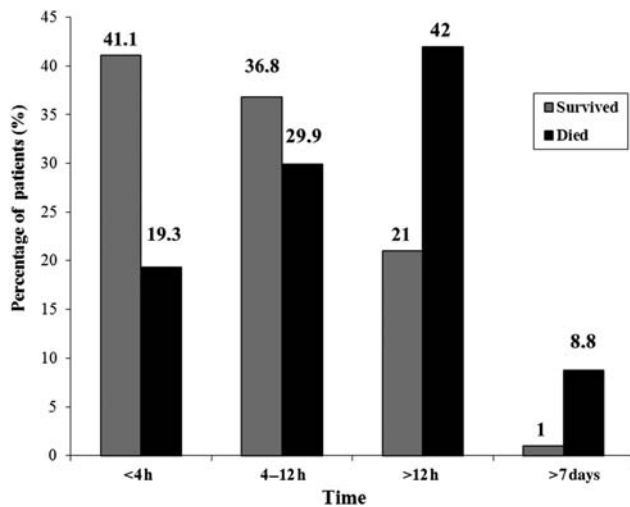


Figure 1: Timing of re-exploration.

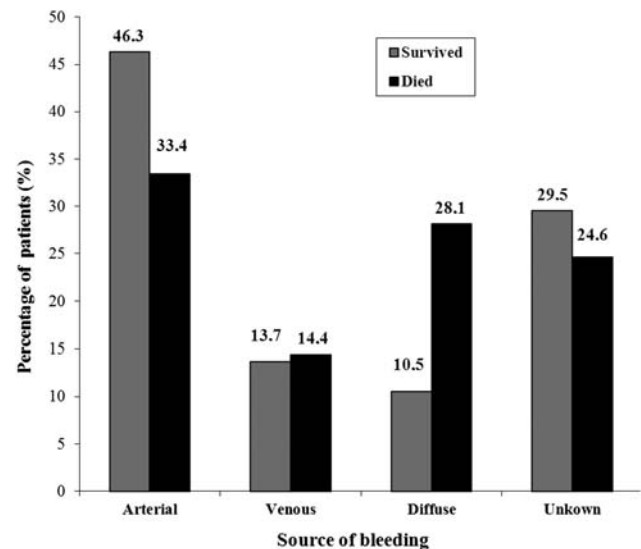


Figure 2: Findings at re-exploration.

Table 5: Characteristics before re-exploration

	Survived	Died	P-value
Time to re-exploration (min)	300	780	<0.001
Blood loss before re-exploration (ml)	1261	1598	0.005
Total blood loss (ml)	3125	3740	0.005
Haematocrit	27.2	24.7	0.001
Lactate	2.68	6.65	<0.001
ECC (min)	80	126	<0.001

the patients was delayed after seven days in 1% of surviving patients. The largest number of surviving patients (41%) were re-explored within 4 h of arrival from the operating room.

The time to re-exploration was significantly prolonged in patients who died. 42% of patients who later died were reopened up to 12 h following initial surgery and 9% of deceased patients were reopened after seven days, as late tamponade was diagnosed. Only 19% of deceased patients were re-explored within 4 h of arrival from the operating room. We also found that, in the deceased group of patients, there were higher levels of lactate and lower levels of haematocrit before re-exploration (Table 5). On the basis of the surgeon's description, the findings at re-exploration were defined as focal bleeding—artery, venous, diffuse general ooze—or the source of bleeding was not located. An identifiable, surgical source of bleeding was found in 72.4% of all patients. Of the 95 surviving patients, 57 (60%) were found to have focal surgical bleeding, 10 (10.5%) were found to have diffuse bleeding, 28 (29.5%) did not have an identifiable source of bleeding (Fig. 2). There was an increased rate of diffuse bleeding—28.1% of patients died.

Also, we evaluated the association between the risk of bleeding and anticoagulation and antiaggregation therapy before the surgery and early after procedures. 54.8% of these patients were either anticoagulated before their operation or had received aspirin up to the time of their operation, compared with 47.5% of patients who were not re-explored. 22.9% of resternotomy patients received aspirin (100 mg per day) in comparison with

26.5% of patients who were not re-explored (statistically not significant). Antiplatelet treatment was discontinued seven days before elective surgery. 31.9% of resternotomy patients were anticoagulated with nadroparinum calcium (Fraxiparin, Glaxo Group Ltd, Greenford, Middlesex, UK) compared with 21% of patients who were not re-explored ($P < 0.05$).

Our results indicate that antiaggregation treatment before operation was not related to an increased postoperative risk of re-exploration and mortality (22.9% resternotomy patients vs. 26.5% in non-resternotomy patients). Anticoagulation treatment before an operation increased the risk of resternotomy (31.9 vs. 21%) and mortality (35 vs. 30%).

One hundred and seven patients (70.4%) had their chest primarily closed and 45 (29.6%) were packed with swabs; the sternum was left open for 1–2 days, because of coagulopathy and diffuse general ooze, and only the skin closed. Fifty-seven (37.5%) of the resternotomy patients died. The length of stay in the ICU of patients who died was longer, 8 days compared with 5 days in surviving patients. The median length of stay in hospital in surviving patients was 11 days (range 6–94 days) and the median length of stay in the ICU was 5 days (2–73). The median length of stay in hospital in deceased patients was 10 days (2–70) and the median length of stay in the ICU was 8 days (2–70). There was no significant difference between hospital stays in both groups of patients.

DISCUSSION

Excessive or continuous bleeding after cardiac operations remains a major source of morbidity and death risk for patients [1]. Postoperative haemorrhage leading to mediastinal re-exploration significantly affects in-hospital mortality and the length of stay [2]. Patients requiring resternotomy are at greater risk from the hazards of transfusion reactions [3], viral infections, suppression of the immune system [4] and surgical reinterventions for haemostasis complications [4]. Surgical re-exploration for haemostasis is necessary in those patients with sudden massive or persistent bleeding that cannot be explained by coagulation

disorders [4, 5]. Mediastinal bleeding in heart surgery is multifactorial [2, 4]. Perioperative bleeding is related to surgical damage to blood vessels and defects in haemostatic mechanisms. The majority of haemostatic defects are related to the exposure of blood elements to the cardiopulmonary bypass circuit [2, 4]. Excessive administration of protamine is a proposed mechanism of bleeding [2]. It has been proved that CBP causes a reduction in the levels of coagulation factors, stimulates fibrinolysis and induces thrombocytopenia and platelet dysfunction [4]. The effects of circulating heparin and protamine must be considered [4]. Heparin rebound may be associated with postoperative bleeding [2]. The mechanism of the reappearance of heparin is the differential elimination of protamine vs. heparin [2]. On the basis of our results, we considered that patients undergoing valve procedures were more likely to undergo re-sternotomy (40.1%) for bleeding than patients undergoing coronary grafting (35.5%). We expect the influence of early postoperative use of warfarin—a vitamin K antagonist (warfarin, Orion Corporation, Espoo, Finland)—and Fraxiparin to cause early bleeding. On the basis of our experience, our current management in patients after aortic valve replacement with bioprosthesis is using a 100 mg aspirin per day (acidum acetylsalicylicum, Zentiva, Slovak Republic) per os from the first postoperative day without higher risks of valve-related complications or valve thrombosis.

CONCLUSION

In this paper, we presented our institutional experience of an acceptably low rate of re-exploration for bleeding/tamponade after cardiac surgery (3.4% of all procedures—this was equivalent to that reported previously by others) [1].

We think that the most important message of our paper is that a delay in re-exploration >12 h is associated with a worse clinical outcome and an increase in mortality. We think that the high mortality which we observed after re-sternotomy (37.5%) could be associated with more severe preoperative status of the patients, with higher rates of comorbidities, higher proportions of patients with more complex procedures and reoperations with longer cardiopulmonary bypass times and, last but not least, with delayed revision.

Conflict of interest: none declared.

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eComment. Postoperative bleeding without re-exploration may increase operative mortality

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The article by Canadyova *et al.* [1] showed expected results in the area of re-exploration for bleeding in cardiac surgery, with an emphasis on the time to carry out the re-exploration for chest bleeding. Indeed, they found that a delay in re-exploration of > 12 h was associated with a worse clinical outcome and an increase in mortality. Similar results were displayed by Karthik *et al.* [2] after analysing a total of 2898 patients undergoing coronary artery bypass surgery (CABG).

In addition to the considerations just mentioned, it is generally recognized that the in-hospital mortality is higher in patients requiring re-operation for bleeding than in those who do not. A meta-analysis by Metha *et al.* [3] evaluated 528 686 CABG patients in >800 hospitals of the Society of Thoracic Surgeons National Cardiac Database. They demonstrated a 4.5-fold higher operative mortality in patients undergoing revision for postoperative bleeding. This is understandable when one considers that the circumstances surrounding this scenario often involve more blood transfusions, a hypovolemic status, and systemic hypotension with all the catastrophic consequences such as secondary organ failure, especially renal and respiratory failure. Vivacqua *et al.* [4] found a direct relationship between the greater need of blood transfusion and the elevated mortality in patients re-explored for bleeding.

Rather interesting data concerning the postoperative bleeding have been published by Christensen *et al.* [5]. Postoperative haemorrhage exceeding 200 ml/h in any single hour or part thereof, or 2 ml/kg/h for 2 consecutive hours in the first 6 hours after surgery, or > 495 ml in the first 24 hours was associated with a higher 30-day mortality and morbidity.

It is important to underline the need to heighten awareness about postoperative bleeding, which may represent an increased risk in operative morbidity and mortality even when the patient does not require re-operation for bleeding.

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eComment. Re: Re-exploration for bleeding or tamponade after cardiac operation

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I read with great interest the article by Canadyova *et al.* [1]. They showed that a delay in re-exploration >12 h was associated with a worse clinical outcome and that the high mortality observed after re-sternotomy (37.5%) could be associated with a more severe preoperative status of the patients, with higher rates of comorbidities, higher proportions of patients with more complex procedures and