Case Report

Efficacy of a Heparin-Coated Closed Circuit for Intractable Bleeding in Adult Cardiac Surgery

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Hemostatic procedures and control of blood pressure concomitant with rapid transfusion of blood products aimed at recovery of coagulability are necessary for intractable bleeding during cardiac surgery. However, when the bleeding is massive and hemostasis is prolonged for several hours, operative maneuvers such as manual compression of the heart can affect hemodynamics, decrease cardiac output, and elevate atrial and venous pressure, with consequent hepatic, renal, and pulmonary dysfunction over time. Herein we present three cases of potentially fatal bleeding during open-heart surgery, in which we used a heparin-coated closed circuit for circulatory support after standard cardiopulmonary bypass. We achieved stable hemodynamics following surgical hemostatic maneuvers and avoided the postoperative multiple organ failure by using a cardiopulmonary support system. (Ann Thorac Cardiovasc Surg 2010; 16: 131–133)

Key words: cardiac surgery, hemostasis, percutaneous cardiopulmonary support, closed circuit

Introduction

The femoro-femoral cardiopulmonary support (CPS) system is useful for maintaining systemic circulation during impaired cardiac function[1–5] when recovery is expected. Because the CPS circuit (including an artificial lung) consumes platelets and promotes bleeding, it is generally believed that hemostasis is required for introduction of CPS. However, it may be difficult to stop bleeding during open-heart surgery, and difficulty in achieving hemostasis is usually associated with severe coagulopathy resulting from prior cardiopulmonary bypass, or with tissue vulnerability because of an infarcted ventricle or thin atrial wall. Manual compression of the bleeding site on the heart is generally effective for control, but this maneuver can restrict motion of the ventricle, decrease cardiac output, and elevate the central venous pressure. Consequently, multiple organ dysfunction can occur and may occasionally be fatal. Here we report three cases (Table 1) in which a heparin-coated closed circuit was used during continual bleeding to maintain hemodynamics and prevent systemic organ damage during hemostatic procedures.

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Case Reports

Case 1

The patient was an 80-year-old male with left ventricular rupture of the blow-out type that occurred 4 days after the onset of acute myocardial infarction. Percutaneous CPS (PCPS) via the femoral vessels and intra-aortic balloon pumping (IABP) was initiated immediately in the coronary care unit, and endocardial and epicardial patch augmentation of the beating heart were then performed in emergency surgery. During attempted weaning from the cardiopulmonary bypass, we observed bleeding around the epicardial patch, probably a result of elevation of the ventricular pressure and increased tension in the ventricular wall, and we subsequently initiated a heparin-coated closed circuit.

Table 1. Patients' characteristics, procedures, and results

Patient No.	Age	Sex	Preoperative diagnosis	Initial procedure	Event during operation	Procedure under CPS system	CPS time for hemostasis (hrs)	Total CPS time (hrs)	Renal failure*	Liver dysfunction**
1	80	Male	AMI, LV rupture (anterolateral ~basal)	Endo- and epicardial patch repair	Bleeding from LV suture line	Compression on the LV	3	96	No	Yes
2	74	Female	AMI, LV rupture (inferoposterior)	Epicardial patch repair	Bleeding from LV suture line	Compression on the LV	3	72	No	No
3	78	Male	MSR AF	MVR, maze	Endocardial patch repair for LVPW laceration, bleeding from LVPW	Compression on the LV	3	3	No	No

CPS, cardiopulmonary support; AMI, acute myocardial infarction; LV, left ventricle; MSR, mitral stenosis and regurgitation; AF, atrial fibrillation; MVR, mitral valve replacement; LWPW, left ventricular posterior wall; *, requirement of hemodialysis; **, total bilirubin > 4.0 mg/dl.

Complete hemostasis with stable circulation was obtained by manual compression on the ventricle around the epicardial patch. The heparin-coated closed circuit was discontinued uneventfully on the fourth postoperative day in the intensive care unit (ICU). The patient was discharged with only a minor neurological deficit and is still alive 30 months postoperatively.

Case 2

The patient was a 74-year-old female with a diagnosis of acute myocardial infarction; she underwent emergent coronary artery bypass grafting. On the 1st postoperative day, she suffered from cardiogenic shock because of left ventricular rupture (blow-out type). Immediately we initiated a CPS circuit for maintenance of systemic hemodynamics, and we then performed rethoracotomy to do epicardial patch repair. In this operation, we applied the compression method for hemostasis, but hardly to perform hemostatic compression. We took 3 hours in hemostatic manipulations for the suture line of the left ventricle under driving CPS and 72 hours for the weaning of the CPS. Although she did not suffer from renal dysfunction or liver dysfunction, unfortunately she died as a result of mediastinitis on the 100th postoperative day.

Case 3

The patient was a 78-year-old male who underwent mitral valve replacement for rheumatic stenosis. At the end of a cardiopulmonary bypass, we discovered massive bleeding from the posterolateral wall of the left ventricle. The heart was rearrested, the implanted valve was removed, and laceration of the posterolateral wall of the ventricular wall was discovered. This was covered by augmentation of the xenopericardium through the mitral annulus with subsequent placement of a prosthetic valve, but bleeding continued from the posterior of the ventricle. The posterolateral wall of the ventricle was compressed with support of a heparin-coated circuit for several hours, hemostasis was ultimately achieved, and CPS was terminated in the operation room. The patient is alive 6 years after the operation.

Discussion

The CPS system is commonly used as a bridge for recovery of cardiac function after surgical intervention.[1–5] It is commonly utilized via the femoral artery and vein in patients with ischemic heart disease or cardiomyopathy, and it improves systemic circulation dramatically at lower central venous pressures. Unloading of the right and left ventricles is favorable for restoration of ventricular contraction, and concomitant unloading of the pulmonary circulation can contribute to the recovery of damaged lungs. Heparin-coated CPS is advantageous in terms of biocompatibility. Experimental and clinical studies have shown that the use of CPS with surface-bound heparin reduces complementary activation, granulocyte activation, and inflammatory cytokines, compared with a CPS system without heparin coating.[12–14] We administered heparin,

observing activated clotting time as the index of anticoagulation and controlled activated clotting time from 150 to 180 seconds.

The CPS system is also effective after open-heart surgery. Ventricular rupture is a life-threatening complication of acute myocardial infarction, and patients presenting with cardiogenic shock will not survive without surgical treatment.[8] For patients in critical condition, such as after repair of a ventricular rupture, multiple organ failure (especially liver and renal dysfunction) may initiate and progress during surgery and can be fatal in the ICU. Several studies have shown that elevated central venous pressure is a significant predictor of postoperative multiple organ failure and is associated significantly with early mortality, especially in elderly patients.[10,11]

The CPS system usually requires concomitant infusion of heparin and impairs coagulability by decreasing platelet counts; therefore massive bleeding is generally considered as a contraindication for CPS. However, for a limited number of patients with massive bleeding, we believe that the CPS system is unquestionably helpful because it allows control of the arterial and ventricular pressures, decreases the wall tension of the left ventricle, and enables effective manual compression of the heart under stable circulation. As a result, a hemostatic state can be achieved, and systemic organ damage is minimized. However, CPS is very likely to be contraindicated in cases with significantly reduced ventricular contraction, since thrombus formation may occur in the pulmonary vessels or left atrium, and successful weaning from the CPS system would not be expected in such cases. Therefore we consider that hemostasis with use of the CPS system is applicable in patients with relatively good ventricular function complicated by intractable bleeding from the ventricular wall, cardiac vein, atrium, and pulmonary vessels.

We conclude that the CPS system is useful and effective for the avoidance of fatal organ dysfunction in patients with massive bleeding after open-heart surgery, especially when the ventricular contraction is relatively good.

References

1. Murashita T, Eya K, Miyatake T, Kamikubo Y, Shiiya N, et al. Outcome of the perioperative use of percutaneous cardiopulmonary support for adult cardiac surgery: factors affecting hospital mortality. *Artif Organs* 2004; **28**: 189–95.
2. Sasaki S, Yasuda K, Matsui Y, Aoi K, Gando S, et al. Therapeutic strategy of perioperative use of percutaneous cardiopulmonary bypass support (PCPS) for adult cardiac surgery. *Jpn J Thorac Cardiovasc Surg* 1999; **47**: 20–6.
3. Mitsui N, Koyama T, Marui A, Mochizuki T, Hayashi Y. Experience with emergency cardiac surgery following institution of percutaneous cardiopulmonary support. *Artif Organs* 1999; **23**: 496–9.
4. Orime Y, Shiono M, Hata H, Yagi S, Tsukamoto S, et al. Clinical experiences of percutaneous cardiopulmonary support: its effectiveness and limit. *Artif Organs* 1998; **22**: 498–501.
5. Hayashi Y, Ohtake S, Sawa Y, Nishimura M, Ichikawa H, et al. Percutaneous cardiopulmonary support with heparin-coated circuits in postcardiotomy cardiogenic shock. Efficacy and comparison with left heart bypass. *Jpn J Thorac Cardiovasc Surg* 2000; **48**: 274–9.
6. Padró JM, Mesa JM, Silvestre J, Larrea JL, Caralps JM, et al. Subacute cardiac rupture: repair with a sutureless technique. *Ann Thorac Surg* 1993; **55**: 20–4.
7. Masaki M, Arakawa K, Yamagishi T, Tahara T, Miyazaki K, et al. Oozing-type of left ventricular rupture treated under percutaneous cardiopulmonary support without surgical repair. *Circ J* 2002; **66**: 769–72.
8. Cohn LH. Surgical management of acute and chronic mechanical complication due to myocardial infarction. *Am Heart J* 1981; **102** (6 Pt 1): 1049–60.
9. Yamashita C, Ataka K, Azami T, Nakagiri K, Wakiyama H, et al. Usefulness of postoperative percutaneous cardiopulmonary support using a centrifugal pump: retrospective analysis of complications. *Artif Organs* 1999; **23**: 360–5.
10. Rady MY, Ryan T, Starr NJ. Perioperative determinants of morbidity and mortality in elderly patients undergoing cardiac surgery. *Crit Care Med* 1998; **26**: 225–35.
11. Lindholm L, Westerberg M, Bengtsson A, Ekroth R, Jensen E, et al. A closed perfusion system with heparin coating and centrifugal pump improves cardiopulmonary bypass biocompatibility in elderly patients. *Ann Thorac Surg* 2004; **78**: 2131–8.
12. Weiler JM, Edens RE, Linhardt RJ, Kapelanski DP. Heparin and modified heparin inhibit complement activation in vitro. *J Immunol* 1992; **148**: 3210–5.
13. Ovrum E, Mollnes TE, Fosse E, Holen EA, Tangen G, et al. High and low heparin dose with heparin-coated cardiopulmonary bypass: activation of complement and granulocytes. *Ann Thorac Surg* 1995; **60**: 1755–61.
14. Steinberg BM, Grossi EA, Achwartz DS, McLoughlin DE, Aguinaga M, et al. Heparin bonding of bypass circuits reduces cytokine release during cardiopulmonary bypass. *Ann Thorac Surg* 1995; **60**: 525–9.