Mechanical Bleeding Complications During Heart Surgery

Arthur C. Beall, Jr., M.D., Kenneth L. Mattox, M.D.,
Mary Martin, R.N., C.C.P., Bonnie Cromack, C.C.P.,
and Gary Cornelius, C.C.P.*

Potential for mechanical bleeding complications is present in all forms of heart surgery, both closed and open. Successful management of such complications often is accompanied best by the rapid institution, or re-institution, of cardiopulmonary bypass, and in some instances it cannot be accomplished without the use of cardiopulmonary bypass. Therefore, the extracorporeal perfusion technologist should be familiar with these complications and with technics required for their management.

CLOSED CARDIAC OPERATIONS

Although the majority of heart operations performed today are done under direct visions during a period of temporary cardiopulmonary bypass, a closed procedure may be elected in certain instances. When such a procedure is performed, however, immediate availability of cardiopulmonary bypass is mandatory for the successful management of the occasional untoward event. One such occurrence is the accidental cutting of the base of the pulmonary artery during closed pulmonary valvulotomy with the Himmelstein valvulatome.

This valvulatome is inserted through a pursestring suture in the right ventricle and cuts a small sliver out of the stenotic valve, one cut usually being made on either side of the valve. If an attempt is made to carry the cut all the way to the valve anulus, however, the wall of the pulmonary artery occasionally is included in the cut, resulting in massive hemorrhage (Fig. 1). Efforts to suture this area with pressure within the pulmonary artery usually result in further tearing and blood loss, and injury to the left coronary artery easily may occur. Therefore, bleeding from such a cut in the base of the pulmonary artery should be controlled temporarily by direct finger pressure while the pump oxygenator is set-up and cardiopulmonary bypass instituted, following which definitive suture is accomplished (Fig. 1).

A number of surgeons still employ closed mitral commissurotomy using the transventricular dilator in selected cases of pure mitral stenosis with minimal or no calcification and no history of systemic embolization. Again, this is acceptable only if a pump oxygenator is available immediately, primarily so that valve replacement can be performed should significant valve insufficiency result from commissurotomy. Additionally, however, due to the high left atrial pressure in such a patient, the left atrial appendage used for finger entry is quite friable and tears may occur. Such a tear is difficult to manage, especially when it occurs in the region of the circumflex coronary artery. Usually, hemorrhage can be controlled by the finger within the atrium while the tear is sutured in a dry field (Fig. 2), but if this cannot be accomplished readily, cardiopulmonary bypass should be instituted and repair carried out while the pressure within the left atrium is relieved.

*From the Cora and Webb Mading Department of Surgery, Baylor College of Medicine, Houston, Texas.

**Supported in part by the U.S. Public Health Service (HL-17269).

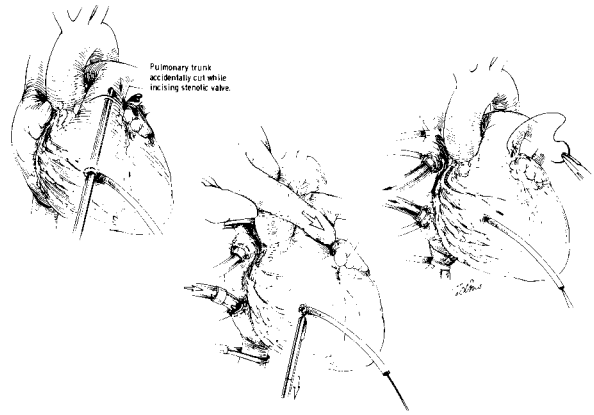

Figure 1. Drawings illustrating cut in base of pulmonary artery during closed pulmonary valvulotomy with Himmelstein valvulatome, temporary control of hemorrhage by direct finger pressure while cardiopulmonary bypass is instituted, and definitive repair.

Fig. 2

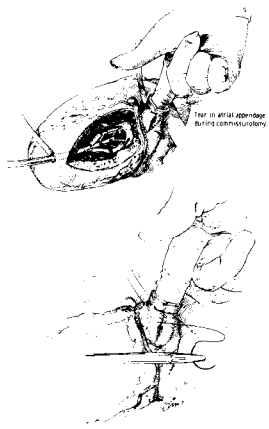

Fig. 3

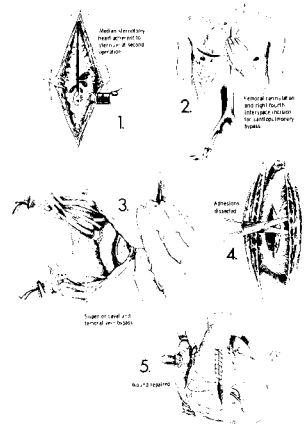

Figure 2. Drawings illustrating tear in left atrial appendage during closed mitral commissurotomy and technic of control by finger within atrium. If repair then is not possible due to friability of atrium, cardiopulmonary bypass is used to allow repair with atrial pressure relieved.

Figure 3. Drawings illustrating injury to right ventricle during median sternotomy for re-operation and technic of management (1) iatrogenic right ventriculotomy, (2) manual control of hemorrhage, cannulation of femoral vein and artery for partial cardiopulmonary bypass, and right anterolateral thoracotomy, (3) superior vena caval cannulation and conversion to total cardiopulmonary bypass, (4) heart freed from undersurface of sternum, and (5) right ventriculotomy repaired and planned re-operation performed.

OPEN CARDIAC OPERATIONS

As clinical open heart surgery enters its third decade, necessity for re-operation is occurring with increasing frequency, due not only to complications of original procedures and implanted devices, but also to the subsequent development of additional cardiac or coronary lesions. Occasionally, the anterior surface of the heart becomes densely adherent to the undersurface of the sternum as a result of the original operation. When this occurs, and despite the utmost care, the right ventricle may be entered as the sternum is divided, whether by Stryker saw, Sarnes saw, or Lebsche knife (Fig. 3-1). Subsequent attempts to separate the sternal edges are associated with massive blood loss, as the right ventricular myocardial edges also are separated. Hemorrhage should be controlled or diminished temporarily by mechanically approximating the sternal edges while the pump oxygenator rapidly is

set up and primed, if this has not been accomplished already. Once the patient is heparinized, lost blood can be collected in the cardiotomy reservoir and returned to the patient, as soon as the femoral vein and artery are cannulated and partial cardiopulmonary bypass instituted (Fig. 3-2). Next, a small, right, anterolateral thoracotomy incision is made, the superior vena cava is cannulated, and tourniquets are placed on both cavae for conversion to total cardiopulmonary bypass (Fig. 3-3). Coronary sinus return then easily is collected in the cardiotomy reservoir while adhesions are divided, freeing the heart from the sternum (Fig. 3-4). Finally, the iatrogenic right ventriculotomy is repaired (Fig. 3-5), and the planned re-operation is performed.

Mechanical bleeding problems also may occur during venous cannulation for cardiopulmonary bypass, especially in patients with high right atrial pressure and those undergoing re-operation. Since the patient already is heparinized, should such a tear occur (Fig. 4) lost blood immediately can be collected in the cardiotomy reservoir and returned to the patient as soon as the aorta or femoral artery are cannulated, if this has not already been done. Venous cannulation then is completed, total cardiopulmonary bypass is instituted relieving pressure within the right atrium, and the tear easily is repaired (Fig. 4). Should such tears occur during venous decannulation, lost blood still can be collected in the cardiotomy reservoir and returned via the arterial line, which is removed last.

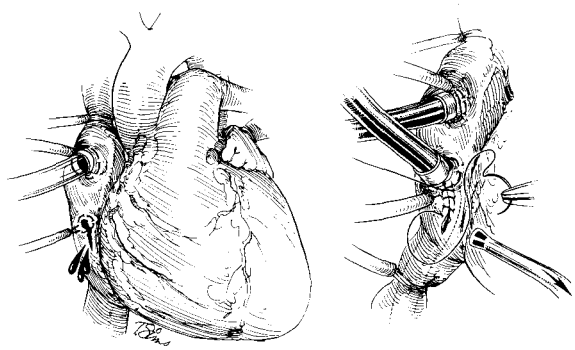

Figure 4. Drawings illustrating tear in right atrium during venous cannulation and technic of completing cannulation, institution of total cardiopulmonary bypass and definitive repair.

Tears in the aorta during decannulation may create somewhat more of a problem, but if neutralization of heparinization is delayed this lost blood also can be collected in the cardiotomy reservoir and returned to the patient via a standard, intravenous infusion line. Aortic hemorrhage then is controlled primarily by direct finger pressure (Fig. 5). Repair is accomplished either by excluding the tear with a partial occluding clamp and suture or by passing sutures beneath the tamponading finger and tying them as the finger is withdrawn (Fig. 5).

It is not the purpose of this report to discuss the mechanical bleeding problems that may occur during the period of cardiopulmonary bypass, as these should not constitute a problem and can be controlled before bypass is discontinued and the patient decannulated. Certain events may occur during bypass, however, that do not manifest themselves until after decannulation, when massive hemorrhage occurs. One such complication is umbilication of the left ventricular myocardium while excising a diseased mitral valve (Fig. 6). Although this can be prevented by exercising care to cut only the tip of the papillary muscle, should this complication occur bleeding often does not manifest itself until after decannulation and return of nor-

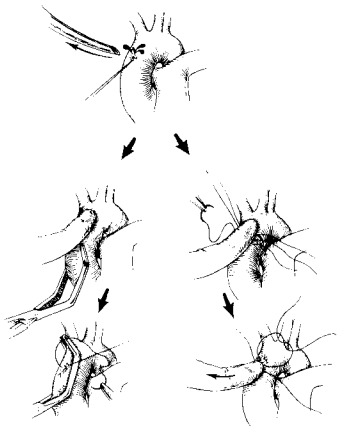

Figure 5. Drawings illustrating tear in aorta decannulation controlled temporarily by direct finger pressure and either tear excluded with partial occluding clamp during suture or sutures passed beneath tamponading finger and tied as finger withdrawn.

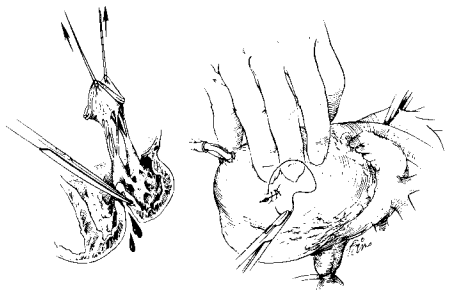

Fig. 6

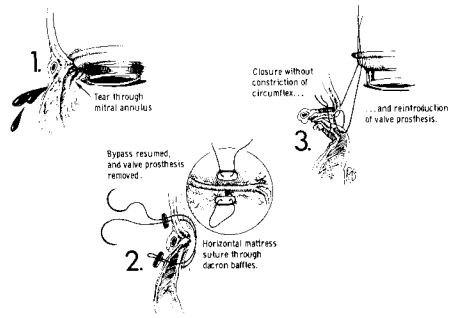

Fig. 7

Figure 6. Drawings illustrating umbilication of left ventricle during excision of mitral valve and suture without tension during cardiopulmonary bypass.

Figure 7. Drawings illustrating tear in left ventricular myocardium beneath circumflex coronary artery during mitral valve replacement and technic of repair: (1) tear on ventricular side of mitral valve prosthesis, (2) re-institution of cardiopulmonary bypass, left atrium re-entered and mitral prosthesis removed, horizontal mattress sutures passed beneath circumflex coronary artery and tied over baffles, and (3) mitral prosthesis re-introduced.

mal ventricular pressure, which results in further tearing. Not only may rotation of the heart necessary for repair result in ventricular fibrillation, but efforts to suture the left ventricular myocardium with normal pressure in the chamber also may result in further tearing and blood loss.

Temporary control of bleeding from such a tear can be accomplished by direct finger pressure. Total cardiopulmonary bypass then should be re-instituted, even if it means completely re-setting up the pump oxygenator and re-heparinizing the patient. Repair then is facilitated by decompressing the left ventricle and employing usual technics for closure of a left ventriculotomy (Fig. 6).

Even more difficult to control after mitral valve replacement is tearing of the left ventricle at the annulus in the region of the mural leaflet. This probably is brought about by loss of annular substance during excision of the diseased valve, and hemorrhage invariably is delayed until after decannulation and neutralization of heparin, when return of normal pressure in the left ventricle associated with sutures in this area result in a tear. This type of tear is particularly treacherous, because it occurs beneath the circumflex coronary artery, which may be occluded by sutures placed during attempted repair (Figure 7-1).

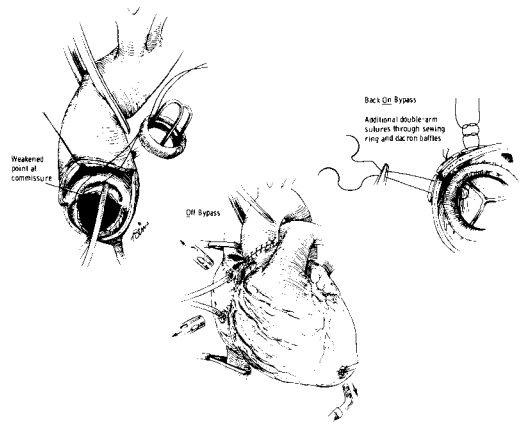

Figure 8. Drawings illustrating tear in weakened area of aortic wall during aortic valve replacement, re-institution of cardiopulmonary bypass, and repair with horizontal mattress sutures using sewing ring of prosthesis as baffle on inside and Dacron baffles on outside of aortic wall.

Again, hemorrhage must be controlled temporarily by direct finger pressure while total cardiopulmonary bypass is re-instituted. The left atriotomy then is reopened. Since the tear is on the ventricular side of the mitral prosthesis, repair is almost impossible with the prosthesis in place. The most expeditious method of repair is to remove the prosthesis, pass double armed sutures through Dacron or Teflon baffles and in through the ventricular myocardium beneath the area of tear, then out through the atrium above the tear, and finally through baffles on the outside of the atrium, where the sutures are tied (Fig. 7-2). Several such horizontal mattress sutures are placed and tied, each going beneath the circumflex coronary artery without compromising it. Once repair has been accomplished, the mitral prosthesis is re-sutured in place (Fig. 7-3), and the operation is completed by closing the left atriotomy and again discontinuing cadiopulmonary bypass.

Mechanical bleeding also can occur following decannulation after aortic valve replacement. This is associated with weakening of the aortic wall at the level of the annulus in the region of the commissure between the left and the noncoronary cusps and usually is brought about by excessive debridement of calcium from this area (Fig. 8). When this is recognized during aortic valve replacement, the area should be buttressed prior to suturing the prosthetic valve in place. If it is not recognized until hemorrhage occurs after decannulation, when normal pressure returns to the root of the aorta, attempts should not be made to place sutures in this area without re-instituting cardiopulmonary bypass. Not only will sutures placed in this area under tension from aortic pressure result in further tearing, but the aortic valve prosthesis itself will tend to hold the tear open.

Bleeding is controlled temporarily by direct finger pressure while the pump oxygenator is set-up again and cardiopulmonary bypass re-instituted. The aortotomy is re-opened, and double armed sutures are passed from inside out through the sewing ring of the prosthetic valve, using the sewing ring as a baffle on the inside of the aorta. These sutures are passed through baffles on the outside of the arota and tied, completely encompassing the area of tear (Fig. 8). Once all of these sutures are in place and tied, the aortotomy is closed and cardiopulmonary bypass again discontinued.

DISCUSSION

Certain principles are involved in the management of mechanical bleeding complications during heart surgery. The first of these is that in this day and age even closed heart surgery should not be done without the immediate availability of a pump oxygenator and an experienced extracorporeal perfusion technologist. Many bleeding complications of closed heart surgery may result in death of the patient unless cardiopulmonary bypass can be instituted rapidly.

Second, primary control of hemorrhage, even that associated with heart surgery, is by manual pressure, usually with a finger. This then allows time for institution of cardiopulmonary bypass, which provides the means for definitive repair. Attempts at primary repair of a torn cardiac chamber under pressure usually result in further tearing and blood loss.

Third, use of cardiopulmonary bypass and its cardiotomy reservoir allows conversion of a mechanical bleeding problem into a controlled situation where lost blood is recovered into the system. With blood loss contained and intracardiac pressure relieved, definitive repair can be accomplished in a dry field and in an unhurried manner. Furthermore, cardiopulmonary bypass provides the means for manipulating the heart into whatever position facilitates accurate repair without compromise of adjacent structures, such as the coronary arteries.

Complications such as described should occur extremely rarely with an experienced operative team. However, the technics illustrated are most helpful in a teaching environment where residents may produce these complications before the staff can prevent them. And, even in the most experienced hands, these rare bleeding complications eventually will occur if one does enough cases. Therefore, the extracorporeal perfusion technologist should be prepared for such occurence on every case if management is to be expeditious and successful.

SUMMARY

Mechanical bleeding problems can be associated with any heart operation, either open or closed. Such complication occurring during closed heart operations may require cardiopulmonary bypass for repair. When they are associated with open heart operations, they may occur before the pump oxygenator is completely prepared for bypass or after discontinuation of bypass and decannulation. Under these circumstances rapid preparation for institution or re-institution of cardiopulmonary bypass may be required. Although such complications are rare today, the extracorporeal perfusion technologist should be familiar with them and with technics for their management.