Vascular Complications

A variety of vascular complications, including arterial injury, interference with peripheral circulation, and leg ischemia, limb loss, and aortic dissection, have been associated with the use of IABP. Vascular complications are the most important side effects that are associated with the insertion and use of IABPs.

Vascular injuries from the insertion of an IABP are the third most frequent arterial injury that vascular surgeons encounter. Cardiac catheterization and coronary angioplasty are the cause for the first and second most frequent vascular injuries that require surgical intervention.[67,68] A number of factors contribute to vascular complications. These include the number of balloon catheter insertions and the number of days that the balloon catheter is in place. Complications among survivors vary, depending upon the presence of remedial complications, such as leg pain, loss of pulse, and other minor injuries which could be treated conservatively and by removal of the balloon catheter. The English language literature has a large number of reports dealing with this subject.[69–99] Most vascular complications are minor. Among these are aortic injuries (1% to 3% incidence) that in less than 30% of patients require repair.[90] Loss of distal pulse and cold leg account for 10% to 20% of complications. Complications that need surgical intervention, in addition to balloon catheter removal, include leg ischemia and major vascular injuries.

The overall incidence of vascular complications with percutaneous femoral cardiac catheterization and angioplasty, as well as circulatory assist, is approximately 1%. Skillman et al, in a study of 7,333 patients, found that 73 patients (1%) required 75 operative repairs for catheterization related vascular complications.[68] The overall inci-

The overall incidence of vascular complications with percutaneous femoral cardiac catheterization and angioplasty, as well as circulatory assist, is approximately 1%. Skillman et al, in a study of 7,333 patients, found that 73 patients (1%) required 75 operative repairs for catheterization related vascular complications.[68] The overall incidence varied according to the type of percutaneous femoral artery procedure performed: 0.6% for diagnostic heart catheterization, 0.9% for percutaneous transluminal angioplasty, 5.2% for transfemoral balloon valvuloplasty, and 11.5% for IABP insertion. The incidence of limb ischemia varies according to the method of IABP catheter insertion. Meta-analysis of a number of reports that have appeared in the literature in the past 27

Table 2
Comparison of Incidence of Severe Leg Ischemia by Various Methods of IABP Insertion*
n = 2577*

Series No.	Author	Surgical n	Surgical Leg Ischemia n(%)	Percutaneous n	Percutaneous Leg Ischemia n(%)	Permanent Injury* n
1	McEnany[2]	532	(49/9.3%)		—	2
2	Martin[15]		—	79	(10/12%)	2
3	Hauser[69]		—	106	(13/12%)	2
4	Beckman[4]	273	(16/5%)		—	1
5	Alpert[91]	79	(13/16%)		—	0
6	Harvey[16]		—	77	(12/15%)	4**
7	McCabe[14]	82	(10/12%)		—	0
8	Goldman[9]	282	(16/5%)	86	(9/10%)***	—†
9	Vignola[10]		—	69		—†
10	Pace[85]	104	(15/14%)		—	4
11	Curtis[71,89]	103	(16/15.5%)	99	(38/38%)	1
12	O'Rourke[72]	94	(10/10%)		—	1
13	Bolooki[1]	366	(32/8%)	51	(10/19%)	3††
14	Goldberg[7]	50	(2/4%)	45	(1/2%)	—
	Total	**1965**	**(179/9.1%)**	**612**	**(88/14.3%)**	**(20/0.32%)**

* Includes all patients who had successful IABP catheter insertion (percutaneous and surgical).

* Amputation or paralysis.

** Three patients with footdrop and one with minor amputation.

*** Includes gangrene.

† Detail analysis was not reported.

†† Two amputations and one serious motor dysfunction.

years shows an overall incidence in the range of 5% to 38% (Table 2). The following are the most important factors that signifcantly affect the occurrence of vascular complications:

1) **Method of balloon catheter insertion**. Percutaneous technique has been associated with a higher rate of balloon catheter passage and a higher incidence of interference with peripheral circulation, as compared with surgical (open) technique (14% versus 9%, Table 2). Presence of an arterial dilator sheath in the iliac artery may contribute to this complication. Anticoagulation with heparin may delay and prevent femoral thrombosis.

2) **Preexisting peripheral vascular disease**. The primary factors in development of vascular complications are preexisting vascular disease and poor collateral blood flow. These are generally associated with extensive iliofemoral atherosclerosis. The obstructed lumen of the vessel by the balloon catheter enhances distal thrombosis and limb ischemia. Manifestations may vary from the simple disappearance of peripheral pulses to severe thrombosis of the femoral artery, which may cause sensory and motor loss and eventually lead to gangrene and amputation of the extremity. Heparinization will not help this problem after they develop.

3) **Urgency of the procedure** has been elemental in many instances where it has led to technical problems and poor patient and femoral artery selection.[9,15]

4) **Female sex** has been a major factor in a number of studies. Women have had a higher incidence of vascular complications with balloon pumping, even in the absence of comorbid conditions such as diabetes and cardiogenic shock.[59,79,80,86,90]

5) **Diabetes** has been implicated in a number of studies as a contributing factor to the development of vascular complications.[9,15,59,85,86]

6) **Obesity** makes catheter placement difficult and may lead to peripheral vascular complications.

7) **The need for large doses of vasopressor agents**, especially alpha stimulators (norepinephrine), for a long period and prolonged duration of circulatory assist may contribute to the development of vascular complications.[9,70]

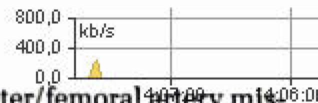
8) **Patients of short stature** have small femoral vessels which are prone to obstruction by the balloon catheter of large size and development of distal ischemia.

In two reported series, the incidence of complications related to balloon pumping increased as a direct result of duration of IABP assist.[9,70] In teaching hospitals, the incidence of balloon complications, in general, may be higher and, in fact, the incidence would be different if balloon catheter insertion was done under the supervision of staff members, as opposed to those performed by the resident physicians without supervision.[88] Late vascular complications include false aneurysm formation and arteriovenous fistula (see below).

Leg Ischemia and Limb Loss

Leg ischemia is the most frequent early complication of balloon pumping.[99–107]

Incidence



Factors that contribute to leg ischemia include balloon catheter/femoral artery mismatch, method of insertion, preexisting peripheral vascular disease, and claudication, female gender, diabetes, hypertension, urgency of balloon catheter insertion, and duration of IABP assist.[74,93,98,103–107] The overall incidence of this complication in surviving patients, which constitutes about 55% of the patients who receive an IABP assist, ranges between 7% to 11% (Table 3). More than 90% of ischemic legs present with loss of distal pulse, cold leg, and rest pain which may subside upon diagnosis, and immediate

Table 3
Incidence of Vascular Complications with Balloon Assist*

Author	Survival		Vascular Complications		Leg Ischemia		Aortic Dissection		Other Mjaor Complications**	
	n	*(%)*	*n*	*(%)*	*n*	*(%)*	*n*	*(%)*	*n*	*(%)*
14 Series*	2577	(52%)	297	(11%)	267	(10.3%)	10	(0.38%)	20	(0.77%)
Shahian ('83)[86]	87	(64%)	11	(12%)	8	(9.1%)	1	(1.1%)	2	(2.2%)
Pennington ('83)[13]	362	(53%)	36	(10%)	26	(7.4%)	3	(0.8%)	7	(2.1%)
Sanfelippo ('84)[87]	637	(48%)	61	(8.4%)	61	(9.6%)	—	—	—	—
Kantrowitz ('86)[59]	733	(58%)	118	(14%)	86	(11%)	4	(0.5%)	15	(2%)
Naunheim ('92)[90]	580	(56%)	68	(11.7%)	65	(11.2%)	3	(0.5%)	4	(0.7%)
Makhoul ('93)[80]	436	—	46	(10.6%)	40	(9.1%)	2	(0.45%)	5	(1.1%)
Total	**5412**	**(55%)**	**637**	**(11%)**	**513**	**(9.4%)**	**21**	**(0.38%)**	**48**	**(0.88%)**

withdrawal of the IABP catheter. Leg ischemia leading to major complications such as limb loss (amputation), and requirement for surgical interventions to relieve the ischemia (thrombectomy), fasciotomy or cross-leg femoral graft, range between 0.7% to 2.2% (Tables 2 and 3).[103–107] The incidence of limb loss varies and is about 0.5% to 0.7%.

Diagnosis

Awareness and continuous observation for early symptoms of leg ischemia play an important role in its early recognition. The most important step is to assure the presence of distal pulses (by doppler stethoscope) and of adequate capillary fling in the foot and toes early after balloon catheter insertion. The primary diagnostic test perhaps, aside from capillary filling, is that of the difference in temperature between the leg with the balloon catheter and the opposite leg which should be assessed and recorded on a continuous basis.

Leg ischemia can be diagnosed initially by a decrease in peripheral pulses (dorsalis pedis and posterior tibialis). Sudden disappearance of these pulses is alarming, but may not lead to severe leg ischemia if the balloon catheter is quickly withdrawn.[2,4,10] Severe ischemia of the leg (rest pain, sensory and motor losses) are indications for prompt reestablishment of blood flow by balloon catheter removal or a cross-leg vascular graft. In general, motor losses appear initially and sensory losses follow. Once established, however, these complications may not be reversible.[80,91,94,102] Anterior compartment syndrome may be present (see below).[108,109]

In a patient who has a weak or absent distal pulse due to peripheral vascular disease prior to balloon catheter insertion, adequacy of capillary filling is an indication of adequate circulation to the foot. In these patients, peripheral pulse oximetry is an acceptable method of assessing adequacy of circulation to the extremity. Generally, balloon catheter insertion through the femoral artery in the affected leg is an invitation for more serious problems.[91,99]

Initially, distal pulses and ischemic leg pain are absent, capillary filling is adequate, and motor function is intact. If circulatory assist does not improve cardiac function and femoral artery blood flow, leg ischemia will become prominent. Ischemic leg pain will then appear. With improvement in cardiac function, the initially absent peripheral pulses may become palpable within a few hours after initiation of IABP. The peripheral pulses, at first, may be audible only with the doppler ultrasound stethoscope and later become palpable.

Prevention

Arterial studies before insertion of the IABP are helpful in predicting development of leg ischemia.[3,97–107] Measurement of differences in ankle/brachial systolic blood pressure could expose preexisting peripheral vascular disease and predict arterial insufficiency.[93-107]

In obese females with diabetes, a surgical approach with passage of the percutaneous catheter through a purse-string suture on the femoral artery may be used.[86] These patients are also more susceptible to wound and groin infection.

Leg ischemia, in some series, was directly related to the number of days that the balloon assist was in place.[2–5,9,59] Therefore, early deployment of balloon catheter is a fair preventive measure. Other measures include anticoagulation, maintaining high arterial blood pressure, and changing the balloon catheter insertion site when distal pulse disappears.[14,15,74]

In patients receiving IABP in our center, low-molecular-weight dextran (Rheomacrodex®) is administered intraversely 10 cc per hour. This has served as a satisfactory preventive measure.[1] In some centers, intravenous heparinization is employed (750 to 1,000 IU per hour), to keep activated clotting time at twice the control value but <100 per second. Low-molecular-weight heparin given twice daily subcutaneously is as effective as i.v. heparin. In the experience of some investigators, no anticoagulant therapy is required. In other hospitals, aspirin is administered either through a nasogastric tube, by mouth, or as a suppository.

Mechanical preventive measures include the use of a fenestrated sheath for insertion of the balloon catheter (Yamanishi et al)[110] and a new side-holed sheath developed by Satoh et al.[111] These devices have apparently been helpful in patients with severe aortoiliac disease and have maintained peripheral perfusion in the femoral artery.

Management

The absence of distal pulse alone may be treated conservatively with a nitroglycerine patch, frequent observation, and anticoagulation.[81–83,97,103] Evidence of leg ischemia requires removal of the balloon catheter. Balloon catheter removal generally improves blood flow distally in more than 90% of patients. Once leg ischemia develops, the safe interval to achieve success in restoring blood flow to the leg and prevention of amputation is less than 6 hours.

Temporizing measures to relieve distal ischemia include intra-aortic (near the isthmus) infusion of papaverine (through the central lumen of the catheter).[112] One half of a vial of papaverine (2 cc = 60 mgm) is infused into the aorta followed by saline solution over a 5- to 10-minute period. The remaining 1 cc of papaverine is then infused. A blood pressure drop of 5 to 10 mm Hg may occur. Within 10 to 30 minutes, peripheral vasodilatation is noted and the leg becomes warm. The use of heat lamps may be helpful. Opie[112] found that in seven of eight patients, this treatment resulted in the return of peripheral pulses without the need for balloon catheter removal.[112]

Urokinase 4000 IU or streptokinase 500,000 IU may be used during the acute phase through the pressure lumen. A loading dose of 250,000 IU streptokinase followed by 100,000 IU per hour over 2 to 3 hours should be helpful. Experience with infusion of these enzymes for femoral clot lysis in patients on IABP is very limited.[113,114] They are mentioned here for purposes of review only and not as a recommendation for the treatment of leg ischemia on an individual case basis.

If leg ischemia persists and peripheral pulses are absent, even after the removal of the balloon catheter, the femoral artery should be explored on an emergency basis with a Fogarty® catheter proximal and distal to the site of catheter insertion.[115] A percutaneously inserted balloon catheter which has not been previously secured to the femoral artery, upon exploration, may cause excessive bleeding.[116] Therefore, control of the proximal femoral artery is mandatory for safe femoral artery exploration. This treatment, if carried out early, may prevent further complications unless blood clots have already embolized to the distal tibial or peroneal arteries. Should IABP assist be required for a longer period of time, another balloon catheter must be placed in the opposite femoral artery.

A cross-leg femoral graft is the method of choice for treatrnent of severe leg ischemia.[91,105–107] The saphenous vein from the opposite leg may be used. A tunnel is made across subcutaneously, above the pubic promontory, and the vein is grafted between the femoral artery of the contralateral leg to the femoral artery of the ischemic leg distal to the site of balloon catheter insertion. The femoral artery with the balloon catheter may be tied off and a cross-leg graft anastomosed to the distal femoral artery after embolectomy is done or as a primary procedure if the femoral artery is clean. This operation was first suggested by Alpert et al[91] and is used in selected patients. We prefer to change the balloon catheter insertion site and embolectomy of the affected artery initially prior to attempting this procedure.

In the presence of ischemic anterior compartment muscles, the sensory and the motor function of the leg and foot will be seriously affected.[108,109] A high anterior compartment pressure confirms this finding, but does not have to be present to diagnose the anterior compartment syndrome. The normal compartment pressure is 20 to 30 mm Hg.[108,109,116] It will increase to >35 mm Hg with muscular edema and herald the need for surgical decompression. Fasciotomy should be done urgently to prevent sensory and motor dysfunction or limb loss (Figure 4).[15,75,79–88,103,107]

Acute Aortic Dissection

Acute aortic dissection occurs in less than 1% of patients after IABP insertion (Table 3).[2,4,9,13–15,119–123] This incidence differs in various reports and it may be dependent on two factors: the method of balloon catheter insertion and the extent of aortoiliac disease.[90,124] The type of balloon catheter does not seem to have a significant effect on this incidence.

The incidence of aortic injury and dissection in autopsies performed on patients who died during balloon pumping is significantly higher than is generally realized.[59,73] In an autopsy study of 12 patients in our medical center, multiple aortic injuries were seen which were not suspected clinically. These ranged from aortic intimal tear and localized hematoma to minimal wall tear due to penetration of the balloon catheter (Figure 6). Of these 12 complications, 10 were in patients who had difficult balloon insertions. Aortic dissection, however, can occur without incurring difficulty during insertion. Therefore, it is possible that some patients who survive balloon pumping have acute aortic dissection without side effects or clinical manifestations. The use of diagnostic studies, such as echocardiogram, may reveal periaortic hematoma of aortic dissection.[125]

It is interesting that in over 400 patients in whom the surgical Datascope® balloon catheter was used, we did not clinically encounter any case of aortic dissection, while with the percutaneous Datascope® balloon catheter, a number of aortic dissections have been observed.[1] The frequency of this complication has decreased since the method of catheter insertion over a guidewire was developed. We have not seen this complication for the last 6 years. We have had one iliac artery perforation, possibly due to guidewire entry and balloon insertion in a small branch of iliac artery in 400 attempts.

When the balloon catheter is used in the cardiac catheterization laboratory, the incidence of aortic dissection is very low and misplacement of the balloon catheter and its deviation from the anatomic course of the aorta is quickly detected. In these patients, the balloon catheter may be removed carefully and reinserted if needed. The patient should be closely observed for signs of blood loss (see below).[120–122]

Figure 6. Necropsy finding in a patient who died after cardiogenic shock, despite intra-aortic balloon assist. There is extensive atherosclerosis within the upper abdominal aorta over the posterior aspect of the vessel at the junction with renal arteries. Percutaneous balloon catheter has passed through an intimal plaque (arrow) without causing aortic dissection. This type of aortic injury is found in a number of patients who receive percutaneous balloon catheter insertion and are studied at necropsy.

Diagnosis

The usual clinical signs of aortic dissection, such as chest and back pain, and history of hypertension, are absent. The balloon catheter — having been advanced in the dissected lumen — frequently produces effective diastolic augmentation.[2,92,121–124]

One indication that aortic dissection may have occurred is that, after an apparently well-positioned balloon, initially diastolic augmentation is minimal, but gradually (as aortic dissection is completed) there is an improvement in the balloon assist curve. Diagnosis of silent dissection may be made by the abnormal position of the balloon catheter in relation to the vertebra on a plain chest film.[3,9,12,16] Anterior direction of the catheter on a cross-table lateral chest film is an alarming finding and requires removal of the catheter.[4,14,122,123]

Prognosis

To date, long-term survival after dissection of the aorta by balloon catheter has been reported by one group only.[4] Other reports have shown a poor outcome after this complication.[3,70,124] One patient with aortic dissection has been reported with successful balloon assist for 21 days until removal of the catheter when circulatory collapse ensued, followed by cardiac arrest.[92] As a result, this complication may be considered life threatening. It may cause sudden death during IABP assist or after the balloon catheter has been removed. Precautions that we have suggested for balloon insertion do not always prevent aortic dissection. Rarely is aortic dissection seen without evidence of an intimal tear.[2]

Management

Aortic dissection has always been associated with femoral artery balloon catheter insertion. Since dissection is retrograde, theoretically, after removal of the catheter, antegrade flow of blood allows return of the dissected lumen to a normal position and should remedy the problem. Bregman et al[11] have reported three patients with aortic dissection due to balloon catheter who eventually underwent other corrective cardiac surgery procedures a few weeks later without complications.

Management is by removal of the balloon catheter. No particular therapy can be employed since the diagnosis generally is either not made and/or is postfacto (autopsy findings). In the course of cardiac catheterization studies, after aortic injury by a balloon catheter has been recognized, removal of the balloon catheter and injection of dye into the aorta may show extravasation of the dye. Usually, the adventitia of the aorta is not penetrated and no intrathoracic rupture is seen. Conservative management has been successful in the majority of these patients.[90,96]

successful in the majority of these patients.[90,96]

Balloon catheter-induced retrograde aortic dissection at the time of cardiac surgery interferes with the establishment of cardiopulmonary bypass if the arterial inflow catheter is placed in the opposite femoral artery. Acute aortic dissection is usually discovered a few minutes after initiation of cardiopulmonary bypass, when blood pressure and oxygenator volume cannot be maintained despite large doses of pressor agents and high perfusion flow rates. Management is by changing the site of the inflow cannula from the femoral artery to the ascending aorta, if possible, or to the axillary artery. Since these patients are always dependent on balloon assist for separation from cardiopulmonary bypass, balloon pumping should not be discontinued until the procedure is completed. At that time, the balloon catheter may be removed from the femoral artery and reintroduced from the ascending aorta.

In the past, we have encountered such a situation where we have removed the balloon catheter and have halted the continuation of cardiopulmonary bypass through the femoral artery inflow line, and changed the inflow and the balloon catheter insertion to the ascending aorta. This allowed for the satisfactory establishment of cardiopulmonary bypass, completion of the operative procedure, and resulted in patient survival.

If acute aortic dissection involves the ascending aorta, the right axillary artery is used for inflow line, and the balloon catheter is left in the femoral artery until a few days later when the patient is no longer balloon dependent.[13] We have had the unfortunate experience with two patients who apparently had silent aortic dissection after percutaneous femoral balloon catheter insertion (without guidewire) preoperatively, and for various reasons, we selected the same femoral artery for cannulation for perfusion inflow. Both patients had the balloon catheter changed to the opposite leg, but required urgent establishment of cardiopulmonary bypass with femoral artery cannulation a few days later. Acute aortic dissection was discovered after bypass with femoral artery cannulation. From this experience, we suggest that in all patients undergoing cardiac surgery while on IABP assist, ascending aorta perfusion or right axillary artery perfusion should be used. The prognosis in patients with acute aortic dissection discovered at the time of cardiac surgery is grave. *At no time should the inflow line be placed into a femoral artery that in the past has been used for placement of an intra-aortic balloon catheter.* Initiation of cardiopulmonary bypass with inflow in the femoral artery that has been used for IABP may result in the development of an acute aortic dissection and, most likely, will lead to the patient's demise.

Other Vascular Complications

Injuries of the Aorta, Iliac and Mesenteric Arteries

We have encountered two patients in whom the balloon catheter exited the lower abdominal aorta. Both patients needed balloon assist because of cardiogenic shock. Aortic perforation was managed by catheter withdrawal and without operative intervention. In an additional patient, when the balloon catheter exited the lower thoracic aorta, the catheter was removed without any incident and the patient was managed without surgical intervention. These patients had extensive LV dysfunction. Withdrawal of the balloon catheter in each of these patients into the iliac artery, its reinsertion over a guidewire into the thoracic aorta, and resumption of the balloon support, were possible. This was not associated with bleeding, perhaps due to hypotension, that was poorly responsive to standard pressor therapy. At necropsy, 3 and 5 days later in each case, a small periaortic hematoma at the level of the mesenteric artery was found with no intra-abdominal bleeding. Similar experiences have been reported by others.[12,13,15,91,120–124]

Minor vascular injuries, such as raising an intimal plaque from the femoral artery during surgical exposure of the artery, or by balloon catheter insertion, is usually treated by local endarterectomy and repair.[2] This may cause asymptomatic diminution of the peripheral pulse and may not require additional therapy. Stent placement in an injured iliac artery that was partially obstructed due to balloon catheter injury has been reported.[126]

Extensive iliofemoral artery damage, due to percutaneous introduction of the introducer sheath and the balloon catheter, requires immediate attention and operative repair.[2,15,16,83,97] Uncontrolled bleeding will make exposure of the affected vessel diffcult, especially if the balloon catheter has been removed.[112] The operation is facilitated if an assistant with a sterile gown and glove presses over the proximal iliac and femoral arteries while the skin incision is being made. The arterial injury should be approached quickly and a tape passed around the vessel to clamp the proximal artery. This exploration may require iliac artery exposure and proximal control. Once the artery is under control, either with a vascular clamp or a vascular tape, the distal end of the artery is found and is controlled prior to assessing the extent of the defect in the arterial walls.

Both arterial and venous injuries should be sought and repaired, preferably with a venous patch or by resection and grafting with synthetic material. Venous injuries should be repaired by direct suturing or vein patch graft.[14,24]

Vascular injuries of more significance are iliac artery tears and arteriovenous fistula. Most of these patients eventually died, a few of them as a direct result of balloon insertion.[2] Therefore, iliac artery tears due to balloon catheter insertion, should be considered a life-threatening complication. Arteriovenous fistulae as a result of balloon pumping has been seen in most centers that use intra-aortic balloon catheter insertion.[127,128] Management of these fistulae is by direct exposure and the use of standard techniques of patching for arterial and venous repair. Pseudoaneurysm should be taken care of approximately 1 or 2 weeks after removal of the intra-aortic balloon, at a time when the tissue surrounding the aneurysm is strong enough to allow dissection. Archie and Mann[128] have reported on an infected femoral arteriovenous fistula due to balloon insertion. These authors were able to successfully manage this complication with extra-anatomic bypass, followed by resection and drainage of the infected area. A detailed account of the methods of management of vascular complications of balloon catheter with specifc reference to arteriovenous fistulae, are given by a number of authors.[67,68,83,89,91,93]

The balloon catheter can enter any of the aortic branches of the intra-abdominal aorta and result in damage to the viscera. Ischemic damage of the liver and kidneys has been reported in one patient.[129,130] Massive bowel necrosis and jaundice as a result of placement of the balloon catheter, and possible thrombosis of the superior mesenteric artery, has been reported in another case.[131] These types of episodes are exaggerated by the presence of hypotension which, in patients in cardiogenic shock, independently can cause gastrointestinal ischemia, bleeding, and gastritis.[132–139] In a report from Emory University, acute mesenteric ischemia developed after cardiopulmonary bypass in 18 patients. A number of these patients had intra-aortic balloon counterpulsation.

The authors felt emergency cardiac surgery, as well as the use of an IABP was associated with a higher incidence of gastrointestinal ischemia than in general cardiac surgery patients.[133] A similar report and word of caution was sounded by Mercado et al[135] who encountered 64 patients in a 5-year period who developed gastrointestinal complications after cardiac surgery, including bleeding, pancreatitis, perforated ulcer, bowel ischemia, and other visceral complications. Reoperative cardiac procedures and use of the IABP increased the risk of developing these complications by 2.5 to 12 times, respectively. The diagnosis was made on the basis of high suspicion, and treatment was done aggressively, medically and surgically. However, the mortality rate in these patients was higher (16%) with circulatory assist and hypotension than in patients without visceral complications (3%).[134,135–139]

In a study of the placement of the intra-aortic balloon catheter in the juxtamesenteric position, Shimamoto et al[135] found that it did not interfere with inflow to the superior mesenteric artery, regardless of the frequency of IABP pulsations.[135]

Peripheral Embolization

Thrombosis of the abdominal aorta or its occlusion in patients on IABP has been reported.[140,141] Other observations include splenic infarction[136] and occlusion of the left internal mammary artery.[142] In one patient, after aortic dissection which involved one of the renal arteries, high serum renin level was discovered which caused uncontrollable arterial hypertension and required nephrectomy in order to medically manage the hypertension.[129] In another patient, the tip of the balloon catheter that was placed through the ascending aorta prevented blood flow to the kidneys and resulted in anuria.[140] Removal of the balloon catheter remedied the problem. Renal arterial obstruction, in that case, was proved by the absence of renal perfusion by scanning.

Peripheral platelet clot embolization to the opposite leg or the arm may develop. This is a direct result of propagation of clots and shower emboli due to balloon pulsations.[2,73] Observation of balloon pulsations within the lumen of the thoracic aorta with a special video camera setup shows dramatic mobilization of platelet and intimal fragments and their propagation. These may result in complications that frequently are seen in a patient with extensive aortic atherosclerosis. Treatment is by prevention and use of heparin in patients who remain in a low output state.[92] For definitive management, more effective (load bearing) methods of circulatory assist may be considered which eliminate prolonged balloon pumping.

Peripheral arterial embolic episodes resulting in organic dysfunction may develop. A signifcant number of these are shower emboli to the brain due to platelet clot formation around the balloon catheter. These include small bowel infarction, superior mesenteric artery obstruction, and a variety of neurologic manifestations mainly due to spinal artery obstruction and aortic dissection.[92,93,138,139] I have been told of a patient in Miami who developed acute pancreatitis while he was on IABP assist. The relation and the role of IABP to this complication was not clear. However, other reports have appeared indicating the possibility of development of acute pancreatitis in patients after cardiopulmonary bypass[133,134] or after cardiac catheterization.[143]