

Neurological Abnormalities in the Leg(s) After Use of Intraaortic Balloon Pump: Report of Six Cases

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• Six patients from a group of 39 who survived after treatment with the intraaortic balloon pump (IABP) had significant neurological deficits in one or both legs associated with the use of the IABP. The device was used in a group of 89 patients initially for cardiogenic shock but its use has been expanded for patients having the following conditions: preshock; severe congestive heart failure; refractory angina; and for those undergoing open-heart surgery. The six patients who had neurological sequelae had eight IABP insertions into the thoracic aorta through the femoral artery and had neurological abnormalities and/or electromyographic abnormalities in nine lower extremities ranging from a foot drop to almost total paralysis of the lower extremity. The pathophysiology of the neurological deficit is postulated to be an obstruction to blood flow, or thromboemboli, in the femoral artery.

The intraaortic balloon pump (IABP) has provided mechanical treatment for some patients with cardiogenic shock, since Kantrowitz and associates¹ initiated clinical trials of the device in 1967. Cardiogenic shock occurs after acute myocardial infarction in from 10% to 15% of patients, 85% of whom do not respond to medical treatment.

As of May 1974, of a total of 118 patients treated with the IABP by Kantrowitz and our group, 89 patients were treated at Sinai Hospital of Detroit and the remainder at Maimonides Medical Center in New York. Of the 39 Sinai patients who survived, six were referred to the Department of Rehabilitation Medicine because of neurological problems in one leg or in both legs. These six patients are the subject of this paper, which includes brief mention of the IABP (description and use), discussion of specific features of the associated neurological problems, and speculation as to the possible underlying pathophysiology.

The Intraaortic Balloon Pump

The IABP is a device (fig 1) that comprises a polyurethane pumping chamber (balloon) that is 14.8 cm long, 0.4 cm in diameter when deflated, and about 1.8 cm in diameter when expanded—at which time it displaces from 27 ml to 33 ml of blood.¹ A polyurethane catheter, from 50 cm to 60 cm long and 4 mm in external diameter, connects the pumping chamber to an external pneumatic driving unit. An external pump, on signals from an electrocardiographic trigger, inflates the IABP during diastole, and deflates it during systole.

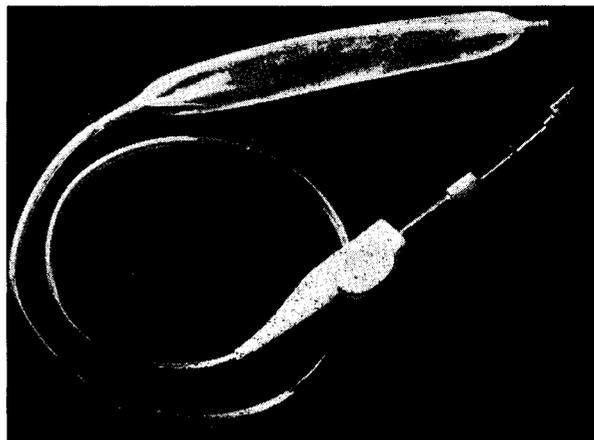


Fig 1—The intraaortic balloon pump (IABP).

To insert the IABP, the patient is provided with local anesthesia, and an incision is made in the femoral artery from 3 cm to 4 cm distal to the inguinal ligament. A 3 cm portion of the vessel is isolated with snares, and a 1 cm arteriotomy is made on the anterior surface. The balloon pump and catheter (stiffened by a stylet) are inserted through an end-to-side Dacron arterial graft 12 mm in diameter into the femoral artery. The balloon is placed in the descending thoracic aorta just distal to the origin of the left subclavian artery. When circulatory assistance is initiated, the graft is sutured to the arterial wall and is tied with a snare. The arterial snare is then released, physiological circulation is restored, the leg is examined and when all seems well, the wound is closed around the graft.² The insertion procedure usually requires from 20 to 30 minutes.

The IABP reduces the workload of the left ventricle during systole and increases coronary artery perfusion during diastole. The balloon is deflated just before the aortic valve opens, reducing the hemodynamic resistance to the emptying of the left ventricle. As the aortic valve closes during diastole, the balloon is inflated and thereupon propels the blood into the coronary arteries and peripheral blood vessels.^{3,4} The IABP cannot be used indefinitely, but in

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Presented at the 51st Annual Session of the American Congress of Rehabilitation Medicine, San Francisco, November 22, 1974.

our patients it has been in place for from several hours to as long as 71 days.

Clinical trials of the IABP at Sinai Hospital of Detroit were followed by clinical trials in nine other cooperating institutions.⁵ The favorable results of the IABP in patients in cardiogenic shock led to use of the device in patients in preshock with low cardiac output and pulmonary edema, and for circulatory assistance in patients who are undergoing cardiac surgery.⁶ Currently, the IABP, an accepted therapeutic device, is being used in an increasing number of patients at several medical centers.

Case Reports

Case 1: A 47-year-old woman in cardiogenic shock was transferred to Sinai Hospital of Detroit on April 3, 1971, from a hospital in Jackson, Michigan (70 miles distant), where she had been admitted the previous day because of severe chest pains. Three hours after admission to Sinai Hospital of Detroit, an IABP was inserted via the right femoral artery. Upon removal of the device 13½ hours later, the right leg was noted to be numb and swollen. Heparin had been injected intravenously from the time of insertion of the IABP. Two days after removal of the IABP, because of continued swelling of the leg, anterior and posterior fasciotomies were performed below the right knee. Nine days later, that leg was stiff; the patient could not move the foot and there was no sensation below, and decreased sensation above, the knee. An initial electromyogram revealed positive waves (PW) and fibrillation potentials (FP) in the right vastus medialis and all distal muscles. There were no motor unit action potentials (MUAP) in the muscles distal to the right knee, and only one MUAP in the vastus medialis. An electromyogram in June 1974 showed PW and FP in the abductor digiti quinti pedis, gastrocnemius and extensor digitorum brevis. MUAP were decreased in tibialis anterior, gastrocnemius and extensor digitorum brevis, and were absent in the abductor digiti quinti pedis. Conduction velocity was decreased in the right peroneal (29 meters/sec) and right posterior tibial (30 meters/sec) nerves. The left side examined for the first time showed no abnormalities. Despite clinical evidence of muscular atrophy below the right knee, the patient could walk on her heels and toes. There was minimum weakness and atrophy three years later.

Case 2: A 42-year-old woman, an insulin-dependent diabetic, was transferred to Sinai Hospital of Detroit on Nov 1, 1971, in cardiogenic shock ten days after admission to a hospital in Jackson, Michigan, because of acute myocardial infarction. Three hours after admission to Sinai Hospital of Detroit, an IABP was inserted via the left femoral artery (heparin was injected intravenously) and was removed 5¾ hours later. Shortly after insertion of the IABP, the left leg became mottled and cold. Forty-eight hours later, a left femoral thrombectomy was performed. The next day the patient had pain in the left leg, and two days later, weakness of dorsiflexion of the foot was noted. Fifteen days after admission to the hospital, the patient had a trace of function in the left tibialis anterior and quadriceps, no function in the toe extensors or flexors, and antigravity function with resistance in the plantar flexors. An electromyogram showed PW and FP in all left lower leg muscles except the internal hamstrings and the gluteus maximus. MUAP were absent or markedly decreased in the left quadriceps and distal muscles. The right extensor digitorum brevis (the only muscle tested on the right side) was normal but there was decreased conduction velocity in the right peroneal nerve (31 meters/sec)

and in the left median nerve (45 meters/sec) (with a distal latency of 5.3 msec for the motor fibers, and no potential obtainable for the sensory fibers). Further hospitalization was necessary and despite attempts at reconstruction of the left femoral artery, an amputation above the left knee was performed on July 3, 1972.

Case 3: A 53-year-old woman had the IABP inserted via the right femoral artery on Dec 18, 1973, when she became hypotensive while having assistance from the extracorporeal cardiopulmonary bypass pump during surgery for aorto-coronary artery bypass at Sinai Hospital of Detroit. Postoperatively, the right leg was painful, the dorsalis pedis pulse could not be felt, a sensory loss was noted, and the patient could not move her toes. Fifty-five hours later, the IABP was removed, and the next day the patient had decreased sensation over the entire right leg except the medial aspect of the upper half of the thigh; reflexes were absent in the right leg and left ankle; there was no function of the right toe extensors, toe flexors and ankle dorsiflexors, and there was weakness of the ankle plantar flexors, knee extensors and hip flexors. An initial electromyogram showed PW and FP with decreased MUAP in the right quadriceps femoris, tibialis anterior, and medial gastrocnemius. A recent electromyogram revealed no abnormalities in the left leg, right paraspinal muscles or musculature of the right thigh, but PW and FP with a decreased number of MUAP in the right tibialis anterior, medial and lateral gastrocnemius, peroneus, extensor digitorum brevis and abductor digiti quinti pedis. Peroneal and posterior tibial nerve conduction velocities were each 41 meters/sec. Leg pain was still present 18 months later.

Case 4: A 60-year-old man was transferred to Sinai Hospital of Detroit on Dec 6, 1973, from another hospital in Detroit because of cardiogenic shock associated with myocardial infarction. Three hours after admission to the hospital an IABP was inserted via the right femoral artery and heparin was administered. Five days later the patient underwent aortocoronary bypass surgery. The IABP was removed 11 days after insertion, 6 days postoperatively. Two weeks after removal of the IABP the patient was started on an ambulation program and was noted to have foot drop in both feet—worse in the left foot. There was no active dorsiflexion power of the toe extensors of the left foot, and only a trace of function on the right, associated with decreased sensation in the peroneal nerve distribution bilaterally. An electromyogram showed PW and FP in the tibialis anterior and extensor digitorum brevis muscles bilaterally. No MUAP were noted in the left extensor digitorum brevis, but a few MUAP were present in the other three abnormal muscles. The nerve conduction velocity was 20 meters/sec for the right peroneal nerve across the right knee, and was unobtainable across the left knee. The velocity from below both knees to the ankles was 37 meters/sec. The patient did not return for follow-up electromyographic examination, but reported clinical improvement.

Case 5: A 55-year-old man was admitted to Sinai Hospital of Detroit on Dec 5, 1973, for management of cardiogenic shock. Five hours after admission, an IABP was inserted (for the first time) via the right femoral artery and heparin was administered. Later that day, infarctectomy and aortocoronary bypass were performed. The first IABP was removed 13 days after insertion only to be replaced 10 days later by a second IABP inserted via the left femoral artery where it remained for 14 days. During this entire time the patient was restless, mentally confused, had Cheyne-Stokes respiration, a pericardial friction rub and a fear of death. He constantly tugged at the arterial lines of the monitoring equipment and caused an ischemic neuropathy of the distal right upper extremity. During the hospitalization the patient

also received conservative treatment for a perforated duodenal ulcer and had *Serratia marcescens* septicemia. On March 13, 1974, for the third time, an IABP was inserted via the right femoral artery for treatment of low cardiac output syndrome. It remained in place for five days. The patient noted coldness of the foot, and had decreased sensation and weakness of dorsiflexion of the toes and foot. An electromyogram showed PW and FP bilaterally in the tibialis anterior, extensor digitorum brevis, abductor digiti quinti pedis, and in the right medial gastrocnemius, quadriceps femoris and gluteus maximus. The right peroneal nerve conduction velocity was 29.0 meters/sec. Electromyographic examination repeated three months later showed lessening but still significant neuropathic findings.

Case 6: A 61-year-old man was admitted to Sinai Hospital of Detroit on Sept 16, 1973, because of severe exertional dyspnea. The diagnosis was aortic valve stenosis and insufficiency of the mitral and aortic valves. On Oct 19, 1973, valve replacement surgery was undertaken. The patient was connected to the extracorporeal cardiopulmonary bypass pump. With a view to facilitating subsequent termination of this assistance, and because the patient's condition was poor, an IABP was inserted (without administration of heparin) through the right femoral artery—after unsuccessful attempts at insertion through the left femoral artery. Although the patient did mention numbness on the top of the foot, this abnormality was not investigated until five months later when he was examined because of another problem. At that time he was noted to have weakness of the toe extensors and tibialis anterior on the right side. An electromyogram performed six months postoperatively showed PW and FP in the right and left extensor digitorum brevis, right abductor digiti quinti pedis and right medial gastrocnemius muscles. There were diminished MUAP in the distal musculature of both feet, with only from 1 to 2 units in the extensor digitorum brevis. The peroneal nerve conduction could not be

obtained in the right lower extremity and was 39 meters/sec on the left. The patient was asymptomatic eight months later.

Summary of Case Data

CLINICAL DATA (TABLE 1)

The series comprises six patients—three men and three women—ranging in age from 42 to 61 years. One patient had IABP devices inserted three times. Four of the eight IABP insertions were for cardiogenic shock, one insertion of which was used also as assistance for a surgical procedure; two were for pre-shock; and two were performed in order to remove the patient from the cardiopulmonary bypass pump. Only one patient (case 2) was diabetic, and two cases (1 and 2) each had a prior 70-mile ambulance trip while in cardiogenic shock. With one exception, heparin was injected for all IABP insertions. The IABP was in place from 6 hours to 14 days.

While the IABP was in place, four patients each had some symptoms and signs including a cold mottled leg, ankle pain, decreased to no dorsalis pedis pulse and weakness of the toes. After the IABP was removed, five of the patients each had similar symptoms and signs, and one patient had signs only.

In three of these patients, all with bilateral abnormalities, neurological deficit was not readily recognized. One patient was noted, during cardiac rehabilitation training, to have foot drop in both feet;

Table 1: Clinical Findings in Six Patients Who Had IABP Assistance

Case no., Age, Sex	Indications for use	Intraaortic balloon pump			Symptoms and signs while in place	Symptoms and signs after removal	Side of insertion	Side of electromyographic findings
		Time inserted (postadmission)	Heparin	Duration				
1 47 F	Cardiogenic shock	3 hr	Used	13.5 hr	None	Right leg cool, numb, swollen, dorsalis pedis pulse decreased	Right	Right; left initially not examined electromyographically
2 42 F	Cardiogenic shock	3 hr	Used	6 hr	Cold mottled left leg	Left leg painful, numb, with absent distal motor power	Left	Left; right initially not examined electromyographically
3 52 F	Removal from cardiopulmonary bypass	During surgery	Used	55 hr	Right leg painful with absent pulse, decreased sensation and inability to move toes	Right leg numb, with absent reflexes and distal motor power	Right	Right
4 60 M	Cardiogenic shock and surgical assistance	3 hr	Used	11 days (6 days postoperatively)	Bilateral ankle pain and cold extremities with weak dorsalis pedis pulse	Foot drop in both feet, without subjective symptoms	Right	Bilateral; left worse than right
5 55 M	Cardiogenic shock (1st); low cardiac output and preshock (2d, 3d)	5 hr	Used	13 days (1st) 14 days (2d) 5 days (3d)	Transient inability to move right foot (1st) Cold mottled right foot, with decreased dorsalis pedis pulse (3d)	Right foot cold, numb, with distal motor weakness	Right (1st) Left (2d) Right (3d)	Bilateral; right worse than left
6 61 M	Removal from cardiopulmonary bypass	Before surgery	Not used	4 days	None	Right foot numb, with distal motor weakness	Right, after failure on left	Bilateral; right worse than left

another, while being examined for a neurological problem in the arm, was noted to have a neurological problem in the leg; and the neurological abnormality in the third patient was first diagnosed five months postinsertion of the IABP. Two of these three patients each had the IABP insertions either bilaterally, or had undergone an attempted insertion in the opposite leg.

involved leg, and was considered to have a generalized diabetic neuropathy, but fibrillation potentials and positive waves were found only in the involved leg. Three patients (cases 1, 5, 6) had slowed or unobtainable peroneal nerve conduction velocities from the knee to the ankle, and in another patient (case 4), the conduction velocity across the right knee was slowed and unobtainable at the left knee. The pattern of abnormality was worse distally in all patients, although in each of four of the patients examined soon after the onset of the problem, the quadriceps also was involved. The paraspinal muscles were normal in the three patients in whom this area was examined. In all except one patient (case 4), the pattern of electromyographic abnormality was compatible with a peripheral neuropathy.

ELECTROMYOGRAPHIC DATA (TABLE 2)

Electromyographic examinations were performed on all patients when seen initially and repeated later on three patients. One patient (case 2), a diabetic dependent on insulin, had a prolonged distal latency of response in the median nerve and a slowed nerve conduction velocity in the peroneal nerve of the un-

Table 2: Electromyographic Data of Six Patients Who Had IABP Assistance*

Factor	Case 1				Case 2				Case 3			
Side of symptoms	Right				Left				Right			
Conduction velocity	Recently				Initially				Recently			
When performed	Rt peroneal, 29				Rt peroneal, 31				Rt peroneal, 41			
Nerves and results, meters/sec	Rt post. tibial, unobtainable				Lt median, 45				Rt post. tibial, 41			
	Lt peroneal, 55								Lt peroneal, 45			
Distal delay median nerve, msec					Sensory, unobtainable							
					Motor, distal delay 5.3							
Needle electrode examination	Normal				Not performed				Normal			
Paraspinals												
Initial results	Rt		Lt		Rt		Lt		Rt		Lt	
	PF	MUAP	PF	MUAP	PF	MUAP	PF	MUAP	PF	MUAP	PF	MUAP
Quadriceps	2+	↓	—	—	—	—	3+	0	2+	↓	—	—
Gastrocnemius	2+	0	—	—	—	—	3+	↓	2+	↓	—	—
Tibialis anterior	3+	↓	—	—	—	—	4+	↓↓	2+	↓	—	—
Extensor digitorum brevis	3+	0	—	—	0	Norm	—	—	—	—	—	—
Abductor digiti quinti	3+	0	—	—	—	—	—	—	—	—	—	—
Gluteus maximus	0	Norm	—	—	—	—	0	Norm	—	—	—	—
First dorsal interosseous	—	—	—	—	—	—	0	Norm	—	—	—	—
Recent results					Leg amputated							
Quadriceps	0	Norm	0	Norm					0	Norm	0	Norm
Gastrocnemius	2+	↓	0	Norm					2+	↓	0	Norm
Tibialis anterior	0	Norm	0	Norm					2+	↓	0	Norm
Extensor digitorum brevis	+	↓	0	Norm					3+	↓↓	0	Norm
Abductor digiti quinti	2+	0	0	Norm					3+	↓↓	0	Norm

Factor	Case 4				Case 5				Case 6			
Side of symptoms	—				Right				Right			
Conduction velocity	Initially				Initially				Recently			
When performed	Rt peroneal, 37				Lt peroneal, 29				Rt peroneal, unobtainable			
Nerves and results, meters/sec	Across knee, 23				Rt peroneal, unobtainable				Lt peroneal, 40			
	Lt peroneal, 37											
	Across knee, unobtainable											
Distal delay median nerve, msec												
Needle electrode examination	Not performed				Normal				Not performed			
Paraspinals												
Initial results	Rt		Lt		Rt		Lt		Rt		Lt	
	PF	MUAP	PF	MUAP	PF	MUAP	PF	MUAP	PF	MUAP	PF	MUAP
Quadriceps	0	Norm	0	Norm	1+	Norm	0	Norm	Not seen for 5 mo			
Gastrocnemius	0	Norm	0	Norm	2+	0	0	Norm				
Tibialis anterior	2+	↓	2+	↓	3+	0	2+	↓				
Extensor digitorum brevis	2+	↓	2+	0	—	—	3+	↓↓				
Abductor digiti quinti	—	—	—	—	—	—	1+	↓				
Gluteus maximus	—	—	—	—	—	—	—	—				
First dorsal interosseous	—	—	—	—	—	—	—	—				
Recent results	Did not return											
Quadriceps					2+	↓	0	Norm	0	Norm	0	—
Gastrocnemius					1+	↓	1+	Norm	1+	Norm	—	—
Tibialis anterior					3+	↓↓	1+	↓	1+	↓	1+	Norm
Extensor digitorum brevis					—	—	1+	↓	2+	↓↓	1+	↓
Abductor digiti quinti					—	—	2+	—	1+	↓	1+	↓

*PF = positive waves—fibrillation potentials (0 to 4+); MUAP = motor unit action potentials; ↓ = decrease in number; 0 = absent; Rt = right; Lt = left.

Discussion

Although the IABP has been used for cardiogenic shock since 1967,¹ it is a relatively new procedure used in several centers.⁵ With experience, the indications for the device as summarized in recent publications^{6,7} are expanding, and in our patients it was used for those in cardiogenic shock or in preshock, as an aid in discontinuing the extracorporeal cardiopulmonary bypass circulation, as an assistance for cardiac surgical procedures and for treatment of refractory angina.

Of the 89 Sinai Hospital of Detroit patients treated with the IABP, the survival of 39 (44%) is considered excellent, as those patients were critically ill and expected to be subject to an extremely high risk of mortality with the use of standard medical and surgical procedures. Of the 39 survivors, six had neurological deficits in one or both legs; it is significant that none of those patients were known to have previous neurological problems. Thus, we must assume that neurological complication was related to the insertion, presence and/or withdrawal of the IABP.

Ischemic lesions of peripheral nerves have been studied extensively.⁸ Such lesions are associated with arterial embolism, trauma from gunshot wounds and fractures, tourniquet paralysis, occlusive vascular disease, diabetic changes, polyarteritis nodosa and other lesions, such as hematoma. All of these conditions can cause nerve lesions without accompanying skin or muscle lesions, and the pattern of neurological involvement and symptoms not always is specific. The histologic changes include segmental demyelination and remyelination, as well as the Wallerian type of degeneration and regeneration.⁹ Although many intraarterial surgical procedures are performed, especially in regard to the femoral artery, ischemia is not considered generally to be a common complication. Barnes and associates,¹⁰ however, found that 23 (14%) of a total of 160 procedures performed in patients undergoing percutaneous femoral artery catheterization for cardiac arteriography had vascular complications, mainly thromboemboli, detected by a Doppler ultrasonic velocity detector. Two-thirds of those patients were asymptomatic. The catheter was in place for approximately one hour. In our patients, the catheter was in place for at least 5¼ hours to as long as 14 days.

Jacobsson and Schlossman¹¹ established that, after percutaneous catheterization of the femoral artery, the catheter is the major cause of thromboembolism. The long catheter with a large diameter was more likely than the short catheter with a thin diameter to cause a problem. They used catheters of 2.2 mm to 2.8 mm in diameter, and the largest catheter that caused most lesions was considerably less than the IABP catheter of 4 mm diameter. Formanek, Frech

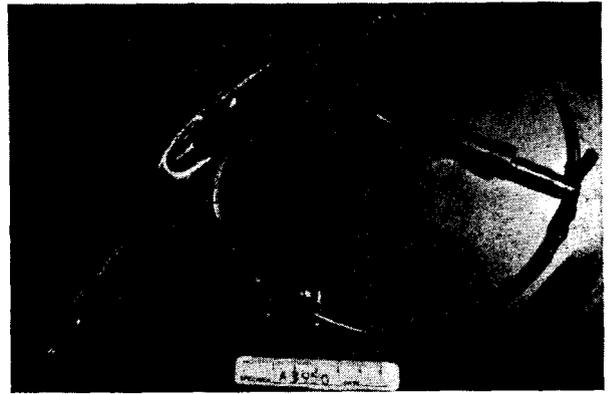


Fig 2—Catheter and balloon removed in toto at postmortem examination. Note excessive amount of fibrin material. (Not from one of the six patients herein reported.)

and Amplatz¹² noted that thrombotic material was deposited on percutaneous catheters used for cardiac and vascular angiography, starting within 30 minutes, and it was seen on all of the catheters that remained in place for one hour. They noted that the thrombotic material moved distally when the catheter was withdrawn, was then peeled from the wall at the entry site, where it either remained or from where it embolized distally. The large catheters, because of the obstructive size and decreased flow around the catheter, had the most thrombotic material.

The condition of the catheter was determined at postmortem examination on others of our patients, from whom the IABP had been removed in toto. Removing the balloon in toto at the time of postmortem examination prevents the possible stripping of any fibrin material while the device is being removed from the femoral artery. In one of these patients, although on heparin therapy continuously during the time of pumping, excessive amounts of fibrin material accumulated on the IABP (fig 2). Of the IABPs that were removed in toto during postmortem examination, this was the only one that showed a great accumulation of fibrin material.

Schneider and associates^{13,14} conducted experiments on the effects of use of the IABP for three days in 37 healthy calves. They tested three balloon designs, a single-chamber device (similar to the one we use clinically) in 10 animals; a triple-chamber device in 12 animals; and a dual-chamber device in 15 animals. All animals underwent changes in the serum albumin/globulin fraction ratios because of increases in the β -globulin and γ -globulin fractions, and an appreciable increase in the total fibrinogen. These changes presumably were due to intravascular trauma produced by the prolonged pumping of the mechanical circulatory assistance device. The authors^{13,14} also used a postmortem perfusion fixation technique coupled with an en-face staining method to demonstrate alterations in the permeability status of the

bovine aortic endothelium. Panoramic examination of the aorta by three-dimensional scanning electron microscopy revealed stripping of the luminal endothelium, with exposure of the subendothelial layer and accumulations of mural thrombus opposite the site of the balloon chamber. These observations indicate that the balloon pumping action had a key role in inflicting injury on the thoracic aorta opposite to the IABP. Among the 15 calves, each pumped with the dual-chamber balloon, five developed bilateral hindquarter paralysis. These complications were believed to result from balloon-kinking episodes. One of the animals with bilateral hindquarter paralysis was also noted to have a massive hematoma in the site of the femoral arteriotomy. Hindquarter paralysis mentioned in those reports appears to be different from the neurological deficit that we have noted, and although an IABP was used, it is of a design different from ours. Moreover, neither paralysis of the hindquarter nor neurological deficits were reported in a paper detailing clinical observation utilizing the dual-chambered IABP.¹⁵

Routine clinical studies of each of our six patients were performed while the IABP was in place, and a cold mottled leg and decreased pulses were noted in each of four of the patients. Two of those patients developed major underlying vascular problems that eventually resulted in leg amputation for one patient, and in fasciotomies below the knee for the other patient. However, to date no specific studies have been performed to evaluate the blood flow characteristics of either leg before insertion of, during use of, and after removal of the IABP. Only after a neurological deficit was suspected were clinical electromyographic examinations performed. No electromyograms were made soon after an IABP insertion, or while the device was in place. While there is no specific evidence as to the pathophysiological cause of the neurological deficit in those patients, it is possible that the complications are vascular in nature and could be associated with an obstructed blood flow or a possible thromboembolic phenomenon that was correlated to insertion, to use or to removal of the IABP. Other causes related to cardiogenic shock, open-heart surgery or presence of the cardiopulmonary bypass pump can be postulated and can be considered to be contributory, yet seem unlikely as initiating factors.

One of our patients (case 4) is the most controversial. He was clinically and electromyographically diagnosed as having bilateral peroneal nerve palsy. The peroneal nerve palsy justifiably could be associated with the IABP, because the other five patients had neurological problems. Eames and Lange⁹ reported one patient who had lateral popliteal nerve palsy after sudden occlusion of the common femoral artery; Richards⁸ reported involvement of only the median nerve in a brachial artery lesion in each of

two patients. Our patient (case 4) is the only one whose neurological deficit was worse on the side opposite to the one that had the IABP inserted, and this raises the possibility of a more proximal aortic lesion rather than a femoral artery problem as a complication of the IABP.

Further clinical evaluation, including blood flow studies and electromyographic examination before insertion, whenever possible, while the IABP is in place, and after its removal, will have to be undertaken in order to determine the exact etiology and the arterial site of the problem causing the neurological deficit.

Currently, we recommend routine beef-lung heparinization of the patient, 5000 units every 4 hours from the time of the IABP insertion to 72 hours after its removal.¹⁶ When heparin is contraindicated, the electric power to the IABP (which when inactive promotes clotting on its surface)¹⁷ should not be turned off, but rather the pressure for inflation should be reduced until no effect is seen on the central aortic pressure wave form.

Summary

The use of an intraaortic balloon pump (IABP) for circulatory assistance is a clinical therapeutic procedure predominantly for patients in cardiogenic shock, but also for patients in preshock, those with severe congestive heart failure, with refractory angina, and for patients undergoing open-heart surgery. The use of this device has increased the survival rates of patients with such problems. At Sinai Hospital of Detroit, at the time of this writing, 89 patients have been treated with the IABP, of whom 39 survived. Of the 39 survivors, six had significant neurological deficits correlated to use of the IABP, with electromyographic abnormalities in one leg or in both legs. Although the specific pathophysiology has not been determined, it is postulated that obstruction to blood flow, or thromboemboli in the femoral artery may play a role. Further clinical blood flow and electromyographic studies of patients undergoing the use of the IABP must be performed. It is important for the clinician to be aware that these neurological complications can occur; moreover, it is entirely possible that the incidence with subclinical manifestation is higher than reported in our study, as in several patients, the neurological deficit in the legs was detected first when the patients were evaluated for other medical problems. If this complication cannot be avoided or lessened, it still is a justifiable risk to use the IABP, considering the gravity of the condition when the IABP is used for care of the patient.

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