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Controlled limb reperfusion as a new surgical technique to reduce postischemic syndrome

To the Editor:

In cardiac surgical practice, acute limb ischemia may occur as a result of the insertion of an intraaortic balloon pump, emboli, dissections, and other complications. Revascularization after prolonged acute limb ischemia is associated with extremely high morbidity and mortality rates ("postischemic syndrome"), a result of combined injury during the ischemia and reperfusion phase. Our studies during the past several years[1-3] have shown that the pathophysiology of ischemia-reperfusion injury in skeletal muscle is similar to that in cardiac tissue after acute coronary occlusion. On the basis of studies of controlled reperfusion after regional myocardial ischemia,[4] which resulted in superior myocardial salvage compared with normal blood reperfusion, we developed a similar approach to skeletal muscle during the past several years.[1-3] Now that we have established the principles of controlled limb reperfusion to avoid the deleterious consequences of postischemic syndrome in isolated rat hind limbs and the in vivo pig model, we are applying this strategy in patients with severe prolonged extremity ischemia. We describe here the successful revascularization of an acute bilateral iliac occlusion after 18 hours of complete ischemia with bilateral controlled limb reperfusion.

A 61-year-old man with atrial fibrillation, previous myocardial infarction, and coronary artery bypass grafting was referred to our institution in May 1991. He had symptoms of complete acute arterial occlusion of both iliac arteries for 18 hours. Both limbs were cold and pulseless and the patient had loss of motoric function, paresthesia, pain at rest, and muscle contractures. Doppler sonographic examination revealed no flow in both lower extremities. The cause of occlusion was cardiac emboli. The patient was transferred immediately to the operating room and received systemic heparinization. Surgical treatment was performed with the patient under general anesthesia. The femoral artery was longitudinally opened from a bilateral groin incision and the emboli were removed with a Fogarty catheter. The right iliac artery was then cannulated with a wire-reinforced 22F cannula with a bullet tip to draw oxygenated blood. This cannula was connected to a reperfusion set (HP Medica, Augsburg, Germany) and the arterial line was put in the head of a roller pump (Fig. 1). An asanguineous solution bag (containing glucose, citrate-phosphate-dextrose, tromethamine, and allopurinol) was connected to the asanguineous solution line; this line was also placed in the head of the roller pump. The different

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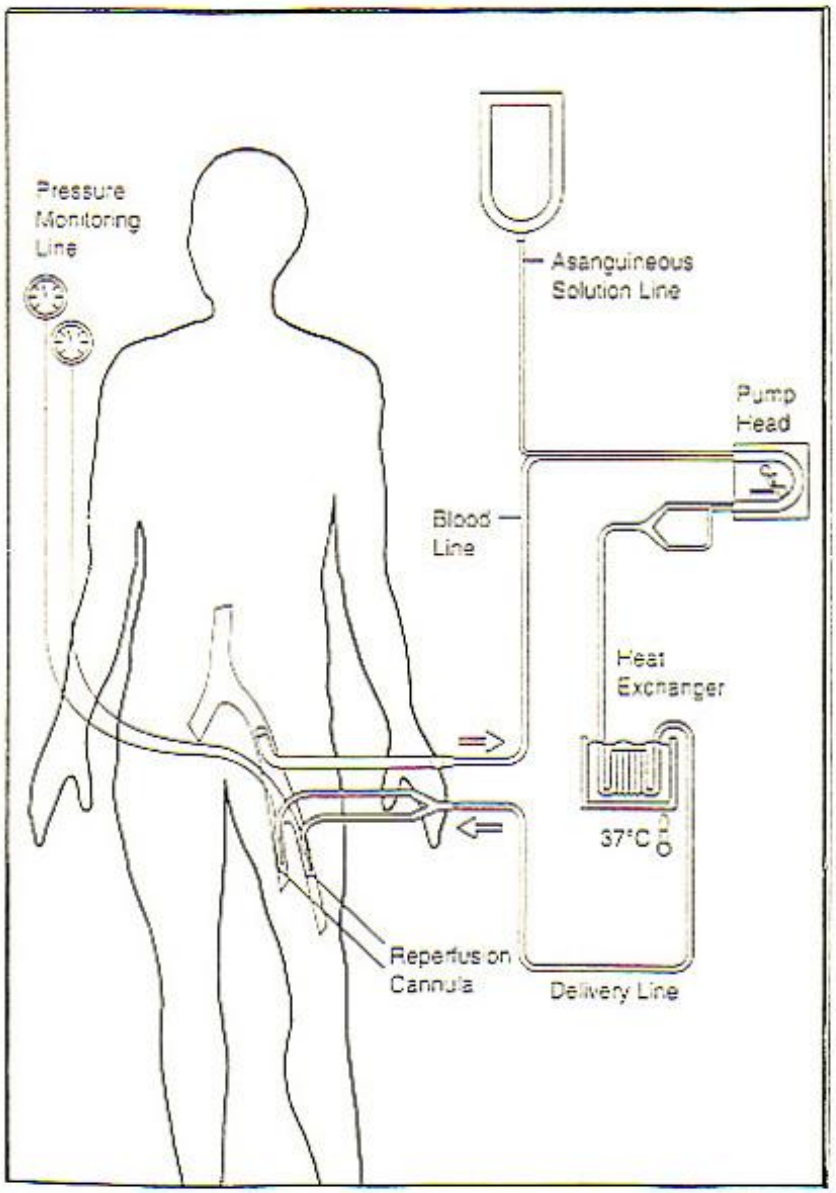

Fig. 1. Schematic representation shows the reperfusion set for controlled limb reperfusion after severe, prolonged ischemia. The iliac artery is cannulated to draw oxygenated blood from the patient. This is mixed with an asanguineous solution at a ratio of 6:1. This controlled reperfusate is warmed by a heat exchanger, passed through an arterial filter, and delivered into the femoral arteries while intraarterial pressure is monitored.

tubing diameters allowed mixing of blood and asanguineous solution at a ratio of 6:1. Both lines were connected with a Y-shaped piece and the modified reperfusate was passed through a heat exchanger and an arterial filter.

This delivery line was connected to two reperfusion cannulas, which were placed into the femoral arteries on either side (Fig. 2). The hypocalcemic, hyperglycemic, alkalotic, and hyperosmolar controlled reperfusate was given at a flow of 200 ml/min (intravascular pressure <50 mm Hg) and a temperature of 37° C for 30 minutes. The cannulas were then removed and the arterial incisions were closed with a venous patch; normal blood reperfusion was started. The metabolic investigations during controlled limb reperfusion showed tremendous oxygen and glucose uptake (Table 1) greater than control values, which suggests active cellular repair during the controlled reperfusion period. The severity of ischemia reflected by the substantial creatine kinase release in the femoral vein and the ongoing lactate production at the end of the 30 minutes of controlled limb reperfusion phase indicates the persistence of an abnormal metabolism.

Despite the prolonged (18 hours) occlusion of both lower extremities, revascularization combined with controlled limb reperfusion did not result in any systemic complications (no episodes of hyperkalemia, myoglobinuric renal failure, pulmo-

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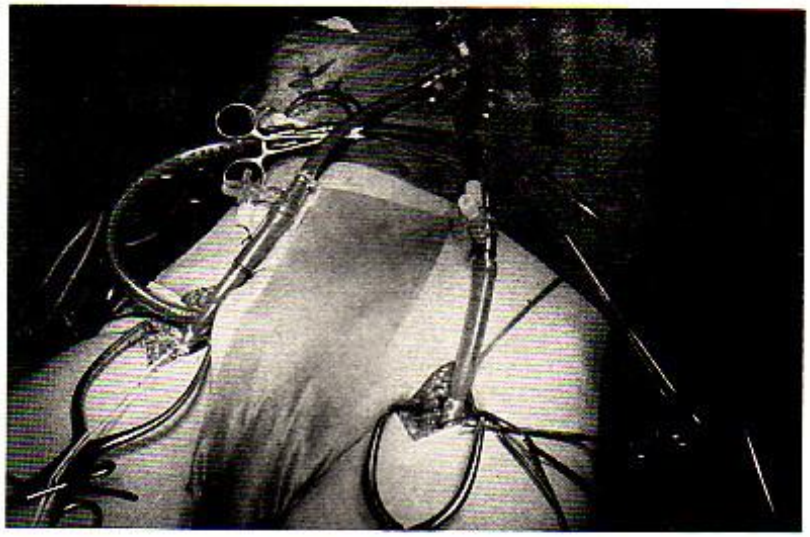

Fig. 2. Intraoperative view shows bilateral controlled limb reperfusion with cannulation of the iliac and femoral arteries.

Table I. *Metabolic data from controlled reperfusate and femoral vein during controlled limb reperfusion*

	Reperfusion		
	2 min	*15 min*	*30 min*
Venous CK (U/L)	1447	1632	2206
AV-glucose (mg/dl)	64	40	82
Percentage glucose extraction	18	12	19
AV-lactate (mg/dl)	−21.0	—	−10.2
Percentage lactate production	288	—	126
AV-O_2 (ml/dl)	8.6	5.8	4.0
Percentage O_2 extraction	52	38	29

CK, Creatine kinase; *AV-glucose*, arteriovenous glucose difference (mg glucose/dl blood); *AV-lactate*, arteriovenous lactate difference (mg lactate/100 dl blood); *AV-O_2*, arteriovenous oxygen content difference (ml O_2/dl blood).

edema, cardiac failure, or acidosis). The patient also gained complete function of both limbs at discharge, as important as the absence of systemic complications. The prophylactically performed fasciotomies were closed on the fifth postoperative day and sensory paresthesia was absent on the seventh postoperative day. At follow-up 6 months after the operation, the patient has an active life and both limbs are functioning well.

In conclusion, controlled limb reperfusion may reduce the complications seen after revascularization of severely ischemic limbs. It may thus evolve as a new surgical approach for patients with severe, acute limb ischemia.

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