Temporary Aortic Control During Resection of Distal Arch Lesions: The Innominate Factor

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SURGICAL excision of aneurysms of the distal aortic arch and proximal descending thoracic aorta introduces problems regarding the viability of organs located distal to the level of the aortic occlusion. As the necessary site of proximal occlusion approaches the origin of the arch vessels, the threat of ischemic damage to distal organs and the strain placed upon the left ventricle by the increased circulatory resistance increase the risk of operation. To reduce these possibilities, many methods have been proposed that involve either partial or total cardiopulmonary bypass or extracorporeal shunts. While we have used most of these methods in the past, during recent years, we have not used extracorporeal shunts or bypass and have relied entirely upon the patient's circulatory adaptability to support the heart, brain, spinal cord and distal viscera during the critical period, until aortic flow is resumed. In those instances in which the proximal clamp was applied between the left common carotid and left subclavian arteries, no ischemic complication occurred. When the necessity arose to cross-clamp between the origin of the innominate artery and the left common carotid artery, we were at first hesitant to proceed without supplying temporary circulation to the carotid artery. Experience gained recently, however, has assured us that when indicated, this procedure is safe.

A similarity seems to exist between the minimal *arterial* outflow tolerated by the intact anesthetized patient and the minimal *venous* inflow tolerated by the experimental animal. Thirty years ago, Andreasen and Watson[1,2] in London and Cohen and Lillehei in Minneapolis[3,4] performed experiments on anesthetized dogs. They wanted to determine the least volume of venous blood returning to the heart that would provide sufficient cardiac output to sustain viability after the full venous inflow was resumed. They found that the flow through only the azygos vein was sufficient to sustain life after a critical period of 10 to 30 minutes of venous occlusion. The flow was 8 to 14 cc per kg of body weight, which represents about 10% of basal cardiac output. In clinical situations, when temporary inflow occlusion was contemplated, their experiments established the "azygos factor" as important. They devised a crude method of pumping blood manually with a syringe from the totally occluded venous return and then returning it to the heart. From these initial experiments, it was determined that cross circulation would be a clinical possibility, thus allowing the heart to be opened for intracardiac repair. This introduced open heart surgery by extracorporeal support.

Lillehei and associates[5,6] used the azygos flow principle in applying the well-known laboratory technique of cross circulation to clinical cases. Thus, knowing that the life of a recipient could be supported by a living donor, Lillehei began his classic experiments and operations with a compatible

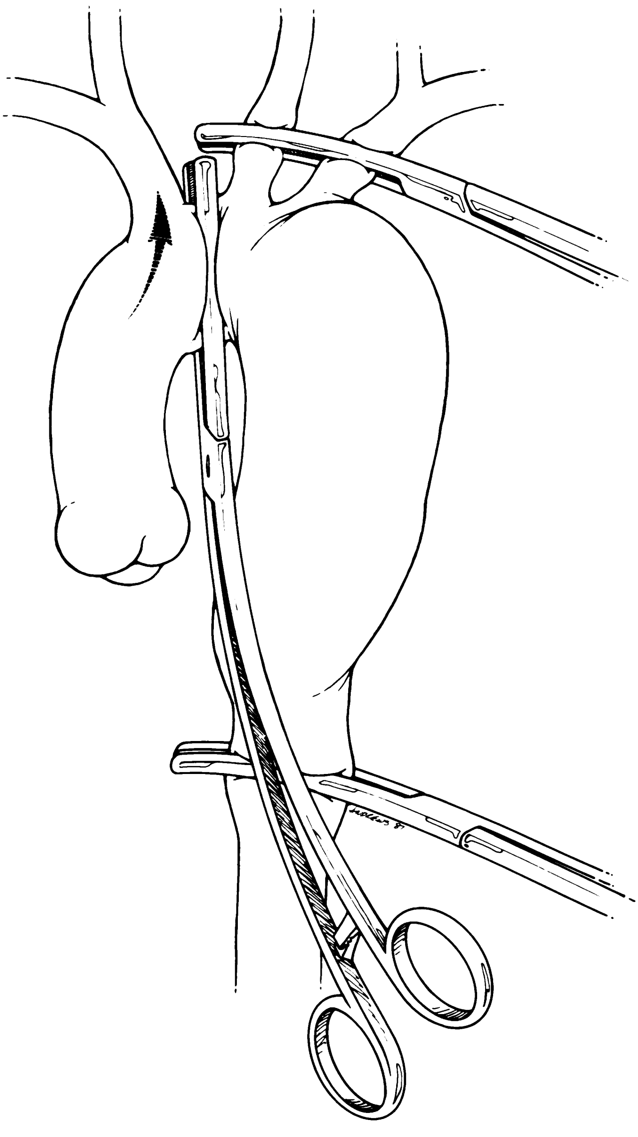

Fig. 1 This drawing shows clamps applied to the aortic arch for resection of aneurysm. Total cardiac output must pass through only the innominate artery.

blood donor, usually the patient's mother. Small children were selected because of the low volume of necessary flow for the recipient, thereby placing the donor at minimal risk from temporary hypotension. Synchronized pumps were used to control the volume of blood that passed between the two patients' venous and arterial circulations. In those early open heart operations, the need for the biological donor arose basically from the lack of a clinically reliable artificial oxygenator. In their first use of a bubble oxygenator, DeWall and Lillehei[7] employed a system of reduced or controlled venous outflow so that the volume of flow through the unproven oxygenator could be lessened. Subsequently, of course, as confidence in artificial oxygenators increased, techniques in temporary cardiopulmonary bypass permitted and encouraged a full venous outflow by gravity drainage.

We resected aortic arch lesions in 15 consecutive patients in whom the aortic arch

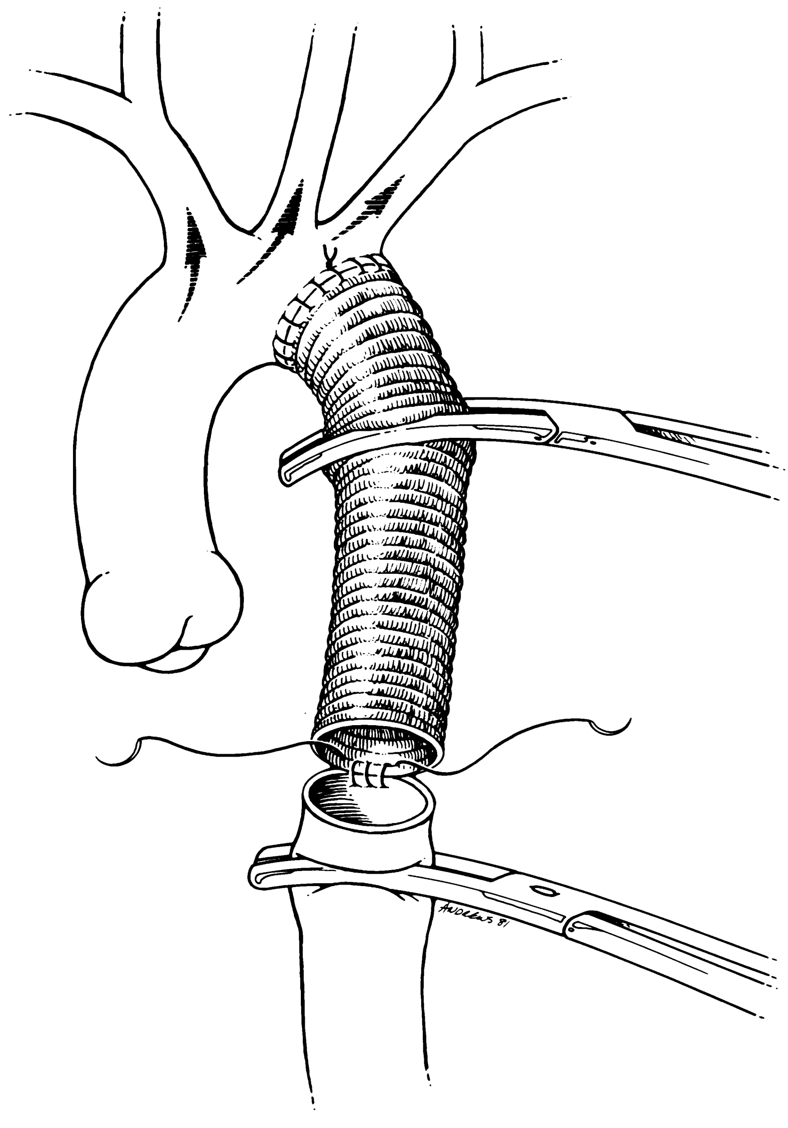

Fig. 2 After the proximal anastomosis has been completed, flow is resumed through the left carotid and subclavian arteries while the distal anastomosis is completed.

was occluded proximal to the left common carotid artery. All survived surgery without cardiac or neurological complications. The ages of patients in this series varied between 50 and 82 years with a mean of 67 years. The periods of restricted flow through only the innominate artery varied between 18 and 40 minutes, with an average of 26 minutes. The technique of arch resection that we used involved clamping the aorta just distal to the origin of the innominate artery while the left common carotid and left subclavian arteries were occluded (Fig. 1). After the proximal anastomosis was completed, the proximal clamp was replaced by a distal clamp on the graft, thus restoring left carotid flow (Fig. 2). In some instances, after the distal aortic anastomosis was completed and aortic flow was reestablished, the subclavian artery was attached separately to the aortic graft with an 8 to 10 mm fabric graft. Periods of hyper- and hypotension during the times of aortic occlusion were controlled cautiously by vasodilator and vasopressor drugs. Gradual rather than abrupt release of cross-clamps was used to control pressure changes.

The importance of the innominate factor or innominate flow principle is obvious because it permits a more complete excision of diseased aorta and extends the limit of resection without extracorporeal circulation. When faced with patients who have arch lesions in critical locations, we are reassured by the observed safety of this technique.

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