Closure of Coronary Arteriotomy in the Dog by Means of an Autogenous Arterial Patch

By Khagendra N. Chatterjee, M.B., and Richard Warren, M.D.

DIRECT OPERATIONS on the coronary artery require temporary occlusion of its blood flow, with the attendant danger of myocardial ischemia and ventricular fibrillation. Closure of the arteriotomy furthermore runs the hazard of narrowing of the artery and subsequent thrombosis. A technique has been developed in dogs whereby these hazards have been circumvented by perfusing the distal segment during occlusion of the artery and by using an autogenous arterial patch for the arteriotomy closure.

Review of Literature

Since Bailey's report in 1957 of survival in man following coronary thromboendarterectomy, and the recent development of the technique of coronary arteriography²-⁴ to localize the block, surgeons have become increasingly interested in direct operations on the artery. Success of such operations has been claimed by Crafoord,⁵ Cannon et al.,⁶ Björk and Hallen,⁷ Sabiston,⁸ and Warren.⁹ It has been generally accepted that success first depends on proper selection of patients with a localized block. The use of a patch graft for closure of the arteriotomy to prevent suture-line narrowing following thromboendarterectomy has been advocated by Senning¹⁰ and by Crawford et al.¹¹

Experimental success of the closure of a coronary arteriotomy with a patch graft has been reported by Senning,¹⁰ DeBakey and Henly,¹² and Ellis et al.¹³ by using cardio-pulmonary bypass during the procedure. Thal and associates¹⁴ performed anastomosis between the internal mammary artery and the left circumflex coronary artery in the dog while perfusing the distal coronary artery with oxygenated blood under pressure. The glass cannula used in the perfusion was inserted through the anastomotic area via the subclavian and internal mammary arteries. Forty-two per cent success was reported, with a follow-up of six months. Absolon et al.¹⁵ have performed anastomosis between a systemic artery and the coronary artery in the dog by using a polyethylene shunt from the aorta to preserve myocardial blood flow. Following this experience, they have recommended cardiopulmonary bypass during the procedure. Ellis and Cooley¹⁶ have reported a 70 per cent patency of the patch segment when autogenous arterial tissue was used. Chatterjee et al.¹⁷ have reported the histological superiority of autogenous arterial tissue over autogenous venous tissue when used as a patch graft in a small-caliber artery.

Materials and Methods

Figure 1 demonstrates the technique employed. Intravenous pentobarbital sodium anesthesia (30 mg./Kg. body weight) was used, and artificial respiration was instituted via a positive-pressure respirator and cuffed endotracheal tube. A left thoracotomy was made at the fifth intercostal space. The left internal mammary artery was dissected for about 5 cm. Small branches were sacrificed. A bulldog clamp was applied to the proximal side of the artery, and the distal end was ligated and cut. A no. 240 polyethylene tube was inserted into the proximal segment of the artery, the distal end was closed with a stopcock, and the arterial clamp was removed. From time to time, the tube was flushed with heparin solution (10 mg./L. normal saline). The distal 2 cm. of the internal mammary artery mounted on the tube was then detached from the main artery by a circular incision, but was left on the tube wrapped in gauze soaked with saline.

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The pericardium was opened anterior to the phrenic nerve. The left atrial appendage being retracted upward, the epicardium over the left anterior descending artery (four dogs) or the circumflex coronary artery (eight dogs) was excised and the artery was dissected carefully for 4 cm. without sacrificing any branches. Two threads were passed around the artery to control the flow during the procedure. A 10- to 15-mm. incision was made anteriorly between the two threads while the artery was clamped proximally with a small bulldog clamp. The backflow from the arteriotomy was controlled by pulling up the distal thread. The stopcock was removed from the end of the polyethylene tube which was then inserted into the internal mammary arteriotomy to perfuse the distal segment of the clamped coronary artery.

The period from the onset of arteriotomy to the beginning of perfusion was less than a minute. The excised distal segment of the proximal part of the internal mammary artery was slid down the tube until it came in contact with the arteriotomy wound. The segment was cut open and trimmed piecemeal as the sutures (7-0 arterial silk treated with mineral oil) were placed. The polyethylene tube was withdrawn prior to the final tie; simultaneously, the bulldog clamp on the coronary artery was removed to re-establish the original blood flow through the patched segment. Any bleeding from the suture line was controlled with gentle gauze pressure. The pericardium was sutured with interrupted sutures and the chest closed. A thoracic tube was placed in the dependent portion; it was removed in the same evening. Penicillin, 400,000 units, was injected intramuscularly for three consecutive days. Heparin was not used for fear of postoperative hemorrhage.

Results (Table 1)

Many preliminary experiments were performed to develop the technique. Those reported here are a consecutive group of 12 operations performed after the technical problems had been satisfactorily solved.

The 12 dogs are divided into three groups: group A, those in which the segments remained open for at least one week (six dogs);
group B, those which died on the first day from operative hemorrhage or other immediate cause associated with the operation, and group C, those in which the segments closed within hours or days and which died of myocardial infarction (three dogs). If one excludes the three dogs of group B as having no bearing on the appraisal of the success or failure of the patch technique, a success rate of 66 per cent (six of nine) may be reported.

The state of patency of this segment was determined by coronary angiography in all animals that survived longer than seven days (fig. 2), and by barium injection, as well as direct inspection, in all those that died, whether early or late. Three animals have been kept as long-term survivors and are now (1/8/62) living 220, 173, and 64 days since operation. In one of these, a second coronary angiogram was done at six months (fig. 3).

In four of the dogs, electrocardiographic tracings were done during the procedure. Figure 4 shows that there was no alteration of the tracing at any point.

Figure 2
Coronary arteriogram at eight days. The patent segment in the left circumflex coronary artery of dog no. 3 is shown.

Figure 3
Coronary arteriogram at six months. The patent segment in the left circumflex coronary artery of dog no. 1 is shown.

Figure 4
Electrocardiogram during operation. Lead II of the electrocardiogram of dog no. 6 shows no alteration during the procedure.
Results of the Patch Segments

<table>
<thead>
<tr>
<th>Dog no.</th>
<th>Artery used</th>
<th>Days</th>
<th>Dog no.</th>
<th>Artery used</th>
<th>Days</th>
<th>Cause of death</th>
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<td>Cir.§</td>
<td>6</td>
<td>7</td>
<td>L.A.D.</td>
<td>1</td>
<td>Effect of anesthesia</td>
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<td>Cir.</td>
<td>21</td>
<td>8</td>
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<td>1</td>
<td>Hemothorax</td>
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<td>3†</td>
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<td>9</td>
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<tr>
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<td></td>
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</tr>
<tr>
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<td>Cir.</td>
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<tr>
<td>6*</td>
<td>Cir.</td>
<td>52</td>
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<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Long-term survival.
†Expired.
‡Sacrificed.
§Cir. = circumflex coronary artery.
||L.A.D. = left anterior descending coronary artery.

Histological study was performed on the operated segments of four dogs which were sacrificed between 14 and 45 days for this purpose. A moderate thickening of both the patch and the adjacent artery was found to consist of smooth muscle and fibrous tissue. No mural thrombus was seen. The internal elastic lamina of the patch was fragmented. There was no evidence of myocardial infarction in the hearts in which the segment was patent.

Discussion
A 66 per cent patency rate for the closure of an incision in an artery 1.5 to 2.5 mm. in diameter indicates a promising future for the clinical application of this technique. The question of whether lasting success can be achieved in a diseased vessel after thromboendarterectomy is still to be answered, but since the coronary arteries in man are more than twice the size of those used here, there is no apparent anatomical obstacle to it.

Summary
A simple technique of application of a patch graft to a coronary arteriotomy without using a cardiopulmonary bypass is described. Twelve dogs were subjected to this procedure, the circumflex coronary artery being used in eight, and the left anterior descending coronary artery in four. A 66 per cent patency of the segment was obtained. In one dog, a coronary arteriogram showed a patent segment six months later. Histological study revealed some intimal thickening of the patch, as well as of the host artery. Gross myocardial infarction was observed in those with occluded segments.

References
11. Crawford, E. S., Beall, A. C., Jr., Ellis, P. R., Jr., and DeBakey, M. E.: Technique per-
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