Submergence of Bleeding Coronary Artery in Myocardial Tunnel: Experimental Study.* (23907)

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The operation of coronary endarterectomy for some cases of obliterating arteriosclerotic heart disease has been proposed for human patients. Bailey(1) and his colleagues have reported success with this method in clinical cases. The present report describes a study in which a freely bleeding coronary artery has been submerged in a myocardial tunnel. Such a procedure may augment coronary endarterectomy in those cases in which a direct surgical approach to the coronary arteries is contemplated.

Method. Twenty-five mongrel dogs of both sexes varying in weight from 15 to 40 lb were operated on under nembutal anesthesia. Ventilation was carried out with a positive pressure respirator connected to a tracheal cannula. In each animal the heart was exposed through the fourth left intercostal space. The pericardial sac was opened by an incision parallel to the phrenic nerve. The anterior descending or Circumflex Ramus of left coronary artery was dissected free from surrounding tissue, beginning one cm distal to bifurcation of main artery, and extending some 3 cm along length of the vessel. Endeavors were made to retain as many branches as possible of these primary coronary arteries. In all cases, however, it was necessary to ligate small branches, particularly those to the left auricle. Caution was required in freeing the left anterior descending vessel from its venae comitantes and their tributaries. Further hazards arose when dissecting perforating myocardial branches arising from the posterior walls of the coronary arteries. The coronary artery having been dissected free, a site of implantation was prepared on the anterior surface of left ventricle beneath normal course of the vessel. A tunnel not less than one inch in length was prepared, commencing 2 cm from anatomical origin of coronary artery at the aorta. A small curved mosquito forceps was inserted through scalpel incision in the epicardium and eased through the myocardium along path of the future tunnel. At its point of emergence the forceps was spread widely and the myocardium incised along tunnel with a scalpel. The trough so formed was deepened 1 cm towards the endocardium. Bleeding from the myocardial bed was minimal, rarely being more than a slow ooze. Preparations for the endarterectomy incision were then made. A common elastic soft rubber band was passed about the coronary artery proximally so as to be able to occlude blood flow through the vessel at will. In these operations the vessels have been totally occluded for periods to three minutes with no serious consequences. Following tension upon the elastic band with temporary cessation of flow in the selected coronary vessel, an elliptical excision varying in size from 2-3 mm was made with scalpel and Iris scissors in posterior wall of coronary artery. Through this opening a May Curette or Spoon Curette was then introduced into the coronary artery in both directions. Presuming conclusion of endarterectomy, the bleeding artery was then submerged in the preconstructed trench and the myocardium sutured over it with 0000 silk, care being taken not to occlude the vessel at its entrance into, or its exit from, the trench. Release of the elastic band was followed by oozing of arterial blood from the implanted vessel, but this was controlled by gentle pressure. Patency and continued function of the vessels have been demonstrated at autopsy sacrifice. In a few cases, immediately following the procedure, the main coronary artery was severed distal to the tunnel. Regular pulsatile ejection of coronary arterial blood was observed. In no animal operated on in this study did a

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TABLE I. Analysis of Animals Surviving Submergence Operation.

Artery submerged	No. of dogs	Weeks post-surgery at sacrifice	State of submerged coronary artery	Remarks
		10-22 wk		
Left anterior descending coronary artery	11	3 at 10 wk 5 at 12 " 1 at 19 " 1 at 20 " 1 at 22 "	8 patent 2 completely stenosed 1 partially "	Regeneration of endothelium at point of excision, 1 animal at 22 wk. Patency demonstrated by vinyl plastic inj. mass, 8 animals.
		10-22 wk		
Left circumflex coronary artery	6	2 at 10 wk 2 at 12 " 1 at 20 " 1 at 22 "	6 patent	Regeneration of endothelium at point of excision, 2 animals. Patency demonstrated by vinyl plastic inj. mass, 4 animals.

hematoma form about the tunnel. The final stage in the operation was to close the pericardial sac and the chest wall. The anatomical distribution, patency of coronary arteries, and site of endarterectomy incision were evaluated at 9-22 weeks following surgery.

Results. Of the 25 dogs operated on 17 survived for critical analysis of the submergence technic at autopsy sacrifice. The results are summarized in Table I. Two further animals surviving operation died within the first postoperative week of pulmonary causes. One animal was found at post mortem to have had massive atalectasis and pneumonia. The other animal died of distemper. The remaining 6 dogs died during the course of procedure, and all were mortalities in early experience-gaining stage of the study. No fatality was encountered in the last 15 submergence operations. The cause of death in the initial cases was invariably an irreversible ventricular fibrillation accompanied by some degree of blood loss and incorrect closure of the myocardial tunnel. It was noted that a tendency to early ventricular fibrillation was more frequently found to accompany mobilization of the Left Circumflex Coronary Artery.

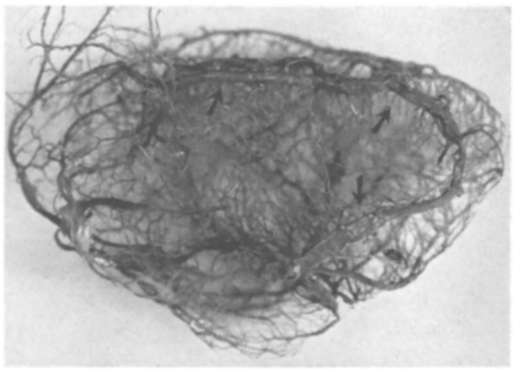

FIG. 2. View from above of circumflex coronary artery (arrows) inj. with vinyl plastic mass 12 wk following submergence operation.

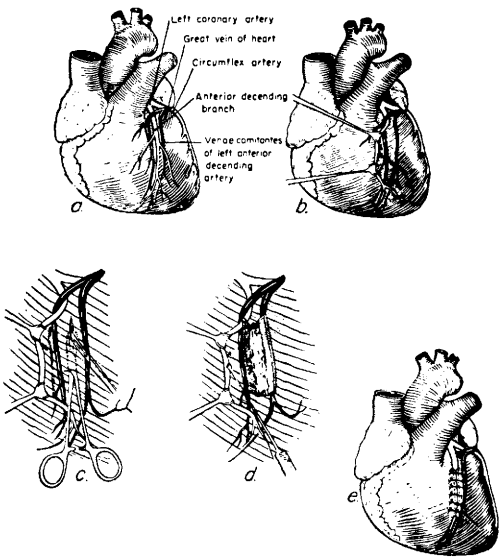

FIG. 1. Submergence procedure for coronary endarterectomy. *(a)* Anatomical structures *in situ*. *(b)* Dissected left anterior descending coronary artery retracted. *(c)* Preparation of submergence tunnel. *(d)* Endarterectomy procedure completed. *(e)* Bleeding coronary artery submerged.

In only 2 surviving animals was a severe complete stenosis of the submerged endarterectomised vessel demonstrated. It seemed probable that such complete obstruction of the coronary arteries was due to an inadequate construction of the tunnel causing angulation of the submerged coronary vessel at the

site of entry to or exit from the submergence tunnel.

Four dogs were sacrificed at 20-22 weeks after operation. There would appear to be no apparent reason why they might not have survived indefinitely, intercurrent disease excepted. In these 4 animals the thoraces were opened under similar conditions to those in the original operation and the submerged vessel was dissected. In 3 cases the vessel was widely patent throughout its entire course, including the segment submerged. In one animal there was narrowing of the vessel with partial obstruction. The sites of excisions in the coronary arteries were identified in these animals as navicular shaped depressions *over which a very thin endothelial membrane had grown* thereby restoring the continuity of the blood vessel wall. The endothelium was "pearly" and clear in other parts of the vessels. In the remaining survivors, sacrifice occurred at a period of 9 to 12 weeks following the submergence operation. The coronary architecture of these animals was investigated utilizing vinyl plastic injection corrosion casts of the coronary arteries(2). No increase in intercoronary anastomoses in the region of the endarterectomy incision and in the area of the myocardial tunnel could be demonstrated when these casts were compared to a standard of anatomy found in fifty normal dogs.

Discussion. The heart muscle is provided with a vasculature more unique and complex than in any other part of the body where arterioles open into a capillary bed which is in turn drained by a system of venules. The architecture of the heart, as in all specialized organs, is peculiar to itself and myocardial muscle presents great differences from skeletal muscle, particularly in its sinusoidal sponge-like character in which true hematomas are seldom, if ever, formed. The present experiments leave no doubt in the vinyl plastic injection casts and the dissection specimens that an incised coronary artery may remain patent with demonstrable blood flow in the majority of animals. An opening left in the coronary artery at time of submergence invariably closes apparently. It would appear unlikely that new collateral branches develop following submergence of a bleeding coronary artery as occurs in some 46% of cases of the Internal Mammary Artery Implantation procedure of Vineberg(3).

A direct surgical attack upon a blocked coronary artery has very much to recommend it as a method of reirrigating an ischemic myocardium, and additionally a point of real interest has been the demonstration of the regeneration of coronary endothelial membrane restoring the continuity of the coronary blood vessel in a normal heart without any late evidence of thrombus or clot formation at the site of excision in the artery.

Summary. 1) An experimental technic developed in dogs is described in which an endarterectomy incision into a normal major coronary artery has been followed by submergence of the freely bleeding coronary vessel into the myocardium. Such a coronary artery was demonstrated to remain patent in 15 of 17 dogs in which the submerged artery was studied at intervals of 9 to 22 weeks after surgery. The procedure has been free from thrombosis that not uncommonly attends insertion of coronary by-pass prostheses or anastomotic procedures upon the coronary arteries. 2) Regeneration of coronary endothelium has been demonstrated at 22 weeks unattended by clot or thrombus formation. It would appear likely that in the operation of coronary endarterectomy upon man the present procedure may simplify the operation and serve as a satisfactory method of controlling the opened vessel in those cases in which pathological change in the coronary artery makes closure of the arteriotomy wound undesirable.

1. Bailey, C. P., May, Angelo, Lemmon, W. M., *J. Am. M. Assn.,* 1957, v164, 641.

2. Day, S. B., *Surgery,* 1957, v41, 220.

3. Vineberg, A. M., Munro, D. D., Cohen, Herman, Butler, W., *J. Th. Surg.,* 1955, v29, 1.

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