Use of Intestinal Loops for Revascularization of the Heart

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Intestinal loops brought up through the diaphragm and attached to the myocardium will cause the formation of connections between the vascular supplies of the heart and intestine. The vessels that develop between these two organs are large enough to transmit thick suspensions of barium sulfate. India ink injected in the mesenteric vessel can be readily found on all surfaces of the heart as well as deep within the myocardium.

In attempts to discover new methods of revascularizing a heart crippled by coronary artery sclerosis, numerous methods that stimulate the production of vascular channels between extracardiac tissues and cardiac muscle have been devised. Thus skeletal muscle,1 lung,2,3 omentum4 and pericardium5 have been attached to the heart with the hope that new channels would develop between these tissues and myocardium. In addition, shunts have been created between the coronary sinus and a systemic artery,6 and the internal mammary artery implanted into the myocardium.7 By using various injection techniques communicating channels have been demonstrated; however, these channels, as demonstrated by visualization techniques, usually were not numerous nor large. These findings may have been predicted only because of the tissues used. Clinical appraisal of the various methods has met with some success. Because of the highly vascular nature of the gastrointestinal tract, it appeared to us that this might be an excellent tissue to use as a source of new blood supply to the heart.

The present investigation was undertaken in order to study the visual development of collateral vascular channels, if any, between the myocardium and portions of the gastrointestinal tract.

Materials and Methods

Thirty-six young and adult mongrel dogs of both sexes were used for the experiments. The operative procedures were divided into two stages for the sake of convenience. At the first stage, the abdomen was opened utilizing Nembutal anesthesia and sterile operative technic. The proximal jejunum or the distal ileum was divided and the distal loop closed. The closed loop was then suspended from the tendinous portion of the diaphragm by a single loosely tied suture. Continuity of the intestinal tract was re-established by end-to-side anastomosis (Roux-en-Y). After a recovery period of two weeks, the second stage of the operation was done through a left thoracotomy incision in the sixth intercostal space. The previously prepared segment of intestine was delivered into the chest through a small incision in the diaphragm. The serosa of the gut was stripped away for a distance of 8 to 10 cm. from the closed end. Similarly, the epicardium of the anterior one-half of the left ventricle was stripped away from the myocardium by blunt dissection. The stripped surfaces of gut and myocardium were placed in apposition so as to cover the exposed branches of anterior descending or circumflex arteries, and maintained by suture of blind loop of gut to myocardium and closure of the pericardium over the heart and gut.

From one to three months after surgery, the animals were studied for the presence of vascular channels between the intestine and the heart using vascular injection techniques. A branch of the superior mesenteric artery was cannulated with an 18 gage blunt-nosed needle. The vascular bed was flushed with normal saline solution and followed by the pulsatile injection of india ink using a 10 cc. syringe. In 28 animals a thick barium sulfate mixture was injected in similar fashion following the ink injection. The vascular channels were observed by direct inspection during injection, by roentgenograms taken during injection, and by histologic examinations of fixed specimens.
RESULTS

In all 36 animals vascular channels between the intestine and the myocardium were easily demonstrated by the injection of India ink. In many instances ink could be seen beneath the endocardial surfaces and in the papillary muscles of the left ventricle. Ink could be observed flowing in the major coronary arteries of the left ventricle and flowing out of the coronary ostia within the aorta. In 22 of 28 animals in which barium sulfate injection followed the India ink injection, similar findings were observed. Barium flowed easily from the intestinal to the coronary vascular bed, displacing the India ink. Roentgenograms of the specimens revealed complete filling of the coronary system. The anastomotic channels appeared to be of large caliber and transmitted the pulsatile flow (fig. 1). Histologic examination of these channels confirmed this impression.

DISCUSSION

The stimulus for the development of anastomoses between the vessels of the heart and the intestine is not known at this time. Both organs were morphologically normal in all respects. Previously it has been suggested that blood vessels from an extracardiac source will grow into the myocardium when the latter has need for more blood. It would appear that under the experimental conditions presented, vascular anastomoses develop between the myocardium and the intestine without the apparent need for blood by either of these organs. Vascular channels develop from myocardium to intestine, but the stimulus for this is not apparent, since the blood supply to the intestine was completely normal anatomically. In one of our other animals in which epicardial and serosal stripping was not attempted, there was no adherence whatsoever between the two organs. It has previously been suggested that the epicardium may act as a barrier to the development of vascular adhesions to the myocardium. Whether the channels developed will serve as an adequate blood supply for an ischemic heart remains to be seen. Our ability to inject barium sulfate suspensions in the mesenteric artery and then to demonstrate its presence in both the connecting vessels and in the coronary vessels suggests that the communications are of at least arteriolar size. It has been shown that barium sulfate suspensions are too thick to pass through capillary sized channels, but will fill vessels of arteriolar size. Whether the size of the channels would increase with a differential gradient of flow such as probably would be present if the coronary arteries were ligated is unknown.
SUMMARY

In a series of dogs, Roux-en-Y loops of small intestine were brought through the diaphragm and sutured to the heart after the serosa of the gut and the epicardium of the heart had been stripped from these structures. Arterial vascular channels could easily be demonstrated between these organs by injection techniques and histologic study. The vascular channels formed were large enough to allow passage of thick barium sulfate suspensions.

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