Experimental coronary artery surgery

Long-term follow-up, bypass venous autografts, longitudinal arteriotomies, and end-to-end anastomoses

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In a previous report we described the results in 65 dogs that had experimental coronary artery procedures performed and were followed up to 6 months. Nine of these animals were kept from periods of 2 to 5½ years. This paper reports the long-term observations of these animals. The study was undertaken to evaluate (1) long-term patency, (2) suture line healing, (3) late development of thrombosis, (4) dimensional alteration of vessels, and (5) histologic behavior of bypass venous autografts, longitudinal arteriotomies, and oblique end-to-end anastomoses.

Materials, methods, and results

This series consists of 5 dogs with aorto-circumflex coronary bypass venous autografts, 2 with longitudinal arteriotomies, and 2 with oblique end-to-end anastomoses of the circumflex coronary arteries. All animals in this series were operated upon under systemic hypothermia (30°—32° C.) without circulatory maintenance by shunt or bypass. None of the animals received anticoagulants.

The status of the coronary repair was studied by serial arteriograms and by morphologic studies after death.

Bypass aorto-circumflex coronary venous autografts. The long-term fate of a segment of the left external jugular vein employed as a free graft between the upper descending thoracic aorta and the circumflex branch of the left coronary artery (Fig. 1) has been observed in 5 dogs. These animals were kept from 4 to 5½ years (average 5 years). Periodic arteriograms were done on all animals. All grafts dilated except the distal portion of one that had partially thrombosed early in the study. The average increase in the greatest diameter of these grafts was three times the original size (original size, 8 mm.). In only one could the dilatation be classified as aneurysmal. Representative grafts are shown in Fig. 2.

The aortic and the coronary anastomoses showed no evidence of luminal narrowing and were well healed. Microscopic sections of the bypass graft showed that the fibromuscular component (media) of the vein had increased in thickness by three and one-half times (Fig. 3).
The area of myocardium supplied by the graft was normal and the grafts were free of thrombosis and fibrin except for the one from the animal with the partial thrombotic occlusion of the bypass graft. This dog's myocardium showed some disappearance of muscle cells and replacement by fatty tissue. However, the circumflex coronary artery in this animal was visualized each time an arteriogram was done. At no time during this animal's 4½ year postoperative course was there any evidence of myocardial failure.

**Longitudinal arteriotomies and oblique end-to-end anastomoses of the circumflex coronary artery.** Two dogs with longitudinal arteriotomies and 2 dogs with end-to-end anastomoses were observed. One dog from each series was sacrificed at 2 years. The remaining 2 were sacrificed at 3½ years. Serial arteriograms showed no luminal narrowing. Gross and microscopic examination of all specimens revealed excellent healing of the suture line without significant intimal proliferation over the sutures or degenerative changes (Fig. 4).

**Discussion**

The dilatation herein reported with long-term bypass aorto-coronary external jugular venous autografts represents the fate of a very thin-walled vein employed as an arterial graft in the thoracic cavity.¹ The changes noted (dilatation and fibromuscular hyperplasia) are similar to those seen in the vein in cases of arteriovenous fistula. We consider it of particular significance that: (1) four out of five grafts showed no thrombus build-up, (2) suture line healing was good without evidence of luminal narrowing, (3) myocardium supplied by this important branch of the coronary artery functioned well for many years without evidence of damage except in 1 animal which had partial thrombus occlusion of its graft, and (4) no graft rupture occurred.

Our studies provide no information as to whether or not such dimensional dilatation would occur with a thicker-walled vein, such as the saphenous. It seems reasonable to believe that the dilatation would not be any greater and probably would be less with a thicker walled vein. Fig. 5 compares

![Diagram of coronary artery bypass graft](image-url)

**Fig. 1.** Diagram and view at operation of aorto-circumflex coronary bypass venous autograft. (From Sauvage et al.: J. Thoracic & Cardiovas. Surg., December, 1963, published by The C. V. Mosby Company.)
Fig. 2. Arteriograms of 2 animals with aorto-coronary venous autografts. A and B: Arteriograms of 1 animal at 1 week (A) and 5 years (B) show the progressive dilatation that took place in the bypass grafts. C and D: Arteriograms of 1 animal at 3 months (C) and 4 years (D) in which aneurysmal dilatation of the bypass graft occurred. Note good coronary flow (CF) in all arteriograms. Gross views of both these animals are shown in Fig. 3.
Fig. 3. Gross and microscopic specimens of aorto-coronary venous bypass grafts (arteriograms seen in Fig. 2). A and B: Gross specimens inflated with air at 120 mm. Hg show the dilated bypass graft. A shows uniform dilatation as seen in 4 out of 5 animals. B shows the 1 animal which had aneurysmal dilatation of the bypass graft. C and D: Microscopic sections (×100; Masson's trichrome stain) of the specimen shown in A. C, Section through the aortic anastomosis (arrow) of the bypass graft. The lumen is in the upper righthand corner. A thin pannus growth has covered the anastomosis and beneath this excellent healing has taken place. D, Section from the middle of the bypass graft which shows proliferation of circular muscle, collagenous tissue, and longitudinal muscle of the fibromuscular layer (media) which measures 200 microns. This is an increase of three and one-half times in thickness of fibromuscular layer over that of the normal external jugular vein of the dog. The total wall thickness (fibromuscular and adventitia) measured 600 microns.
Fig. 4. Long-term end-to-end anastomosis and longitudinal arteriotomy of circumflex coronary artery. 

A, Arteriogram of end-to-end anastomosis 2 years postoperatively. This is representative of all arteriograms delineating end-to-end anastomoses and longitudinal arteriotomies. Serial arteriograms showed no luminal narrowing. 

B, Gross specimen of end-to-end anastomosis at approximately 2 years. Arrow indicates area of anastomosis. Healing was excellent without luminal narrowing. 

C, Gross specimen of longitudinal arteriotomy at approximately 3½ years. The suture line is covered by a thin layer of transparent tissue. 

D, Microscopic section (×100) which is representative of the healing of the end-to-end anastomoses and longitudinal arteriotomies. Note the thin pannus growth over the luminal surface of the suture.
Fig. 5. Comparison of jugular vein and saphenous vein in dog and man. Same magnification throughout (×40), with all measurements in microns (Masson's trichome stain used). A, Normal canine jugular vein such as is used for aorto-coronary bypass. Fibromuscular layer (media) is 60 microns thick. Total wall thickness (fibromuscular and adventitia) measured 400 microns. B, Saphenous vein of dog. Fibromuscular layer measures 120 microns; total wall thickness 340 microns. C, Human jugular vein from a 65-year-old woman. Fibromuscular layer measures 100 microns. Total wall thickness: 500 microns. D, Human saphenous vein from a 79-year-old man who had no known disease of this vessel. This section was taken from the upper third of the vein. Fibromuscular layer measures 800 microns. This vein shows variable wall thickness and hyperplastic intima containing muscle cells. Note the well-defined circular and longitudinal fibromuscular layers.
the jugular and saphenous veins of dog and man and shows the fibromuscular layer of the human saphenous vein to be twelve times thicker than that of the canine external jugular vein.

It is reassuring to observe that longitudinal arteriotomies and end-to-end anastomoses can heal without stricture formation and remain patent over long periods of time.

Summary

A follow-up study of 5½ years of 9 dogs undergoing experimental coronary artery surgical procedures has been presented. Bypass aorto-circumflex coronary grafts, employing the external jugular vein, have been found to undergo significant dilatation.

Longitudinal arteriotomies and oblique end-to-end anastomoses of the coronary arteries were found to maintain long-term patency without stricture formation or histologic evidence of degenerative change.

REFERENCES


(For Discussion, see page 631)