Internal Mammary Artery Implantation for Angina Pectoris:

Angiographic Evaluation of Beck and Vineberg Procedures

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FROM a series of 130 patients with angina pectoris treated by operation, 100 have been followed and our impression that operation is worthwhile has been confirmed. The Beck procedure relieved symptoms in two thirds of the patients and increased capacity for work in 41 per cent.[8] Because the degree of improvement was modest we became interested in the possibilities of thrombendarterectomy. Our first patient treated by thrombendarterectomy for a completely occluded left descending coronary artery has, after 5½ years as shown by coronary angiography, a patent artery and is free of symptoms and working full time. He is able to perform a workload of 600 kilopondmeter per minute at the age of 70. Generalized disease in all three major coronary arterial branches has made implantation of the internal mammary artery, according to Vineberg,[11] an alternative operation. Bigelow *et al.*[2] showed, by cineangiography, flow of contrast medium to the heart via the implanted artery, and in two patients followed for 5 years they demonstrated a communication with the coronary system.

This paper discusses the technic and results obtained in a follow up of the first 22 patients having internal mammary artery implantation together with the Beck operation and evaluates results of adding the Vineberg procedure to the Beck operation.

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Material

Of 130 patients 84 have been operated upon according to the Beck procedure, nine have had thrombendarterectomy[8] and seven have had resection of left ventricular aneurysms.[3] In 30 patients the Beck operation has been combined with internal mammary artery implantation into the left ventricle according to Vineberg.

Technic of the Vineberg Procedure

The original technic of Vineberg included implantation of the internal mammary artery in the anterior part of the left ventricle. The internal mammary artery was ligated at its distal end and the two distal side branches were left open in the tunnel produced in the myocardium. This technic left a blind sack at the end of the internal mammary artery in which thrombosis may have caused occlusion of the majority of implants performed earlier. Bigelow left the distal end of the internal mammary artery open within the myocardium and we have done likewise (Fig. 1) since he was the first to show long-term patency of the internal mammary artery by cineangiography. A tunnel between 2–3 cm. long is prepared within the myocardium of the

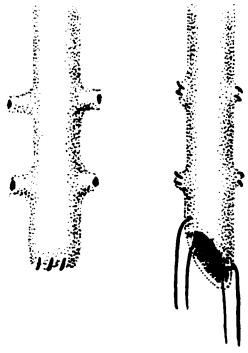
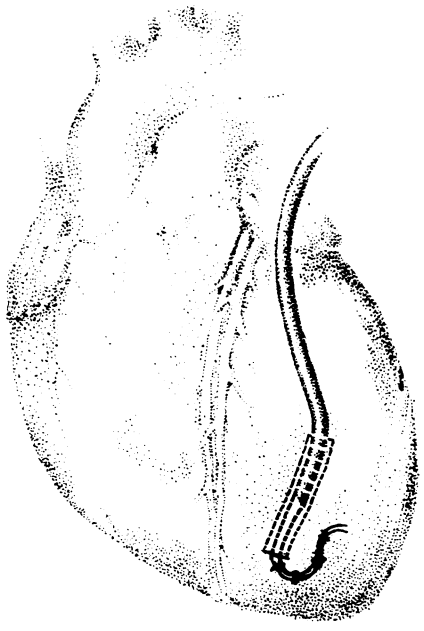


FIG. 1. (Left) Diagram demonstrating the original Vineberg technic for implanting the internal mammary artery and to the left the modification suggested by Bigelow.

FIG. 2. (Right) Diagram demonstrating the internal mammary artery in its tunnel and the fixation by a loop of fine silk sutures through the end of the artery sutured to the anterior wall of the left ventricle.



left ventricle anteriorly. The internal mammary artery is divided obliquely and two 5-0 sutures passed through opposite margins of the cut opening. The artery is not clamped, only manually compressed by fingers during this period, and blood is flushed through the artery intermittently to prevent thrombosis and undue trauma to the intima. The two silk sutures are tied to make a knot 1 cm. from the end of the artery. Then the sutures and the artery are drawn through the tunnel in the myocardium and once the knot is visible the silk sutures are tied to the thread in a position which provides that the opening of the internal mammary artery is left half way in the tunnel. The loop of silk on the anterior side of the left ventricle is fixed to the ventricle by a row of fine silk sutures each tied to the loop (Fig. 2). The distal incision in the myocardium is closed by isolated sutures and the central hole into the tunnel is left open and permitted to bleed until bleeding stops spontaneously. Any suture in this central opening of the tunnel may kink the implanted artery and facilitate thrombosis. If the internal mammary artery is left open to bleed without resistance it flows at the rate of about 15–20 cc./min. Flow through the internal mammary artery was measured with an electromagnetic flowmeter. A mean flow rate of 15 cc./min. and a systolic peak flow of 20 cc./min. was measured in two instances. Immediately after implantation of the internal mammary artery the same mean flow of 15 cc./min. and the same peak flow could be measured by the electromagnetic flowmeter as before implantation.

Removal of the epicardium and abrasion of the inside of the pericardium is performed before the internal mammary artery implantation. Trichloracetic acid is, however, spread over the heart *after* implantation as is introduction of asbestos powder in the pericardial sack. Prepericardial fat tissue is approximated to the pericardium, care being taken not to kink the internal mammary artery.

Results

Of the 30 patients operated upon by a combined Vineberg-Beck procedure two died in the postoperative period. One death was of a 58-year-old man (Case 17) who

TABLE 1. *Clinical Data and Postoperative Results with Angiographic Investigation*

No.	Sex	Age	Angina Duration (yr.)	Infarction	Heart Size (ml./m.²)	Serum Cholesterol (mg. %)	Blood Pressure (mm. Hg.)	Preop. Coronary Angiogram		
									Left	
								Right	Descending	Circumflex
1	M	46	2	−	440	400	140/90	3	2	4
2	F	39	3	−	340	300	150/100	3	3	2
3	M	58	5	−	460	230	165/95	3	2	2
4	M	61	3	+	510	260	165/85	2	4	2
5	M	45	2	+	500	400	160/110	3	3	2
6	M	63	7	+	400	310	150/90	4	3	3
7	M	50	4	+	400	235	160/90	4	2	2
8	M	42	5	−	460	435	180/105	2	2	2
9	M	39	2	−	430	340	160/110	4	2	1
10	M	45	2	+	500	280	170/115	3	2	2
11	F	53	3	−	370	250	155/90	2	2	2
12	M	53	8	−	340	390	140/90	2	2	2
13	M	58	6	+	370	215	155/95	4	3	4
14	M	50	6	−	315	320	180/100	4	3	2
15	M	59	3	−	520	250	140/90	1	2	2
16	M	36	1	+	390	300	150/100	2	3	2
17	M	58	10	−	400	275	140/80			
18	F	53	3	+	600	380	180/100	4	1	1
19	M	41	1	−	300	325	180/125			
20	F	52	11	+	340	370	170/100	4	3	3
21	M	53	13	+	540	270	200/120	2	2	2
22	M	47	8	+	380	350	155/100	3	2	2

Preop. coronary angiographic evaluation: 1 = Normal lumen, 2 = Constriction of the lumen to less than 2/3, 3 = Constriction of the lumen with retarded circulation, 4 = Total occlusion.

succumbed 24 days after operation in circulatory failure after several attacks of tachycardia. At autopsy there were several infarctions and a patent internal mammary artery. The second death (Case 21) was of a 53-year-old man who died 14 days after operation with hemiplegia. Autopsy showed thrombosis of both the right internal carotid artery and the implanted internal mammary artery. In contrast three patients of 84 operated upon by the Beck procedure died in the immediate postoperative period 1, 4, and 10 days after operation.

Results of the Vineberg procedure are summarized in Table 1. In 14 of 20 patients examined between 9 and 26 months postoperatively the internal mammary artery was patent (Fig. 3, 4). Fifteen of 20 patients were subjectively improved and objective improvement could be demonstrated in 11.

Comparison Between Beck Procedure and Vineberg-Beck Operation

An attempt was made to compare results in patients operated upon according to Beck and those operated upon with internal mammary artery implantation as well. The 14 patients with angiographically patent internal mammary artery have been used for comparison. Results are summarized in Table 2. By objective improvement we mean improvement of at least 150 kilopondmeter/minute in exercise tolerance test using the bicycle ergometer. A tendency to a greater objective improvement in 14 patients with a patent internal mammary artery was supported by the fact that seven patients were working fulltime in their previous occupations. The observed difference between the percentage in Group II and the percentage in Group I with respect

of the Implanted Internal Mammary artery in 22 Patients (Vineberg Procedure)

Postop. Angiography of Implant. Int. Mammary Art.										
Patent	Network of Small Vessels on Heart	Contrast Medium in Myocardium	Contrast Medium in Coronary Vessels	Anticoagulant Treatment	Follow Up in Months	Exercise Tolerance Test (kilopondmeter/minute) Before	Exercise Tolerance Test (kilopondmeter/minute) After	Improvement Objective	Improvement Subjective	Comments
−				−	12	200	400	+	+	Working 50%
−				+	23	600	300	−	−	Pain in right leg. Narrow iliac art.
+	+	−	−	−	9	200	600	+	+	Working fulltime
+	+	−	−	+	12	300	150	−	+	Not working
+	+	+	+	+	16	300	600	+	+	Working
+	+	−	−	+	16	150	300	+	+	Not working
+	+	−	−	+	16	300	600	+	+	Fulltime work
−				+	17	400	600	+	+	Fulltime work
+	+	−	−	+	16	300	650	+	+	Not working
−				+	9	600	800	+	+	Working 50%
+	+	−	−	+	9	450	300	−	+	Working fulltime
+	+	+	−	+	9	200	200	−	+	Working fulltime
+	+	−	−	−	9	200	600	+	+	Working fulltime
−				−	9	300	300	−	−	Not working
+	+	−	−	−	13	600	600	−	+	Working fulltime
+	+	−	−	+	9	200	200	−	−	Not working
(+)				−	—	200	—	−	−	Died 24 hours postop. with patent int. mam. art. Infarction.
−				+	10	150	200	−	−	Not working
+	+	+	+	+	26	300	500	+	+	Working fulltime. Blood pressure 140/100. Hypertension cured.
+	+	−	−	−	9	200	200	−	−	Not working
(−)				+	−	400	—	−	−	Died 14 days postop. Hemiplegia. Thrombosis int. mam. art.
+	+	−	−	−	10	300	400	+	+	Not working

to the patent implanted internal mammary artery (6/14–9/73) is of such magnitude that the probability of obtaining a difference at least as great as the observed value is less than 0.05 if no real difference is assumed to exist. Thus the difference cannot reasonably be caused by random error.

Discussion

The conclusions from these results are that Beck's operation in the treatment of angina pectoris will provide sufficient improvement to justify the procedure. The degree of improvement was modest, however, and the procedure should be combined with other methods, i.e., internal mammary artery implantation or, if possible, coronary artery thrombendarterectomy. This pilot study shows first that a thrombendarterectomized left descending coronary artery remained patent 5½ years after operation with an excellent clinical

TABLE 2. *Comparison between Results Obtained in Patients Operated Upon Without (Beck) and With Patent Implanted Internal Mammary Artery (Beck and Vineberg)*

	Improved		Objective Improvement		
	Subjective	Objective	Slight 150 kpm. per min.	Significant 300 kpm. per min.	Average Degree of Improvement in Improved Patients
I. Beck	56/75	30/73	21/73	9/73	150 kpm. per minute
II. Beck + patent internal mammary art.	12/14	8/14	2/14	6/14	300 kpm. per minute

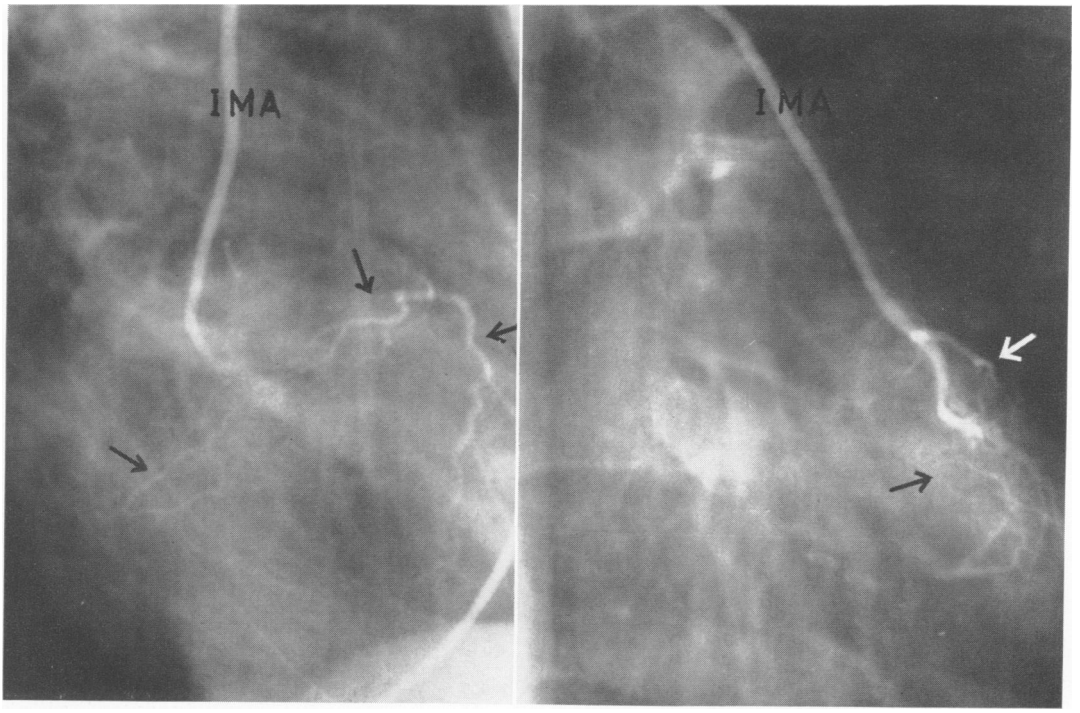


FIG. 3. Case 19. Lateral (A) and frontal (B) arteriograms demonstrating filling of coronary artery branches (arrows) and diffusate opacification of myocardium from the implanted internal mammary artery (IMA) 26 months postoperatively.

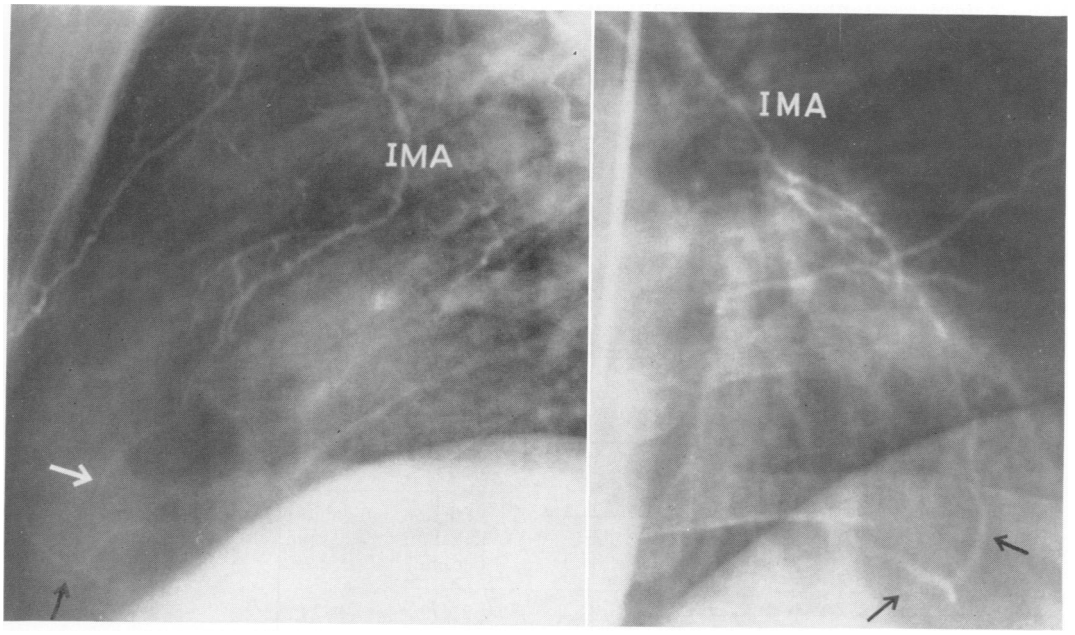


FIG. 4. Case 5. Lateral (A) and frontal (B) angiograms showing flow from the implanted internal mammary artery (IMA) to coronary arteries (arrows) at follow up 15 months postoperatively.

result and the patient working full time at the age of 70 (Fig. 5A, B). This shows that the completely occluded coronary artery can be thrombendarterectomized and that it can stay patent without anticoagulant treatment for more than 5 years. It seems justifiable to choose *thrombendarterectomy* first in all suitable cases. In most cases, however, the disease is widespread in small peripheral branches. In these cases thrombendarterectomy cannot improve peripheral flow. An angiogram of such an unsuitable case is shown in Figure 6. In this 56-year-old man a thrombendarterectomy in main branches of the descending and circumflex coronary arteries did not improve flow due to peripheral changes and the patient died following operation. Unfortunately these unfavorable cases are in the majority and *internal mammary artery implantation* is at present the best available alternative. As some improvement was obtained by the Beck method we thought it logical to add the internal mammary artery implantation to a typical Beck procedure. This study confirms the work of others (Bigelow,[2]

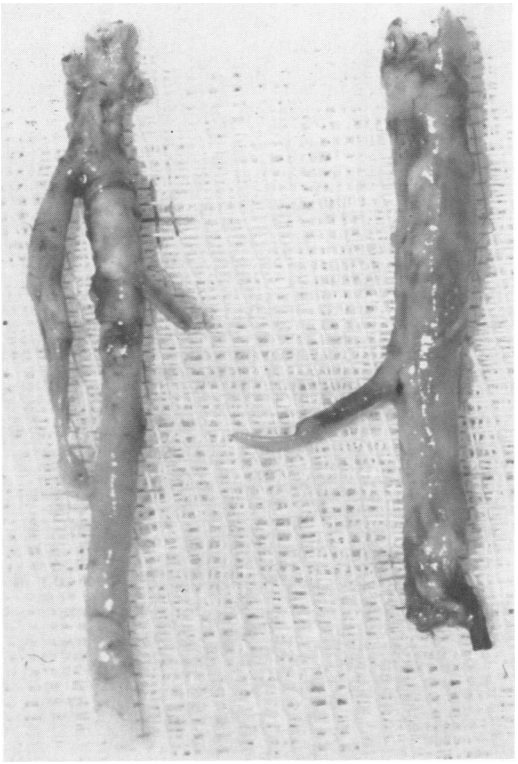


FIG. 5A. Size and shape of thrombus removed from the occluded left anterior descending coronary artery.

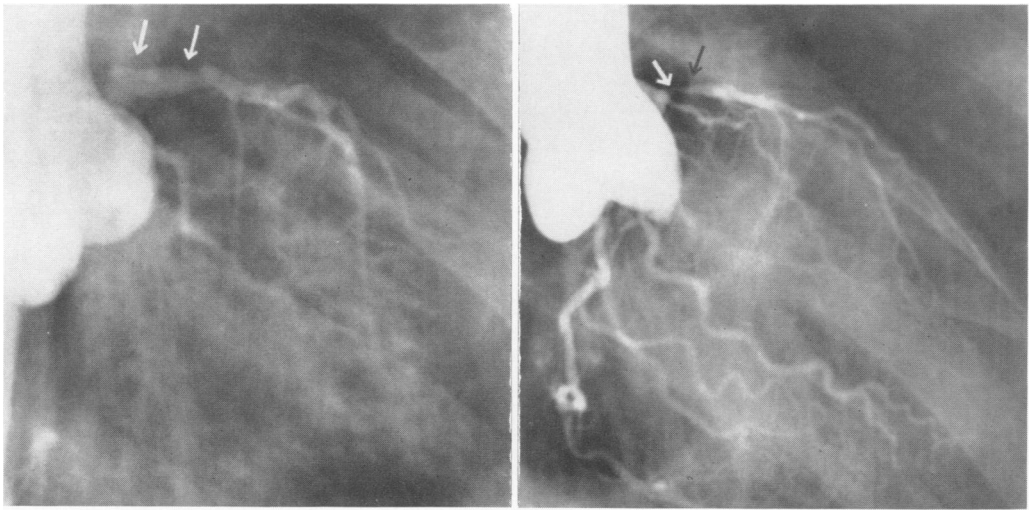


FIG. 5B. (Left) Coronary angiogram in same patient as in 5A 5½ years later demonstrating patency of and normal flow in left descending coronary artery. Moderate irregularity of the vessel at site of thrombendarterectomy (arrows).

FIG. 6. (Right) Coronary angiogram demonstrating 7–8 mm. long narrowing of first part of left anterior descending artery (arrows). Peripheral branches considered to have only minor changes. At operation, however, arteriosclerotic changes were found to be much more extensive than expected, both in the main branch and peripherally.

Effler and Mason Sones[5, 6]) that the internal mammary artery will stay open in a number of cases. In our series the artery had remained open in 14 of 20 cases investigated by angiography. During the surgical procedure, flow of blood as measured by an electromagnetic flowmeter was approximately the same in the intact internal mammary artery as when measured after its implantation into the left ventricle. In one case (19) with patent internal mammary artery a significant hypertension was found cured at the follow up 26 months after operation.

Summary

After thrombendarterectomy a totally occluded left descending coronary artery has been shown to be patent by angiography in a symptom-free patient 5½ years after operation. In patients undergoing the Beck procedure combined with internal mammary artery implantation 14 of 20 investigated by angiography 9 to 26 months after operation had patent vessels. Subjective and objective improvement were of greater magnitude than with the Beck procedure alone. Hypertension was cured in one case.

References

1. Beck, C. S.: Revascularization of the Heart. Surgery, **26**:82, 1949.
2. Bigelow, W. G., Basian, H. and Trusler, G. A.: Internal Mammary Artery Implantation for Coronary Heart Disease. J. Thor. Cardiov. Surg., **45**:67, 1963.
3. Björk, V. O.: Ventricular Aneurysm. Thorax, **19**:162, 1964.
4. Brofman, B. L.: Long Term Influence of the Beck Operation for Coronary Heart Disease. Amer. J. Cardiol., **6**:259, 1960.
5. Effler, D. B., Groves, L. K., Mason Sones, F. and Shirey, E. K.: Increased Myocardial Perfusion by Internal Mammary Artery Implant: Vineberg's Operation. Ann. Surg., **158**: 526, 1963.
6. Effler, D. B., Groves, L. K., Sones, M. F. and Shirey, E. K.: Endarterectomy in the Treatment of Coronary Artery Disease. J. Thor. Cardiov. Surg., **47**:98, 1964.
7. Garrett, H. E., Kinard, D. E. W. S. and DeBakey, M. E.: Coronary Endarterectomy for Angina Pectoris. Bull. Cardiov. Res. Center, Baylor Univ., **2**:3, 1963.
8. Hallén, A., Björk, L. and Björk, V. O.: Coronary Thrombendarterectomy. J. Thor. Cardiov. Surg., **45**:216, 1963.
9. Hallén, A.: Angina Pectoris. A Clinical Study with Special Reference to Surgical Treatment. Acta Chir. Scand. **Suppl., 323**, 1964.
10. Longmire, W. P., Cannon, J. A. and Kattus, A.: Direct-vision Coronary Endarterectomy for Angina Pectoris. New Eng. J. Med., **259**: 993, 1958.
11. Vineberg, A.: Treatment of Coronary Artery Insufficiency by Implantation of the Internal Mammary Artery into the Left Ventricular Myocardium. J. Thor. Surg., **23**:42, 1952.
12. Vineberg, A. and Walker, J.: Surgical Treatment of Coronary Artery Heart Disease by Internal Mammary Artery Implantation: Report of 140 Cases Followed Up to 13 Years. Dis. Chest, **45**:190, 1964.