

# The Role of Surgical Revascularisation in the Treatment of Ischaemic Heart Disease

## A REVIEW ARTICLE

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### SUMMARY

After the initial reports on aorta-to-coronary artery bypass grafting, the evolution of this procedure has witnessed a number of medical criticisms and surgical appraisals. These include reports of late histological changes in the saphenous vein graft and the unacceptability of the procedure as a definitive method of therapy for patients suffering from ischaemic heart disease.

This review indicates that revascularisation of the myocardium in patients suffering from intractable angina results in symptomatic relief in a high percentage of patients, and that it provides protection against subsequent complications.

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Since Favalaro<sup>1</sup> in Cleveland and Johnson *et al.*<sup>2</sup> in Milwaukee 6 years ago introduced the technique whereby a severely narrowed or obstructed coronary artery can be bypassed by means of a reverse autogenous saphenous vein graft, there has been a growing interest in this procedure. This increased enthusiasm occurred despite continual warnings from the more conservative cardiologists<sup>3</sup> that the operation could, at best, be palliative and that there was no evidence that the procedure would alter the natural history of ischaemic heart disease.

The minimal requirements for an operative procedure to be considered of therapeutic value are twofold. Firstly, the procedure must lead to an improvement in the quality of life of the patient, and secondly, it must not result in a worsening of the natural history of the disease and so reduce the life expectancy of the patient. There is now sufficient evidence to show that an aortocoronary bypass fulfils both these criteria.

As confidence in direct myocardial revascularisation grew and improvements in the technique resulted in a diminution of both mortality and complications, the indications expanded. At present there are four major indications for this operation: (i) refractory angina pectoris; (ii) pre-infarction angina; (iii) lesions constituting a threat to life; and (iv) treatment of coronary artery stenosis present in conjunction with operable valvular disease or ventricular aneurysms.

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### Intractable Angina Pectoris

With its present limitation, it is generally agreed that the mere presence of angina pectoris is not an indication for aortocoronary bypass surgery, except in certain circumstances which will be mentioned later. In a substantial percentage of these patients, current medical treatment can result in significant symptomatic relief. Furthermore, recent prospective material surveying entire large populations has established the yearly mortality of the total population with angina pectoris to be in the region of only 3-4%.

Any physician will admit that there remains a number of patients who, in spite of the most intensive medical treatment, are left with such severe angina pectoris that it interferes significantly with their normal life pattern or produces totally disabling symptoms. It is in this group of patients that aortosaphenous vein bypass has proved itself of real therapeutic value. The reasons for making this statement are: (a) the operation can be performed with an operative mortality of 5-7%; (b) approximately 80-90% of patients are symptomatically improved more than a year after the operation and 50-60% are rendered asymptomatic by the operation; (c) evidence is accumulating to show that direct revascularisation of the myocardium in patients with intractable angina improves the patient's life expectancy.<sup>4-7</sup>

This last statement has been disputed by certain cardiologists. They neglect to take into consideration the fact that the rate of attrition of patients who have undergone aortocoronary bypass has always been compared with all patients suffering from angina pectoris. This is obviously an unfair comparison, as patients selected for surgery are only those in whom medical treatment has failed and, therefore, it is fair to conclude that in this group of patients there will be a higher percentage with widespread severe coronary artery disease than in the group as a whole.

Unfortunately, there have been only a few studies showing the medical fate of patients similar to those operated upon. Such a study was reported by Adam *et al.*<sup>8</sup> in Dallas, where the fate of a medical group was made comparable with that of the surgical group because they were all studied and selected for aortocoronary graft, but for one or another reason, 33 patients did not undergo surgery. In the medical group there was a 24.2% mortality in 8 months, compared with a 12% mortality in the surgically managed group over the same period. This is a small group, but it does suggest the efficacy of the surgical approach.

Additional evidence was forthcoming from an actuarial study of the rate of attrition of 1105 patients after aortocoronary artery bypass surgery, compared with unoperated patients with coronary artery occlusion reported by Cooley *et al.*<sup>9</sup> The initial mortality of 6.8% and the 2.7% yearly rate of attrition compare favourably with the 4% annual attrition rate for single vessel disease, 6% for double vessel disease and 10% for triple vessel disease managed medically. It therefore appears that an aortocoronary artery bypass fulfils the two criteria mentioned earlier.

Despite the excellent results mentioned, there have been disturbing features which need further clarification and study.

A 15-20% incidence of peri-operative myocardial infarction is one of the reported complications which concerns the surgeon.<sup>3,10</sup> Less than 5% of patients develop low cardiac output or die as a result of the infarction. In the other 10-15% the complication is asymptomatic and is diagnosed on enzymatic or electrocardiographic aberrations.

As myocardial infarction is a rare complication in other forms of open heart surgery, it is highly suggestive that accepted operative techniques may not be safe in the treatment of patients with severe disease of the coronary arteries. The use of electrical fibrillation and cross-clamping of the aorta to prevent coronary blood flow and to allow a still heart at normal temperatures during the anastomosis of the vein to the coronary artery, although well tolerated by patients with ischaemic heart disease, must appear high on the list of suspect manoeuvres. Recently, more adequate protection of the myocardium has been suggested, and the result of this and its effect on the rate of peri-operative myocardial infarction are eagerly awaited.

The second undesirable feature<sup>8,11-15</sup> is the histological change that occurs in the vein subjected to arterial haemodynamics,<sup>16</sup> and a vein closure rate of 10% within the first postoperative month and a further 15% within the first year. Fortunately, after one year, there seems to be a marked fall in the percentage of closures, as reported by Flemma *et al.*<sup>17</sup> Some important observations have been recorded regarding this complication. Adam *et al.*<sup>8</sup> noticed that some patients remain asymptomatic following the closure of one or even all the grafts. In general, however, there is a good correlation between the presence of symptoms and graft closure. With regard to the rate of closure, from data so far published it appears that the future of an aortocoronary artery vein bypass will be very similar to that described by DeWeese *et al.*<sup>18</sup> in the femoral-to-popliteal artery bypass operations, in which 73% of the vein grafts in living patients should be patent at the end of 5 years.

Early saphenous vein closure is probably the result of thrombosis of the graft, owing to either technical mistakes or bad selection of patients.

Adequate distal flow-off is essential to the success of the grafting. In this respect, it appears that the diseased coronary arterial tree is favoured, in that postmortem studies<sup>19</sup> have shown that in approximately 90% of the coronary arteries in which proximal stenosis is present,

the distal vessels are patent. In some cases, however, the atherosclerosis involves the entire extramyocardial portion of the coronary artery. Unless distal flow-off can be assured by distal blind endarterectomy, the bypass graft will block as a result of the slow velocity of flow through the graft.

Since a large percentage of early closures are caused by technical errors, this will diminish with increasing surgical expertise in judgement and technique.

The aetiology of late closure<sup>17</sup> is somewhat more difficult to understand and is probably the result of more than one aetiological factor.

In rare cases, development of atherosclerosis in vein grafts used in femoral artery bypass has been described. This complication has also been described in veins used in aortocoronary bypass operations, but it is a very rare cause of late closure.

It has been said that distal vessels are less affected by atheroma because the proximal obstruction protects this area against the trauma of the arterial pulsation, and this in turn slows down the changes associated with atheroma. Theoretically, it appears that distal revascularisation will speed up the development of atheroma in the distal coronary tree, and this may result in late closure of the graft.<sup>8</sup>

Subintimal fibrous hyperplasia or arterialisation of the vein has been described in many instances where veins are used as arterial substitutes.<sup>16,20-23</sup> It is, therefore, not surprising that it is the predominant lesion found at late histological examination of coronary vein bypass specimens.

Whether the changes in flow pattern, such as increased velocity<sup>15</sup> and turbulence,<sup>24</sup> are causes of these changes, or whether other factors such as surgical trauma at the time of operation or nutritional factors play a role, is not clear. Flemma *et al.*<sup>17</sup> have shown that these histological changes are present in moderate and severe disease at the time of bypass in 5% of saphenous veins.

Changes in technique to prevent this late complication are already being investigated. Among the most promising of these is the direct suture of the internal mammary artery to the coronary artery, or the use of a segment of this artery or the radial artery as a free graft.<sup>25</sup> The patency rate of these procedures is excellent.

In an effort to produce maximum velocity flow,<sup>26</sup> studied by several groups and ourselves, the distal saphenous vein, which usually measures 3-4 mm in external diameter, has been used.

### Unstable Angina Pectoris

Surgical experience over the past 20 years has shown that in areas such as the brain, bowel, and periphery, threatened ischaemic death can be prevented, or at least limited, by prompt revascularisation of the affected area. It is somewhat surprising, therefore, that the cardiologists, even after the benefit of aortocoronary saphenous vein bypass has been clearly demonstrated in cases of intractable angina pectoris, are reluctant to accept this operation as sound surgical treatment for threatened ischaemic death of the myocardium. It is true that individuals threatened by imminent myocardial infarction are not

easily selected. There are, however, clinical syndromes which experience has shown often lead to myocardial infarction and even death. These are crescendo or pre-infarction angina pectoris, and the so-called Prinzmetal angina.

**Crescendo or pre-infarction angina pectoris** which may present as: (i) rapidly progressive angina of recent onset; (ii) exacerbation of previously stable angina; and (iii) recurrent bouts of protracted anginal pain unresponsive to medical therapy.

There are few positive signs to guide the physician—there are no diagnostic ECG changes, although ST-segment changes may occur, and there are no serum enzyme abnormalities. A slight rise in the SGOT has been described 4-8 days after such an episode.

The natural history of this syndrome has been carefully studied<sup>27-30</sup> and several reports have shown that 20-40% of these patients will develop acute myocardial infarction and will die.

As a result of these findings, a more aggressive approach towards these patients is suggested. This attitude is supported by the fact that the angiographic lesions encountered in the coronary arteries of these patients are very similar to those in stable angina pectoris. In a review of recent literature, Thomas *et al.*<sup>31</sup> described a series of 420 patients presenting with unstable angina pectoris treated surgically, with an operative mortality of 4.3% and a postoperative course much the same as for patients treated on a more selective basis.

**Prinzmetal angina** also appears to fall into this group of acute coronary insufficiency.<sup>32,33</sup> Although in some cases the syndrome is associated with very minimal coronary artery disease, other cases have been demonstrated where significant coronary artery lesions are present, especially in localised areas of the coronary tree.

### Anatomical Lesions Constituting a Threat to Life

Last year Johnson and Kayser<sup>34</sup> published a report in which they followed up 112 patients who were catheterised and advised to have revascularisation in 1969, 1970 and 1971. None was operated upon and 61 have since died.

On studying the coronary lesions in this group of patients, these authors found that some lesions of the coronary arteries are more lethal than others, and these patients should be revascularised even when symptoms are insignificant.<sup>34</sup> These lesions appeared to be severe stenosis of the left main coronary artery, and triple artery disease.

**Severe stenosis of the left main coronary artery.** Some studies have shown that the mortality rate in these patients is as high as 50% by the end of two years if unoperated. High mortality rates after surgery on patients with these lesions are also reported,<sup>35</sup> but on balance it appears that the prognosis in such patients is better with surgery.

**Triple artery disease.** A 10% yearly death rate has been described in patients with severe triple vessel disease.<sup>36,37</sup> These patients also appear to be protected by coronary artery revascularisation.

### Coronary Artery Disease in Patients Undergoing Open Heart Surgery for Other Reasons

In patients who have failed to survive valve replacement, 13-29% have been found to have significant coronary artery disease. Even among patients surviving aortic valve replacement, a large number with severe coronary artery disease have been described, especially in those with poor postoperative haemodynamics.<sup>38,39</sup> From these findings it appears that patients with significant coronary artery lesions who undergo valve replacement should be revascularised, even if they have no symptoms from ischaemia.

Although the first reports of the combined operation showed a prohibitive operative mortality,<sup>40</sup> more recently a mortality rate as low as 4% has been described.

It is suggested that present accepted policy should be to perform coronary angiography only on patients investigated for valvular disease, with a history or symptoms suggestive of ischaemic heart disease. If significant coronary artery lesions are discovered, revascularisation should be performed at the same time as the valvular lesion is operated upon.

Patients with ventricular aneurysm or akinetic ventricular areas following ischaemic death should undergo a detailed study of the coronary lesions present, and any significant disease must be dealt with at the time the aneurysm is resected.<sup>41,42</sup> The revascularisation will protect the jeopardised areas of the remaining myocardium.

### ACUTE MYOCARDIAL INFARCTION

This communication will not attempt to resolve the present controversy regarding the value of revascularisation immediately following an acute myocardial infarction.

At this stage it appears that revascularisation operations may prove to be of value in three situations: (i) within the first few hours after an acute myocardial infarction to prevent extension of the myocardial death;<sup>43</sup> (ii) in recurrent angina within the recovery phase after an acute myocardial infarction indicating extension of the lesion;<sup>44</sup> (iii) in myocardial infarction with shock not responding to medical treatment. In this group of patients it is necessary to assist the circulation immediately before the operation.<sup>43</sup>

### CONTRA-INDICATIONS

There are two definite contra-indications to saphenous vein bypass surgery. One has already been dealt with, namely inadequate distal flow-off, and the second one is severe ventricular dysfunction.<sup>45</sup>

If heart failure is established in patients with coronary artery disease, it is usually due to fibrous replacement of the dead muscle and not to ischaemic cardiomyopathy, and to expect improvement of myocardial function by revascularisation appears to be not only unscientific but foolhardy. Total cardiac replacement is the only treatment that can offer hope to these patients.

Recently, certain criteria for surgery in patients suffering from ventricular dysfunction as the result of ischaemic heart disease have been suggested: (a) associated angina, suggesting viable ischaemic heart muscle; (b) patients with only intermittent episodes of heart failure; and (c) patients with localised proximal disease.

There is no doubt that as the ventricular function decreases, the mortality rate of revascularisation operations increases. At which point ventricular dysfunction contra-indicates a coronary artery bypass operation, remains to be established.

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