Coronary Artery Bypass Grafting - The State of the Art

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There is now considerable evidence that surgery for cononary artery disease relieves angina very effectively and indeed is more effective in the treatment of angina than medical treatment in matched and randomised series. Furthermore, coronary artery bypass surgery improves life expectancy in those patients who have significant disease of the left main stem or of all three major vessels *three vessel disease.* Some data behind these statements will be mentioned in this article.

It is first important to appreciate the anatomy we are discussing. The left main stem is a small part of the origin of the left coronary artery and clearly disease here is liable to put the whole of the left ventricle at risk. The right coronary artery, the left anterior descending and the left circumflex are the three major vessels. The term three vessel disease implies disease of each of these vessels. Clearly there are sub-branches of these vessels, and these in turn may be diseased. There is some variation between patients in the relative distribution of their coronary arteries and in the number and size of their sub-branches. This variation plays some part in the assessment of the patient for operations and in the technicalities of where and how many grafts are placed. However, it has not been used in the analysis of the results of the trials for angina or survival.

Angina Relief

Between 1973 and 1976 over 750 patients were randomly and prospectively entered through a multicentre European trial of medical versus surgical treatment of patients with at least 50% stenosis in two major vessels (European trial or ECSS). The surgical group had an 84% improvement of angina by 1 year compared to 45% improvement with medical treatment: at three years, 78% of the surgical group were improved with nearly 50% totally free of angina, whereas in the medical group 50% were improved at three year and just under 20% were free of angina. These differences were highly significant statistically. There have been several other matched studies, particularly in the United States of America, which have shown the benefit of surgery over medicine for angina relief. In individual surgical series, Loop was quoted 87% free of angina at 5 years and Bourassa 50% absence of angina at seven years. There is little doubt that the relief of angina is due to revascularization of the heart and not due to a placebo effect, nor to infarction. There is good correlation between relief of angina and graft patency or completeness of revascularization (by completeness I mean that all the major vessels which were diseased were grafted). Exercise tolerance after bypass grafting is greater after surgery than after medical treatment, (European Trial). Other studies have suggested improvement of left ventricular function after coronary revascularization.

TABLE 1

EUROPEAN TRIAL (ECSS) ANGINA RELIEF

	1 yr.		2 yr.		3 yr.	
	Free	Improved	Free	Improved	Free	Improved
MED.	17%	45%	17%	48%	20%	50%
SURG.	58%	83%	55%	79%	50%	78%
	•	•	•	•	•	•

• all comparisons M vs S p 0.001

Life Expectancy

Stenosis of left main coronary artery of 50% or greater provides the patient treated medically with a life expectancy of 60% at five years, but if treated surgically his life expectancy is 94% at five years (European trial). Life expectancy in these figures of course includes any operative or hospital mortality related to surgery or other medical treatment. When the stenosis of the left main coronary artery is much greater than 50%, the heart is very much at risk and it is our practice at present to keep people in hospital for surgery if they have 70% or greater stenosis of the left main coronary artery.

Table 2 shows survival figures for left main disease and three vessel disease as taken from the European randomised prospective trial. These results have been confirmed in the previous Veteran's administration study (VA Study) and the Collaborative coronary artery surgical study in America (CASS).

Patients with 50% or greater stenosis of three vessels *(three vessel disease)* have also been shown to have an improved prognosis after surgical treatment than after medical. The European study showed a 95% survival in the surgical group at five years compared to 85% in the medical group. The CASS study, which looked at 15,000 patients in the United States of America and Canada showed that surgery provided an improved chance of either survival or freedom from a major heart attack in patients who have three or two vessel disease, compared to those treated medically. There has been no evidence to show that patients with one vessel disease have prolonged survival by surgery as against medicine. Probably the aspects which affect survival relate to the ability to develop collaterals from non-involved coronary arteries and relates to the quantity of heart which has not been affected by chronic ischaemia or infarction. (Table 3).

Risks

The risk of dying at operation has been gradually decreasing over the last 10 years. In 1972 operative mortality was 5.6%, in 1976 3%, in 1978 2% and in 1983 it is probably less than 2%. These figures were taken from the three major randomised studies mentioned above. Improvements have come about through a combination of factors, which include our familiarity and experience in coronary artery surgery, improvements in the understandng in preserving the energy stores of the heart during the operation, by general improvement in understanding of patients undergoing heart surgery and improvement in the overall team experience and possibly by technical improvements with magnification. The major factor which still affects the risk of operation is the condition of the patient's ventricle. Those who have poor left ventricular function as a result of multiple previous myocardial infarction have a higher risk of operative death and also carry less good long-term prognosis.

To illustrate this, Table 4 shows a five year survival of patients treated medically sub-divided by the degree of dysfunction of the left ventricle. Surgery will improve each group, but the best results are obtained from those with good or moderate left ventricular dysfunction because severe left ventricular dysfunction is not improved much, if at all, following cardiac surgery.

Patency

Most surgical series show between 80 and 90% graft patency at one month and between 70 and 80% graft patency at five years (Bourassa). The veins used for the coronary grafts do always show changes as a result of being made to work as arteries.There is always intimal hyperplasia and in some cases there will be severe thickening and atheroma occasionally occurs in the vein grafts themselves. There is also some continuing progression of the disease in the native arteries, as the operation itself does nothing to alter the etiology of the condition. There is therefore a continuing incidence of return of angina, due either to increasing disease in the native vessels or of problems with the vein graft, or to a combination of both. Graft patency as expected, is best when the arteries grafted are the largest, and fare the worst with those of less than 1.5 mm diameter.

Re-Operation

Because of the obvious palliative nature of the disease mentioned above, re-operation is becoming increasingly indicated. The results of re-operation are less good than those of the first operation, but there is still a 50% chance of providing benefit to the patient in terms of release of angina by a second operation.

Surgery following Myocardial Infarction

Immediate surgery following myocardial infarction has not been shown to be of value. However, there is a series by Rogers, indicating that surgery at 6 weeks following myocardial infarction gave better long-term survival and instance of further infarction, in those patients who had about 25% or more of ventricular muscle at risk from tight stenoses. This study has not yet been translated into surgical practice, except that it is now the basis for another European trial of coronary artery surgery for 3-vessel disease 6 weeks following infarction. The results of this trial will obviously be eagerly awaited in a few years' time.

Assessment of Vessel Disease

Coronary angiography is the final delineator of the state of the coronary vessels and of the left ventricular function. Exercise ECG's provide the most important screen through which patients who have angina can be assessed as suitable for coronary angiography. Not only can this tell whether there is ischaemia on exercise, but also by using a technique which we have developed at St Mary's of mapping from both front and back chest leads,

TABLE 2

LIFE EXPECTANCY % SURVIVAL

LEFT MAIN DISEASE	M	S	Significance
ECSS at 5 yr	62	93	< .037
CASS at 3 yr	69	91	< .001
VA at 2 1/2 yr	60	88	< .01
3 VESSEL DISEASE			
ECSS at 5 yr	85	95	< .001
2 VESSEL DISEASE			
(with 50% LAD involvement)			
ECSS at 5 yr	82	92	

TABLE 3

EVENT-FREE SURVIVAL CASS at 3 yrs

	M	S
3 VESSEL DISEASE	66	89
2 VESSEL DISEASE	74	95

event = death, myocardial infarct, or re-operation

TABLE 4

% SURVIVAL RELATED TO LEFT VENTRICULAR FUNCTION (LV)

DUKE SERIES at 5 yrs	MED	SURG
NORMAL LV	90	—
MODERATE LV DYSFUNCTION	68	—
SEVERE LV DISFUNCTION	38	—
SEATTLE HEART WATCH at 5 yrs (mild angina)		
NORMAL LV FUNCTION	92	95
MODERATE LV DYSFUNCTION	70	90

EJECTION FRACTION

>50%	"Normal"
30 - 50%	"Moderate" dysfunction
<30%	"Severe" dysfunction

whether ischaemia is likely to be in the region of 1,2 or 3 coronary arteries.

Summary

The current indications for coronary artery surgery are:-

1 Stable angina which has continued to produce pain despite medical treatment, or, angina in patients unable to tolerate medical treatment, or, angina for those who medical treatment poses such a limitation of lifestyle or work that they find this unacceptable and prefer surgery.

2 Patients who have *unstable* angina require urgent coronary artery surgery as the pain cannot be settled with intravenous nitrate infusion. Unstable angina is angina which is occuring on minimal or no exertion and at rest.

3 As a result of a coronary angiogram, patients with 50% or more stenosis of the left coronary main coronary artery, or of all three vessels, will be considered for surgery even if asymptomatic, provided they have good or moderate left ventricular function. Those who have a very tight stenosis (95%) of the left anterior descending vessel alone, would also be considered because of the impending likely anterior infarction.

4 Cardiac failure and arrhythmias are not usually indications for surgery, and surgery after myocardial infarction has been discussed above and the results of the European trial are awaited.

Incidence and Prevention

The current rate of coronary artery bypass grafting in the United Kingdom is about 100 cases per 1,000,000 per year. It is estimated that we ought to be doing 300 cases per 1,000,000 per year in the United Kingdom to cope with the incidence of the disease in this country. These figures are taken from comparisons and analysis of the work done in Australia and North America.

It is likely that the incidence of coronary disease will continue at the same rate for some years to come, and it is very difficult to define any factors which we can do something about which will reduce this incidence. The first thing, is to stop people smoking, as undoubtedly, smoking has a high correlation with coronary artery disease and indeed those who have coronary artery surgery who are foolish enough to continue smoking have a much higher incidence of return of angina than those who do stop smoking. Contol of blood pressure and weight are considered important and in those who have very high cholesterol and triglyceride levels, the reducing of these may be of some value, although we have no data to support this yet. Much emphasis has been put on altering our dietary habits, but there is as yet very little hard evidence to show which part of our diet is directly related to causing coronary artery disease. The most popular is related to the high levels of animal fats that we eat and considerable effort has been related to making us in general reduce our animal fat consumption. Stress has also been suggested as a causative factor and it has been suggested we should reduce the amount of stress in our everyday lives and work. Unfortunately the continuing incidence and the increasing demand for coronary artery surgery is likely to provide little relief in stress for the cardiac surgeon!

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