Br Heart J 1980: **44**: 630–7

Incidence of coronary artery disease in patients with valvular heart disease

G W MORRISON,* R D THOMAS,† S F M GRIMMER, P N SILVERTON,‡ D R SMITH

From the Department of Cardiology, The General Infirmary, Leeds

SUMMARY The case notes, cardiac catheterisation data, and coronary arteriograms of 239 patients investigated for valvular heart disease during a five year period were reviewed. Angina was present in 13 of 95 patients with isolated mitral valve disease, 43 of 90 patients with isolated aortic valve disease, and 18 of 54 patients with combined mitral and aortic valve disease. Significant coronary artery disease was present in 85 per cent of patients with mitral valve disease and angina, but in only 33 per cent of patients with aortic valve disease and angina. Patients with no chest pain still had a high incidence of coronary artery disease, significant coronary obstruction being present in 22 per cent with mitral valve disease, 22 per cent with aortic valve disease, and 11 per cent with combined mitral and aortic valve disease. Several possible clinical markers of coronary artery disease were examined but none was found to be of practical help. There was, however, a significant inverse relation between severity of coronary artery disease and severity of valve disease in patients with aortic valve disease.

Asymptomatic coronary artery disease is not uncommon in patients with valvular heart disease and if it is policy to perform coronary artery bypass grafting in such patients, routine coronary arteriography must be part of the preoperative investigation.

Angina occurs commonly in valvular heart disease[1–8] but does not necessarily signify the presence of coronary artery disease,[1–3 8] This is particularly true in patients with aortic valve disease[1–8]; it also applies in those with mitral valve disease. In addition, there are some patients without angina who still have significant coronary obstruction.[3 8–10] In patients being considered for valve surgery it is generally accepted that the presence of angina is an indication for coronary arteriography as part of the preoperative investigations.[1 8 11–13] Much less is known of the need for routine coronary arteriography in patients without angina. Patients with coronary artery disease do less well after surgery,[11 13–17] and this has led to increasing interest in the possibility of treating coronary artery disease at the time of valve surgery. During the past five years it has been our policy to perform routine coronary arteriography on patients aged 45 years or more as part of the preoperative investigation, and coronary artery bypass grafting is performed for significant lesions whenever feasible, even when angina is absent. We have performed a retrospective study of these patients in order to answer three main questions. First, what is the incidence of significant coronary artery disease in patients with valve disease with and without angina? Second, are there any clinical features predictive of such disease? Third, how often are such lesions amenable to surgical correction?

*Present address: St. James's University Hospital, Leeds LS9 7TF

†Present address: Royal United Hospital, Bath BA1 3NT.

‡Present address: Department of Cardiovascular Studies, The University, Leeds LS2 9JT.

Received for publication 22 May 1980

Methods

We reviewed the case notes of all adult patients who underwent coronary arteriography as part of the preoperative cardiac catheterisation for valvular heart disease during the period 1 January 1975 to 31 December 1979. Patients with valvular heart disease resulting directly from ischaemic heart disease (for example papillary muscle dysfunction) were excluded. A note was made of each patient's age, sex, and smoking history. The clinical history was examined for evidence of angina pectoris. Episodes of typical anterior chest pain, with or without radiation, precipitated by exertion and relieved

by rest or an oral nitrate, were regarded as "typical angina". In addition, there were some patients who had chest pain with some, but not all, of these features, and these were classified as "atypical chest pain". Patients without pain were classified as "no chest pain". A record was made of any past cardiac ischaemic events and past or current drug treatment. The electrocardiogram was examined for rhythm, evidence of cardiac ischaemia, and previous myocardial infarction. Heart size was assessed by the radiological cardiothoracic ratio.

The data obtained at cardiac catheterisation were reviewed. Pulmonary hypertension was indicated by a pulmonary artery mean pressure greater than 20 mmHg. Left ventricular end-diastolic pressure was measured directly. Mitral valve gradients were measured indirectly between pulmonary artery mean wedge pressure and left ventricular end-diastolic pressure. Aortic valve gradients were measured by withdrawal from left ventricle to aorta. Pressures were measured at rest using Statham (P23 Gp) strain gauges recording on an ultraviolet light recorder. The zero reference point was 10 cm above the level of the catheter table. The severity of valve obstruction was graded on a simple scale, from 0 to 4, according to the gradient at rest. For mitral stenosis: 0=no gradient; 1=1 to 4 mmHg; 2=5 to 10 mmHg; 3=11 to 19 mmHg; 4=more than 20 mmHg. For aortic stenosis: 0=no gradient; 1=1 to 34 mmHg; 2=35 to 49 mmHg; 3=50 to 74 mmHg; 4=more than 75 mmHg. Haemodynamically "significant" valve obstruction was arbitrarily defined as grade 3 or 4. The severity of mitral or aortic valve regurgitation was assessed from the left ventricular or aortic root cine angiogram and graded on a simple scale from 0 to 4 according to the criteria of Yang *et al.*[18] Haemodynamically "significant" regurgitation was said to be present with a grade of 3 or 4. The overall severity of valvular disease was assessed by summing all the grades of stenosis and regurgitation, this then being called the valve score. On the basis of the data obtained from cardiac catheterisation and angiography the patients were assigned to one of three groups, depending upon the presence of "significant" disease as defined above: isolated mitral valve disease; isolated aortic valve disease; combined mitral and aortic valve disease.

Left ventricular function was assessed from the ejection fraction, calculated from the left ventricular volumes obtained from single plane right anterior oblique ventriculography.[19] Coronary arteriography was performed by the Judkins or Sones technique. Both coronary arteries were injected in at least three projections using magnified images. The arteriograms were analysed by a cardiac radiologist and at least one other experienced operator. In the case of borderline lesions, or a disparity in reporting, a third opinion was obtained. All reporting was done without clinical knowledge of the patient. The severity of coronary artery stenosis was assessed as the maximum percentage reduction in luminal diameter, seen in any one of at least three different projections, as compared with the diameter of the vessel proximal to the obstruction. The severity of each lesion was graded on a simple scale from 0 to 4 as follows: 0=no obstruction; 1=1 to 49 per cent; 2=50 to 69 per cent; 3=70 to 99 per cent; 4=total occlusion. Obstructions of grade 2 or more were said to be "significant". The maximum narrowings on five major vessels' branches were assessed. The left main stem; left anterior descending; circumflex; obtuse marginal (large lateral) branch of the circumflex; and right coronary arteries were chosen because of their surgical importance in coronary artery bypass grafting. Major vessel disease was assessed as zero, single, double, or triple, and the overall severity of coronary artery disease was estimated by summing the grades of stenosis in the five vessel branches listed above. This total was called the coronary score.

Finally the decision made at the time of investigation regarding surgery was recorded and the operation notes examined to obtain details of the procedure performed.

The significance of differences between groups was tested using Student's t test for unpaired data or χ^2 as appropriate. The significance of correlations was tested by linear regression analysis.

Results

During the study period, 239 patients with valvular heart disease underwent routine coronary arteriography as part of their preoperative cardiac catheterisation. Isolated mitral valve disease was present in 95 (40%) with isolated stenosis in 35 and isolated regurgitation in 10, the remaining 50 having mixed lesions. Isolated aortic valve disease was present in 90 (38%) with isolated stenosis in 37, isolated regurgitation in 28, and mixed lesions in 25. There were 54 (23%) patients with combined mitral and aortic valve disease. A few patients also had tricuspid valve disease but the severity of this was not assessed. The average age of the patients was 51·0 ± 8·7 years (±SD), with no differences between the valve groups. There were 117 men and 122 women. Typical angina was present in 74 (31%) patients, atypical chest pain in 34 (14%), and no chest pain in 131 (55%). Coronary arteriography was therefore performed as a routine screening procedure in more than half the patients.

Table 1 *Relation between angina and coronary artery disease in 239 patients being investigated for valvular heart disease*

Nature of chest pain	No. of patients	No. (%) of patients with coronary lesions						
		No significant disease			Significant disease			
		No irregularity	1 to 49% occlusion	Total	Single vessel	Double vessel	Triple vessel	Total
Angina	74	29 (39)	12 (16)	41 (55)	17 (23)	11 (15)	5 (7)	33 (45)
Atypical chest pain	34	16 (47)	8 (24)	24 (71)	6 (18)	0 (0)	4 (12)	10 (29)
No chest pain	131	64 (49)	41 (31)	105 (80)	13 (10)	7 (5)	6 (5)	26 (20)

Coronary arteriography disclosed at least one major vessel with significant narrowing in 69 (29%) patients, but in 109 (46%) there was not even minimal irregularity. Details of the relation between the incidence of angina and the incidence of coronary artery disease overall are given in Table 1. Significant coronary lesions were present in 33 of 74 (45%) patients with angina and in 26 of 131 (20%) patients with no chest pain. On the other hand, in 26 of 69 (38%) patients with significant coronary artery obstruction there was no clinical suspicion of angina. The distribution of lesions in the five major vessel branches examined is shown in Table 2. In the next part of the study the relation between chest pain and coronary artery disease in each of the three valve groups was examined.

ISOLATED MITRAL VALVE DISEASE (Table 3)
Typical angina was present in 13 (14%) patients of whom 11 (85%) had significant coronary lesions, four having triple vessel disease. Of the 63 (66%) patients with no chest pain, 14 (22%) had significant coronary lesions, four with triple vessel disease. Of the 35 patients with isolated mitral stenosis, only three (9%) had angina and all of these had significant coronary lesions. Of the 22 (63%) patients with isolated stenosis and no chest pain, five (23%) proved to have significant coronary disease.

ISOLATED AORTIC VALVE DISEASE (Table 3)
Typical angina was present in 43 (48%) patients of whom 14 (33%) had significant coronary lesions, one with triple vessel disease. Of the 41 (46%) patients with no chest pain, nine (22%) had significant coronary lesions, two with triple vessel disease. Of the 37 patients with isolated aortic stenosis, angina was present in 23 (62%) of whom nine (39%) had significant coronary artery disease. Twelve (32%) of the patients with isolated aortic stenosis had no chest pain but three (25%) had significant coronary lesions.

COMBINED MITRAL AND AORTIC VALVE DISEASE (Table 3)
Typical angina was present in 18 (33%) patients of whom eight (44%) had significant coronary lesions, but none with triple vessel disease. Of the 27 (50%) patients with no chest pain, three (11%) had significant coronary lesions, none with triple vessel disease.

In all three groups angina was therefore more likely to be associated with significant coronary artery disease than when chest pain was absent. Only in patients with isolated mitral valve disease, however, was angina a very good marker of significant coronary obstruction. Other factors were therefore examined which might possibly help to identify patients with coronary artery disease.

Table 2 *Distribution and severity of coronary artery disease in 239 patients being investigated for valvular heart disease*

Maximum per cent reduction in luminal diameter	No. (%) of patients with coronary artery lesions				
	Left main stem	Left anterior descending coronary artery	Circumflex coronary artery	Obtuse marginal*	Right coronary artery
0	227 (95)	161 (67)	178 (75)	206 (86)	148 (62)
1–49	10 (4)	36 (15)	34 (14)	14 (6)	57 (24)
50–69	2 (1)	20 (8)	13 (5)	3 (1)	14 (6)
70–99	0 (0)	20 (8)	13 (5)	16 (7)	15 (6)
100	0 (0)	2 (1)	1 (0·5)	0 (0)	5 (2)

*Or large lateral branch of the circumflex.

NATURE OF VALVE LESION

The mean (±SEM) coronary scores for each valve group were as follows: isolated mitral valve disease = 2·82 ± 0·37, isolated aortic valve disease = 1·78 ± 0·26, combined mitral and aortic valve disease = 1·45 ± 0·27. The severity of coronary artery disease was therefore greater in patients with mitral valve disease than with aortic valve disease ($p < 0·05$) or combined aortic and mitral valve disease ($p < 0·01$), there being no difference between the two latter.

SEVERITY OF VALVULAR DISEASE

The mean (±SEM) valve scores for each group were as follows: isolated mitral valve disease = 4·17 ± 0·21, isolated aortic valve disease = 3·84 ± 0·21, combined mitral and aortic valve disease = 6·88 ± 0·28. There was no significant difference between mitral and aortic valve disease, but, by virtue of having two valves affected, patients with combined mitral and aortic valve disease had higher scores ($p < 0·001$). Because the group with the highest mean valve score (the combined group) had both the lowest incidence and also the lowest overall severity of coronary artery disease (mean coronary score), it was decided to study the relation between these factors in more detail. In each group there was a negative relation between valve score and coronary score but this was of statistical significance only in patients with isolated aortic valve disease ($p < 0·05$).

PRESENCE OF ANGINA

As shown above, angina was not a good marker of the presence of significant coronary lesions. It was least good in patients with isolated aortic stenosis and best in isolated mitral stenosis. The mean (±SEM) coronary scores for those patients with angina were compared with those having no chest pain in each valve group. Though patients with angina tended to have higher mean coronary scores (±SEM), this was only significant for patients with isolated mitral valve disease (angina = 5·9 ± 1·2, no chest pain = 2·0 ± 0·3; $p < 0·001$).

AGE

In all three groups coronary scores tended to increase with age and the correlation was significant for patients with isolated mitral valve disease ($p < 0·01$) and combined mitral and aortic valve disease ($p < 0·025$). Though patients aged below 45 years did not have routine coronary arteriography it was performed in 41. The indication for this was the presence of angina in 13 of whom three had significant coronary obstruction. None of the 23 patients with no chest pain had significant coronary lesions.

SMOKING

Of the 239 patients, 129 (54%) were habitual cigarette smokers. Though smokers tended to have significant coronary lesions more frequently, and higher mean coronary scores (±SEM), the differences did not reach levels of statistical significance (mean coronary score for smokers 2·31 ± 0·26, for non-smokers 1·84 ± 0·28; $p < 0·1$).

SEX

The mean (±SEM) coronary score for men tended to be higher than for women but the differences were only of statistical significance for isolated mitral valve disease (men = 4·27 ± 0·72, women = 2·22 ± 0·42; $p < 0·02$).

Table 3 *Relation between angina and coronary artery disease in patients with isolated mitral valve disease, isolated aortic valve disease, and combined mitral and aortic valve disease*

Nature of chest pain	*No. of patients*	*No. (%) of patients with coronary artery lesions*						
		No significant disease			*Significant disease*			
		No irregularity	*1 to 49% occlusions*	*Total*	*Single vessel*	*Double vessel*	*Triple vessel*	*Total*
		Isolated mitral valve disease						
Angina	13	1 (8)	1 (8)	2 (15)	5 (38)	2 (15)	4 (31)	11 (85)
Atypical chest pain	19	11 (58)	2 (11)	13 (68)	2 (11)	0 (0)	4 (21)	6 (32)
No chest pain	63	23 (37)	26 (41)	49 (78)	7 (11)	3 (5)	4 (6)	14 (22)
		Isolated aortic valve disease						
Angina	43	20 (47)	9 (21)	29 (67)	6 (14)	7 (16)	1 (2)	14 (33)
Atypical chest pain	6	2 (33)	2 (33)	4 (67)	2 (33)	0 (0)	0 (0)	2 (33)
No chest pain	41	27 (66)	5 (12)	32 (78)	5 (12)	2 (5)	2 (5)	9 (22)
		Combined mitral and aortic valve disease						
Angina	18	8 (44)	2 (11)	10 (56)	6 (33)	2 (11)	0 (0)	8 (44)
Atypical chest pain	9	3 (33)	4 (44)	7 (78)	2 (22)	0 (0)	0 (0)	2 (22)
No chest pain	27	14 (52)	10 (37)	24 (89)	1 (4)	2 (7)	0 (0)	3 (11)

LEFT VENTRICULAR END-DIASTOLIC PRESSURE, CARDIOTHORACIC RATIO, EJECTION FRACTION, MEAN PULMONARY ARTERY PRESSURE

The relations between coronary score, and left ventricular end-diastolic pressure, cardiothoracic ratio, ejection fraction, and mean pulmonary artery pressure were small and inconsistent. Furthermore, there were no significant differences between patients with coronary scores greater than 6 and those with no coronary lesions. Nor were there any differences in the incidence of angina or coronary artery disease between those patients with and without pulmonary hypertension, but mean pulmonary artery pressure was usually only mildly increased and only 10 patients had levels more than 50 mmHg.

MULTIPLE REGRESSION ANALYSIS OF FACTORS PREDICTIVE OF CORONARY SCORE

As many of the factors described above are likely to be interrelated a multiple regression analysis was performed to identify which were independently predictive of the coronary score. In patients with isolated mitral valve disease, age in the presence of angina was predictive ($p < 0.005$), and age in patients with combined mitral and aortic valve disease ($p < 0.025$). None of the factors was predictive in patients with isolated aortic valve disease.

SURGICAL MANAGEMENT

Isolated mitral valve disease

Seventy-one patients had valve surgery. Significant coronary obstruction was present in 18 (25%) but the vessels were angiographically suitable for coronary artery bypass grafts in only 14. Eventually 18 grafts were performed in 13 patients. Coronary artery surgery was performed in seven (11%) of the original 63 patients with isolated mitral valve disease but no chest pain, representing 13 per cent of such patients coming to surgery.

Isolated aortic valve disease

Sixty-nine patients had valve surgery. Significant coronary obstructions were present in 21 (30%) and the vessels were angiographically suitable for coronary artery bypass grafts in 20 (29%). Eventually 30 grafts were performed in the 20 patients. Coronary artery surgery was performed in three (7%) of the original 41 patients with isolated aortic valve disease and no chest pain, representing 10 per cent of such patients coming to surgery.

Combined mitral and aortic valve disease

Forty-six patients had surgery. Significant coronary obstructions were present in nine (20%) with the vessels angiographically suitable for coronary artery bypass grafts in all of these. Eventually eight grafts were performed in eight patients. Coronary artery surgery was performed in two (7%) of the original 27 patients with combined mitral and aortic valve disease and no chest pain, representing 8 per cent of such patients coming to surgery.

Discussion

The first part of this study was designed to determine the incidence of angina and coronary artery disease in patients undergoing investigation for valvular heart disease. As in a previous study[1] angina was much commoner in the presence of aortic valve disease (48%) than in mitral valve disease (14%). The incidence of angina was greatest in those with isolated aortic stenosis (62%) and least in those with isolated mitral stenosis (9%). Previous reports of angina in association with isolated aortic valve disease have reported incidences between 45 and 70 per cent.[1–8] Most studies have been of patients with isolated aortic stenosis, though there seems to be little difference in the incidence of angina between those patients with predominant stenosis and those with predominant regurgitation.[1 2] In this study, angina was more frequent in the presence of predominant stenosis.

Compared with aortic valve disease, little attention has been given to the incidence of angina in patients with isolated mitral valve disease, possibly because it was thought to be relatively uncommon. Baxter *et al.*,[1] however, reported 33 per cent of such patients with angina, a higher figure than that reported here (14%), but much must depend upon the criteria used in making a clinical diagnosis of angina. Baxter *et al.* do not state their criteria and, not having a separate group with atypical chest pain, such patients may have been included in their angina group. It is clear, however, that angina can occur in association with mitral valve disease (even isolated mitral stenosis) and the incidence in this study is higher than that of 5·5 per cent previously reported for a general population of similar age distribution.[20] The incidence of angina in patients with combined mitral and aortic valve disease (33%) was intermediate between the two other valve groups.

There are several reasons why angina might show an increased incidence in the presence of valvular heart disease.[21] Aortic valve disease is associated with increased left ventricular wall tension and myocardial oxygen requirement, while coronary blood flow and perfusion gradient may be decreased. In mitral stenosis, angina may result from low cardiac output and decreased coronary perfusion, but our findings suggest that in the presence of this

lesion it is more likely to be associated with severe coronary artery disease than it is in aortic valve disease. In this study pulmonary hypertension did not predispose to angina, but pulmonary pressure was severely raised in only a small number of patients.

In contrast to the symptom of angina, the incidence of significant coronary lesions was highest in isolated mitral valve disease (33%) and lowest in isolated aortic valve disease (28%). Comparison with previous studies is hindered by differences in the criteria used to classify a lesion as "significant". In this study, luminal narrowing of < 50 per cent was used, as our surgical policy is to graft such vessels if possible. When similar criteria have been used by others in patients with aortic valve disease, significant lesions were found in fewer patients (17%).[1] Other reports, taking 75 per cent narrowing as "significant", show an incidence of coronary artery disease of 14 per cent[2] and 23 per cent.[3] Swanton *et al.*[8] reported 23 per cent of patients with isolated aortic valve disease as having "significant" coronary lesions, but did not state the criteria used.

There have been few angiographic studies of the coronary arteries in patients with isolated mitral valve disease. Baxter *et al.*[1] reported lesions greater than 50 per cent narrowing in 22 per cent of patients. In isolated mitral stenosis significant coronary lesions have been reported in 18 per cent of patients at angiography[22] and in 32 per cent at necropsy.[23] In the present study 33 per cent of patients with mitral valve disease had at least one major coronary obstruction, thus confirming the substantial incidence of concomitant coronary artery disease in these patients.

Not only did patients with mitral valve disease have significant coronary lesions more frequently than those with aortic valve disease, but the overall severity (as assessed by the coronary score) was greater. It is not clear, however, whether mitral valve disease predisposes to coronary artery disease or whether aortic valve disease is relatively protective. It has been suggested that the rheumatic process induces coronary disease[24] but necropsy evidence disagrees.[25] Nakib *et al.*[26] suggest that in the presence of aortic stenosis, the severity of coronary artery disease is inversely related to the valve gradient, supporting a protective mechanism.

As a possible relation may exist between severity of coronary artery disease and severity of valve disease, an attempt was made to correlate an index of severity of valve disease (valve score) with one of the severity of coronary artery disease (coronary score). The group with the highest valve score (combined mitral and aortic valve disease) had the lowest coronary score but the converse did not hold. Valve score and coronary score had an inverse relation in all groups but this was only of statistical significance in patients with isolated aortic valve disease. The method used is arbitrary and does not take into account other factors, such as cardiac output, but nevertheless it appears that coronary artery disease may contribute to the severity of symptoms in patients with valvular heart disease. Further, clinical deterioration leading to consideration of valve surgery may be the result in part of increasing severity of coronary artery disease rather than deterioration caused by the valve itself. Identification of coronary disease must therefore become an important part of preoperative investigation, and its alleviation a consideration in any surgical intervention.

If this is accepted, how can identification of coronary artery disease be achieved? Taking angina as a marker of coronary artery disease our findings agree with previous studies,[1–4 12] where angina in aortic valve disease indicates significant coronary lesions in only 33 per cent of patients. Angina in mitral valve disease is more significant, 85 per cent of such patients having major coronary obstruction. In this series, all patients with isolated mitral stenosis and angina had significant coronary artery disease. While angina is a poor marker of coronary artery disease in aortic valve disease, in mitral valve disease it is valuable. An absence of angina is less useful. The substantial incidence (22%) of significant coronary disease in patients with aortic valve disease but no chest pain in the present study confirms that the absence of chest pain in isolated aortic valve disease does not rule out the presence of significant coronary artery disease. The figures for mitral valve disease without chest pain are similar.

In the second part of this study other factors, possibly predictive of the presence of coronary artery disease, were examined. Though men tended to have more severe coronary artery disease than women, the difference was significant only in isolated mitral valve disease. The severity of coronary artery disease increased with age but there was no age below which it could be confidently excluded. No significant differences were found between smokers and non-smokers. Surprisingly, there was no significant relation between severity of coronary artery disease and several simple indices of left ventricular function. Previous studies have shown that the resting electrocardiogram is also of little value.[1 10] In a multiple regression analysis of these factors only angina and age in patients with isolated mitral valve disease, and age in patients with mitral and aortic valve disease, were predictive of the severity of coronary artery disease. It there-

fore seems clear that, if it is desirable to identify patients with coronary artery obstructions before valve surgery, there is no simple alternative to routine coronary arteriography. We have no data to set a lower age limit for this recommendation. Though coronary artery disease was found in patients aged below 45 years, coronary arteriography was not performed as a routine procedure in this group.

A remaining question is whether significant coronary artery disease, if found, should be treated by coronary artery bypass grafts. Coronary artery disease may contribute to symptoms before and after valve surgery and the mortality of surgery may thus be considerably influenced. Poor results have been attributed to uncorrected coronary artery disease,[11 13–15] with twice the perioperative mortality of patients with no coronary artery disease.[27] Long-term survival is also reduced.[16] Previous reports of aortic valve replacement with concomitant coronary artery bypass grafts have suggested higher,[13 28–31] lower,[27 32 33] or unchanged[16 34 35] mortality as compared with aortic valve replacement alone. In all except one of these studies,[32] coronary artery bypass graft was performed immediately after valve replacement, inferring that during the phase of valve replacement the distal myocardium was at risk from underperfusion. Macmanus *et al.*[32] report a comparison of patients treated in this sequence with a group treated in the reverse order and suggest that coronary artery bypass grafting performed first reduces the risk of operative myocardial infarction. In the present series the overall perioperative (within four weeks) mortality of valve replacement combined with coronary artery bypass graft was 20 per cent compared with 5·9 per cent for valve replacement alone. Patients undergoing coronary artery bypass grafts, however, represent a group with increased risk by virtue of their coronary artery disease and to make true comparisons of perioperative mortality and the degree of postoperative improvement it would be necessary to carry out a randomised prospective trial of patients with similar degrees of valvular and coronary disease.

In conclusion, this study has shown that asymptomatic coronary artery disease is common in patients undergoing assessment for valve surgery and that there are no adequate clinical markers for such coronary lesions. We therefore believe that routine coronary arteriography is necessary for proper diagnosis in patients with valvular heart disease before surgery. The yield of significant coronary lesions has been shown to average 33 per cent in patients aged 45 years or over but we have no data as to the incidence in lower age groups.

We thank Dr P G Keates for reporting the coronary angiograms, Dr W Whitaker who allowed us to study his patients, and Mr M I Ionescu who performed the operations.

References

1 Baxter RH, Reid JM, McGuiness JB, Stevenson JG. Relation of angina to coronary artery disease in mitral and aortic valve disease. *Br Heart J* 1978; **40:** 918–22.
2 Basta LL, Raines D, Najjar S, Kioschos JM. Clinical, haemodynamic and coronary angiographic correlates of angina pectoris in patients with severe aortic valve disease. *Br Heart J* 1975; **37:** 150–7.
3 Harris CN, Kaplan MA, Parker DP, Dunne EF, Cowell HS, Ellestad MH. Aortic stenosis, angina, and coronary artery disease: interrelations. *Br Heart J* 1975; **37:** 656–61.
4 Mandal AB, Gray IR. Significance of angina pectoris in aortic valve stenosis. *Br Heart J* 1976; **38:** 811–5.
5 Lewes D. Diagnosis of aortic stenosis. Based on a study of 25 proved cases. *Br Med J* 1951; **i:** 211–6.
6 Wood P. Aortic stenosis. *Am J Cardiol* 1958; **1:** 553–71.
7 Baker C, Somerville J. Clinical features and surgical treatment of fifty patients with severe aortic stenosis. *Guys Hospital Reports* 1959; **108:** 101–25.
8 Swanton RH, Brooksby IAB, Jenkins BS, *et al.* Determinants of angina in aortic stenosis and the importance of coronary arteriography. *Br Heart J* 1977; **39:** 1347–52.
9 Moraski RE, Russell RO Jr, Mantle JA, Rackley CE. Aortic stenosis, angina pectoris, coronary artery disease. *Cathet Cardiovasc Diagn* 1976; **2:** 157–64.
10 Lacy JP, Goodin RR, Flowers NC. Coronary atherosclerosis in valvular heart disease: the need for coronary arteriography (abstract). *Am J Cardiol* 1975; **35:** 151.
11 Linhart JW, Wheat MW Jr. Myocardial dysfunction following aortic valve replacement. The significance of coronary artery disease. *J Thorac Cardiovasc Surg* 1967; **54:** 259–69.
12 Bonchek LI, Anderson RP, Rösch J. Should coronary arteriography be performed routinely before valve replacement? *Am J Cardiol* 1973; **31:** 462–6.
13 Loop FD, Phillips DF, Roy M, Taylor PC, Groves LK, Effler DB. Aortic valve replacement combined with myocardial revascularisation. *Circulation* 1977; **55:** 169–73.
14 Sharratt GP, Rees P, Conway N, Myocardial infarction complicating aortic valve replacement. *J Thorac Cardiovasc Surg* 1976; **71:** 869–71.
15 Fishman NH, Youker JE, Roe BB. Mechanical injury to the coronary arteries during operative cannulation. *Am Heart J* 1968; **75:** 26–33.
16 Richardson JV, Kouchoukos NT, Wright JO III, Karp RB. Combined aortic valve replacement and myocardial revascularisation: results in 220 patients. *Circulation* 1979; **59:** 75–81.
17 Roberts WC, Morrow AG. Late postoperative

pathological findings after cardiac valve replacement. *Circulation* 1967; **35** & **36,** suppl I: 48–62.
18 Yang SS, Bentivoglio LG, Maranhão V, Goldberg H. *From cardiac catheterisation data to haemodynamic parameters.* Philadelphia: F A Davis, 1972.
19 Kasser IS, Kennedy JW. Measurement of left ventricular volumes in man by single-plane cine-angiocardiography. *Invest Radiol* 1969; **4:** 83–90.
20 Eriksson J, Enge I, Forfang K, Storstein O. False positive diagnostic tests and coronary angiographic findings in 105 presumably healthy males. *Circulation* 1976; **54:** 371–6.
21 Anonymous. Angina and aortic valve stenosis. *Br Med J* 1977; **i:** 597–8.
22 Befeler B, Kamen AR, MacLeod CA. Coronary artery disease and left ventricular function in mitral stenosis. *Chest* 1970; **57:** 435–9.
23 Tadavarthy SM, Vlodaver Z, Edwards JE. Coronary atherosclerosis in subjects with mitral stenosis. *Circulation* 1976; **54:** 519–21.
24 Zeek P. Studies in atherosclerosis. I. Conditions in childhood which predispose to the early development of arteriosclerosis. *Am J Med Sci* 1932; **184:** 350–6.
25 Gardner FE, White PD. Coronary occlusion and myocardial infarction associated with chronic rheumatic heart disease. *Ann Intern Med* 1949; **31:** 1003–9.
26 Nakib A, Lillehei CW, Edwards JE. The degree of coronary atherosclerosis in aortic valvular disease. *Arch Pathol* 1965; **80:** 517–20.
27 Copeland JG, Griepp RB, Stinson EB, Shumway NE. Long-term follow-up after isolated aortic valve replacement. *J Thorac Cardiovasc Surg* 1977; **74:** 875–89.
28 Berndt TB, Hancock EW, Shumway NE, Harrison DC. Aortic valve replacement with and without coronary artery bypass surgery. *Circulation* 1974; **50:** 967–71.
29 Rossiter SJ, Hultgren HN, Koesk JC, Wuerflein RD, Angell WW. Ischemic myocardial injury with aortic valve replacement and coronary bypass. *Arch Surg* 1974; **109:** 652–8.
30 Loop FD, Favaloro RG, Shirey EK, Groves LK, Effler DB. Surgery for combined valvular and coronary heart disease. *JAMA* 1972; **220:** 372–6.
31 Anonymous. Coronary arteriography before aortic valve replacement. *Br Med J* 1979; **i:** 1443–4.
32 Macmanus Q, Grunkemeier G, Lambert L, Dietl C, Starr A. Aortic valve replacement and aorto-coronary bypass surgery. Results with perfusion of proximal and distal coronary arteries. *J Thorac Cardiovasc Surg* 1978; **75:** 865–9.
33 Ross JK, Monro JL, Manners JM, *et al.* Cardiac surgery in Wessex: review of 1000 consecutive open heart procedures. *Br Med J* 1976; **ii:** 1485–9.
34 Riner RN, Tajik AJ, Wallace RB, Frye RL. Aortic valve replacement and myocardial revascularisation: early mortality (abstract). *Am J Cardiol* 1979; **41:** 412.
35 Merin G, Danielson GK, Wallace RB, Rutherford BD, Fluth JR. Combined one-stage coronary artery and valvular surgery. *Circulation* 1975; **47** & **48,** suppl III: 173–6.

Requests for reprints to Dr G W Morrison, Department of Cardiovascular Studies, The University, Leeds LS2 9JT.