DIAGNOSTIC SELECTIVE CORONARY ARTERIOGRAPHY*

M. S. GOTSMAN, M.D., M.R.C.P., M.R.C.P. (GLASG.), D.T.M. & H., W. S. WINSHIP, M.B., CH.B., M.MED. (PAED.), J. R. QUANTRILL, M.B., CH.B., D.P.H., D.M.R.D. AND R. L. VAN DER HORST, M.B., CH.B., M.MED. (PAED.),
Cardio-Thoracic Unit, Wentworth Hospital and the University of Natal

Selective coronary arteriography is an excellent technique to demonstrate the living anatomy and pathology of the coronary vascular tree.[1-11]

We have used this technique for the past year and this paper will describe the indications, problems and value of the procedure, with special reference to our unit in which a large portion of the patients are Bantu.

PATIENTS AND METHODS

Coronary arteriography was undertaken in patients in whom coronary artery disease was suspected on clinical or electrocardiographic criteria (Table I).

TABLE I. INDICATIONS FOR CORONARY ARTERIOGRAPHY

1. *Clinical Coronary Artery Disease.*
   (*a*) To establish the diagnosis.
   (*b*) To assess the type and extent of involvement.
   (*c*) To assess LV function.
   (*d*) Performed as a routine before surgery for:
      (*i*) Revascularization of myocardium (Vineberg operation).
      (*ii*) Coronary endarterectomy.
      (*iii*) Resection of ventricular aneurysm.
2. *Angina Pectoris in an Atypical Clinical Situation.*
3. *ECG Indicating Ischaemic Heart Disease in an Unusual Patient.*
4. *Left Ventricular Disease with Angina Pectoris.*
5. *Before Cardiac Surgery*: to exclude coronary artery disease in a patient with angina pectoris.

Local anaesthesia was used, with 50 mg. pethidine as a sedative. The right brachial artery was exposed through a small cutdown immediately above the skin crease in the right antecubital fossa. Routine right- and left-heart catheterization was then performed and the cardiac output was measured by the direct Fick principle. The end-diastolic pressure in the left ventricle was measured. Left ventricular function was also assessed by selective ventriculography, and this was followed by aortography to demonstrate the aortic valve and root, and the ostia of the coronary arteries. A No. 7 or 8F Sones coronary artery catheter with a 1- or 1½-in. tip was then used for selective catheterization of each coronary orifice. A 4-way tap system permitted continuous monitoring of aortic pressure, flushing of the catheter and intermittent injection of 76% Urografin which was used as a contrast medium. The patient was turned into each oblique position (60° right and left anterior oblique positions) and each coronary ostium intubated in turn. A trial injection of 2 ml. of Urografin confirmed that the catheter tip had entered the coronary ostium. The patient was then asked to hold his breath in inspiration, and 6 ml. of Urografin was injected rapidly by hand under radiographic control. Two to three injections were made into each coronary artery in each position. Cinephotography was performed through a 9-in. Philips image intensifier using a 35-mm. Arriflex camera, filming 32 frames per second with Kodak 'Cineflure' film. Angiography was then repeated after sublingual administration of isorbide dinitrate, a potent coronary vasodilator.

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RESULTS AND DISCUSSION

The clinical material is analysed in Table II. Satisfactory coronary arteriograms were obtained in all but one of the patients, and the ease of performing the procedure improved with experience. The patients had ECG changes immediately after the injection of contrast medium, but these returned rapidly to normal once the contrast medium had cleared. Serious bradycardia with hypotension occurred in 2 patients but was improved by an intravenous injection of atropine. One patient developed intermittent claudication of the right arm after arteriotomy and angiography showed thrombosis of the right brachial artery.

TABLE II. CLINICAL MATERIAL — DIAGNOSTIC CATEGORIES

Diagnosis	*No. of cases*
1. Occlusive coronary artery disease (atheroma)	
(*a*) With angina pectoris only	2
(*b*) With severe ischaemic fibrosis	5
2. Aortic valve disease with severe angina	
(*a*) With organic coronary artery disease	4
(*b*) Without CA disease	2
3. Idiopathic hypertrophic obstructive cardiomyopathy (Hocum) (with angina)	3
4. Cardiomyopathy in Whites	1
5. Bantu patients with atypical symptoms	
Chest pain 1	
Infarct pattern on ECG 2	
VPA + post-ectopic T-wave change 1	
Hocum 1	5
6. Young females with angina pectoris and normal coronary arterial tree	2
7. Mitral stenosis with atypical angina	
(*a*) With organic coronary artery disease	1
(*b*) Without coronary artery disease	2
8. ASD with abnormal ECG	1
9. Congenital fistula between coronary artery and right ventricle	1
10. Mitral incompetence with posterior leaflet prolapse	1

Normal Anatomy (Fig. 1)[12]

The left coronary artery arises from the upper part of the left coronary sinus of Valsalva. It has a short main stem of 1 - 2 cm. and then divides into 2 main branches. The anterior descending branch runs down the anterior inter-ventricular septum, giving off diagonal branches which supply the anterior surface of the left ventricle, and 2 or 3 perforating branches which supply the anterior portion of the inter-ventricular septum. Often a terminal branch curves round the apex of the ventricle.

The circumflex branch of the left coronary artery is the other major branch and passes to the left in the atrio-ventricular groove supplying branches downwards to the free wall of the left ventricle and up to the atrium. A large marginal branch passes down the obtuse margin of the left ventricle to supply its lateral surface. The circum-

flex branch can be identified easily: it follows the same course as the coronary sinus which drains into the right atrium.

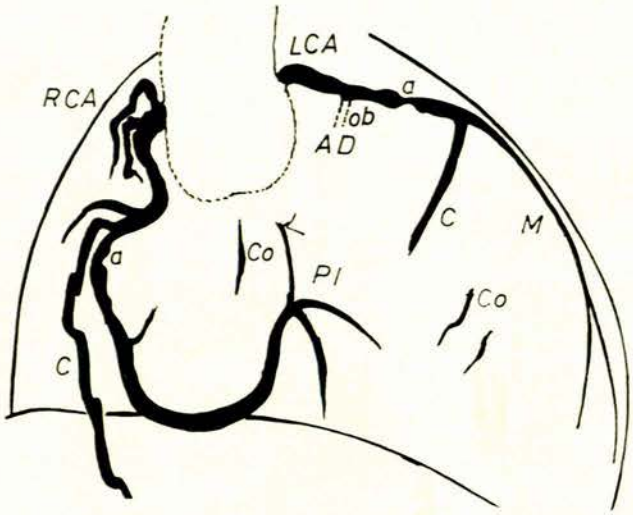

Fig. 1. Superimposed tracings of a selective left and right coronary arteriogram in the left anterior oblique position to show the normal anatomy and atheroma (a) of the left and right coronary arteries, with obstruction of the anterior descending (AD—ob) and circumflex (c) left coronary arteries with well-developed collateral circulation (Co). LCA = left coronary artery; RCA = right coronary artery; PI = posterior inter-ventricular artery; C = circumflex artery; M = marginal artery.

The right coronary artery arises from the right sinus of Valsalva and has a long, undivided course in the atrioventricular groove between the right atrium and ventricle. It passes to the crux of the heart where a terminal branch follows the left atrioventricular groove and another major branch passes down the posterior inter-ventricular groove. Major branches include a small ascending branch to the sino-atrial node, larger branches to the atrium, a large marginal branch to the margin of the right ventricle, smaller right ventricular branches and perforating branches in the posterior inter-ventricular septum. It also supplies a small artery to the atrioventricular node.

In the majority of patients, the right coronary artery is 'dominant'—it supplies the crux of the heart and gives off the posterior inter-ventricular artery. In 20% of patients this region is supplied by a left coronary artery which is then regarded as 'dominant'. The artery to the crux of the heart usually gives off the artery to the atrioventricular node. Occasionally the sinus node artery arises from the origin of the circumflex left coronary artery.

Technical Quality of Angiography

Three techniques of coronary arteriography give good results. Nordenstrom[10] utilizes non-selective aortography. The procedure is undertaken under general anaesthesia and the endo-bronchial pressure is raised to 2 atmospheres to stop the venous return to the heart. The cardiac output then falls and contrast is selectively layered within the root of the aorta. Biplane serial roentgenography on 14 × 14-in. roll film at 6 exposures per second provides excellent anatomical details of the smaller vessels. This is a good technique but requires general anaesthesia. Judkins[11] uses a catheter with a preformed tip inserted percutaneously into the femoral artery and performs multiple injections in different positions. This procedure has great promise. The Sones technique is now employed in many centres.[1-9] It is a difficult technique and requires perfect radiography.

Our X-ray equipment was not ideal and we could not obtain adequate magnification. A 6-in. image intensifier with 100-mm. focal-distance lens is needed for optimum radiographic quality. Despite these disadvantages our films were of adequate quality and resolution.

Occlusive Coronary Artery Disease

Seven patients had atheroma of the coronary arteries. Two had obstruction of one artery with well-developed collateral vessels and good left ventricular function; 5 others had localized abnormalities of the pattern of ventricular contraction—akinesis, dyskinesis or aneurysm formation. Two of the latter group had obstruction of one vessel, 2 had obstruction of 2 vessels and 1 had obstruction of 3 vessels. In general, patients with severe clinical disability and shortness of breath had more severe left ventricu'ar dysfunction and more extensive artery disease.

One 33-year-old patient had severe angina pectoris and good left ventricular function. His left internal mammary artery was implanted into the anterior surface of the left ventricle. Surgery was not undertaken in the other 6 patients: their angina was too mild or their left ventricular dysfunction too severe.

In each patient, coronary arteriography was the only exact method to determine the anatomy of the coronary artery obstruction and disease, and the extent to which the collateral circulation had developed. The left ventriculogram identified the degree of left ventricular dysfunction.

Aortic Valve Disease with Severe Angina Pectoris

Patients with aortic stenosis or incompetence often present with classical angina pectoris. Left ventricular hypertrophy increases the oxygen demand of the heart and each lesion compromises coronary perfusion on a haemodynamic basis. Thus, in aortic stenosis, the systolic pressure in the left ventricle exceeds aortic pressure, whereas in aortic incompetence the low aortic diastolic pressure is unable to maintain an adequate diastolic coronary blood flow.

Six older subjects presented with severe angina pectoris. Four had associated organic disease of the coronary arteries, while 2 did not have coronary artery disease.

Selective coronary arteriography, therefore, is mandatory in patients with aortic valve disease associated with angina pectoris. Many of these patients are regarded as cases of ischaemic heart disease and their aortic systolic murmur is attributed to aortic valve sclerosis. Often the aortic stenosis is severe and responsible for the patient's symptoms.

Idiopathic Hypertrophic Obstructive Cardiomyopathy

Three patients with this syndrome presented with severe angina pectoris: 2 were diagnosed and referred as cases of ischaemic heart disease. The correct diagnosis was confirmed by catheterization and left ventriculography, and the coronary arteries were demonstrated to be large, but normal and patent.

A clinical diagnosis can be made if the diagnosis is kept in mind, but if the patient presents with severe angina pectoris or if the physical signs are slightly atypical, the diagnosis may be missed.

Cardiomyopathy in White Patients

One older subject with heart failure had electrocardiographic features of left ventricular damage. Coronary arteriography was undertaken to exclude coronary artery disease.

Myocardial fibrosis, secondary to ischaemic heart disease, and primary myocardial disease may resemble each other if there is no history of angina pectoris. Coronary arteriography is then the only method of arriving at the correct diagnosis.

Bantu Patients with Atypical Symptoms

Ischaemic heart disease was suspected on clinical grounds in 5 patients. One young subject had typical precordial pain but had normal intracardiac dynamics and coronary arteriograms. Two had an infarct pattern on the electrocardiogram and a loud 3rd heart sound. Both had localized, non-contractile segments of the left ventricle due to localized cardiomyopathy without coronary artery disease. Another patient had numerous ventricular premature systoles with post-ectopic T-wave changes and a loud 3rd heart sound. She also had primary myocardial disease. The 5th patient had hypertrophic obstructive cardiomyopathy. In each case coronary arteriography demonstrated normal coronary arteries.

Angina in Young Females

Two premenopausal women with typical angina pectoris had abnormal electrocardiographic patterns in keeping with coronary artery disease. There was no evidence of diabetes or hypercholesterolaemia. Both had normal coronary arteriograms, thus excluding significant disease of the large coronary arteries. These patients probably have abnormalities of the coronary arteries—small vessel angina.[13]

Mitral Stenosis with Atypical Angina

Angina pectoris also occurs in patients with mitral valve disease and may be due to severe pulmonary hypertension, coronary artery embolism or associated organic atherosclerotic coronary artery disease.[14] Three patients with mitral valve disease and severe pulmonary hypertension presented with atypical angina pectoris. One patient had organic coronary artery disease and in the other 2 the coronary arteries were normal.

CONCLUSIONS

Coronary arteriography is a simple, safe and reliable procedure, provided it is undertaken by experienced personnel who have facilities available for immediate resuscitation when cardiovascular catastrophes such as ventricular fibrillation or complete heart block occur. The indications for coronary arteriography have now crystallized and we perform the investigations in any patient with coronary artery disease in whom surgery is contemplated, any patient with valvular heart disease who might be subject to open heart surgery and who has a history of angina pectoris, and unusual patients with difficult diagnostic problems in whom coronary artery disease is suspected. The last group includes Bantu patients who present with angina pectoris or an electrocardiographic pattern in keeping with myocardial infarction.

SUMMARY

Selective coronary arteriography was performed on 30 subjects. It was a simple, safe and reliable technique and was performed in patients with coronary artery disease awaiting surgery, in patients awaiting cardiac surgery who also had angina pectoris, and in patients with angina pectoris or atypical heart disease in whom a confident diagnosis was needed.

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REFERENCES

1. Sones, F. M. jnr and Shirey, E. K. (1960): Circulation, **22**, 815.
2. Sones, F. M. and Shirey, E. K. (1962): Mod. Conc. Cardiov. Dis., **31**, 735.
3. Proudfit, W. L., Shirey, E. K. and Sones, F. M. jnr (1966): Circulation, **33**, 901.
4. Proudfit, W. L., Shirey, E. K. and Sones, F. M. (1967): *Ibid.*, **36**, 54.
5. Proudfit, W. L., Shirey, E. K., Sheldon, W. C. and Sones, F. M. (1968): *Ibid.*, **38**, 947.
6. Sewell, W. H. (1965): Amer. J. Roentgenol., **95**, 673.
7. Cohen, L. S., Elliot, W. S., Klein, M. D. and Gorlin, R. (1966): Amer. J. Cardiol., **17**, 153.
8. Elliott, W. C. and Gorlin, R. (1966): Mod. Conc. Cardiov. Dis., **35**, 117.
9. Hultgren, H., Calciano, A., Platt, F. and Abrams, H. (1967): Amer. J. Med., **42**, 228.
10. Nordenstrom, B. (1964): Radiol. Clin. N. Amer., **2**, 377.
11. Judkins, M. P. (1967): Radiology, **89**, 815.
12. James, T. N. (1965): Circulation, **32**, 1020.
13. Likoff, W., Segal, B. L. and Kasparian, H. (1967): New Engl. J. Med., **276**, 1063.
14. Wood, P. (1954): Brit. Med. J., **1**, 1113.