

Coronary angiography

Review of 1500 consecutive cases¹

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Fifteen hundred coronary angiograms have been performed by the staff of Harefield Hospital since 1970. Only 2 deaths have occurred in the last 1000 consecutive cases though there were 5 in the first 500 cases. This drop in the mortality is ascribed to careful attention to detail and better training of the operators. It is concluded that the Judkin's method of coronary angiography in trained hands is a safe method of investigation but that because of the very serious potential dangers it is unjustifiable for new units to start unless there is a fully experienced investigator in charge.

With the advent of successful revascularization of blocked and narrowed coronary arteries, using venous bypass grafts from the aorta, the demand for coronary angiography has risen rapidly during the past 5 years. At Harefield 25 arteriograms were performed in 1970 but 615 in 1975 (Fig. 1) though circumstances beyond our control reduced the number conspicuously at the end of the last year. Information about the safety of this examination is, therefore, important.

Emanuel (1975) circularized 50 British centres undertaking coronary angiography in 1973. Of the 46 who replied, only 9 knew the mortality rate for their institution; the highest was up to 0.6 per cent. The morbidity ranged from 0.9 to 2.2 per cent. In 1973, Petch, Sutton, and Jefferson reported a series of 400 angiograms with an overall mortality of 1.5 per cent; 2.4 per cent for the 248 done by Judkins' (1967) method and a zero mortality for the 111 by Sones and Shirey's (1962) method. Adams, Fraser, and Abrams (1973), in a nationwide survey of the United States, found a 0.8 per cent mortality for Judkins' technique and a 0.13 per cent mortality for Sones'.

The purpose of this paper is to review our experience with particular reference to complications.

Coronary angiography at Harefield Hospital
Originally, coronary angiograms were carried out by whichever investigator, consultant, or registrar

Received 10 March 1976.

¹Based on a paper given to the Third European Congress of Radiology in Edinburgh in June 1975.

was on rota for that day. Our morbidity and mortality (2%) was unacceptably high so the policy was changed and only 2 consultants, 1 in cardiology and 1 in radiology, undertook coronary angiography, with a registrar assisting. This continued until more experience had been gained. The coronary team was then increased to include first the senior registrar and then registrars. At present we have 3 consultants, 1 senior registrar, and 2 registrars allowed to undertake coronary angiography unsupervised. This gives an average of

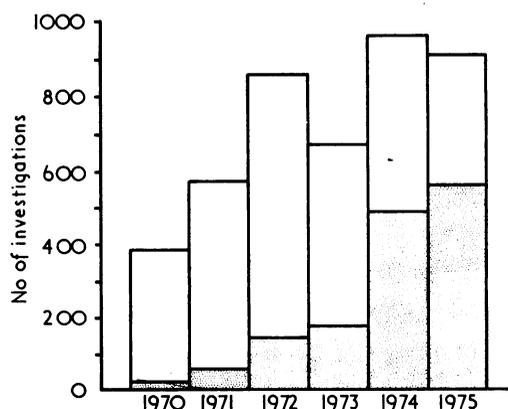


FIG. 1 Cardiac investigations performed each year at Harefield Hospital. The shaded blocks represent coronary angiogram and the open columns the investigations undertaken without coronary angiography.

100 angiograms per year per operator in this hospital. One consultant also catheterizes elsewhere. In addition, a physician and/or his registrar from a neighbouring hospital catheterizes up to 2 patients once a week. These latter have not been included in the study.

There is only one room suitable for doing coronary angiograms in the hospital. This is equipped with pulsed cine, a high definition caesium iodide intensifier, and high speed tubes, as well as a biplane roll film changer. It has to cope with most of the other cardiac investigations as well, including the children.

A second room with non-pulsed cine and an ordinary intensifier is available for other investigations, such as pacemaker procedures and pulmonary angiograms.

The number of investigations which do not include coronary angiography (Fig. 1) has declined since 1972. This is probably because of the greater readiness to undertake coronary angiography in patients suspected of having predominantly a non-ischaemic diagnosis. For instance, all patients with aortic valve disease now have coronary angiograms performed routinely as well as those with cardiomyopathy. Routine re-examination of patients after coronary artery bypass grafting also accounts for a substantial number of patients (Fig. 2).

The age distribution shown in Fig. 3 has not changed significantly over the years and is predominantly in the sixth decade. The male and female ratio has also remained steady at approximately 5:1.

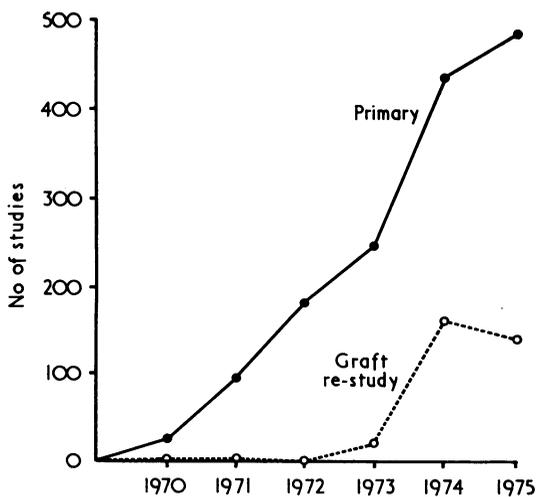


FIG. 2 Incidence of restudies by years.

Angiographic method

Patients are all premedicated with atropine and diazepam (Valium) or papaveretum and hyoscine. The Judkins technique is used routinely and in only 21 patients has this proved impossible (1.4%). Patients are x-rayed on a rotating cradle (since October 1973) and films taken exclusively on cine film.

A left ventricular angiogram is first made in the right anterior oblique position after the injection of 40 to 50 ml Conray 420 at 10 ml/s, using a Medrad injector. Selective coronary injections are made using hand injections with individually filled syringes containing 10 ml urografin 76 per cent.

Usually 3 injections are made into the left coronary artery, with the patient in the right then left anterior oblique and then left lateral positions. Two views are taken of the right coronary artery, the left and right obliques. The degree of rotation is adjusted individually so that the heart shadow is clear of the spine.

Pressure monitoring from the catheter tip is continuously displayed during the investigation as well as the electrocardiogram. Pacing electrodes are not inserted before coronary angiography and have never been required. Whole body anticoagulation with heparin was used routinely for about 6 months, in approximately half the cases in 1974, but this has been abandoned because there was no obvious advantage and extra danger of bleeding during and after the procedure was apparent.

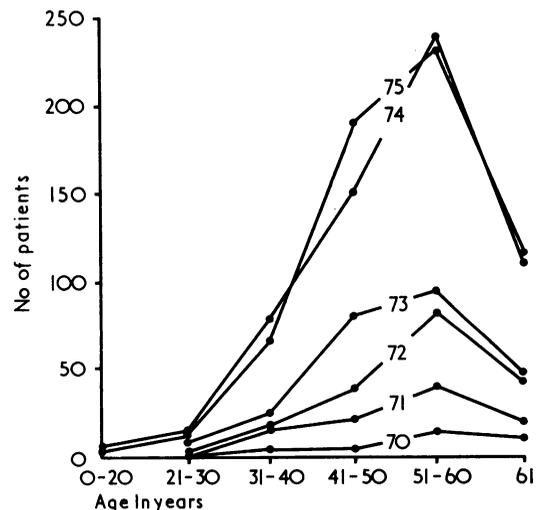


FIG. 3 Age distribution each year.

Mortality

Throughout the series there have been 7 deaths occurring with 36 hours of investigation. Up to the end of 1973 there were 5 deaths resulting from 400 coronary angiograms (1.2%). In the 2 years (1974 and 1975) 2 deaths occurred in 1064 coronary angiograms (0.19%). The first 4 patients who died all had severe coronary artery disease, with poorly functioning ventricles. One patient had a ventricular aneurysm. Only one patient arrested on the table. He was immediately transferred to the theatre and cardiopulmonary bypass was instituted within 20 minutes. When the coronary arteries were opened back bleeding was seen with no sign of coronary embolism. The ventricle which showed patchy fibrosis and evidence of diffuse ischaemic damage, failed to take over and the patient died. At necropsy there was no sign of coronary dissection or other catheter trauma.

The interval between angiography and death, in the others, has been between 2 and 35 hours after returning to the ward. The last 3 deaths occurred in patients who were being investigated for crescendo angina. They had been admitted with rest pain which was not relieved by medical treatment. Coronary angiography was undertaken with a view to emergency coronary grafting. In no case did the necropsy show any evidence of recent damage to a coronary artery. Such patients are not now investigated until after an intra-aortic balloon has been introduced and counterpulsation started. Since starting this regimen no further death has occurred.

Morbidity

Cardiac infarction, the most expected complication of coronary angiography, did not occur in any of the series.

The most important lesion resulting from coronary angiography was cerebral embolus. This occurred in 12 patients. Six of these were in the first 400 and six in the next 1000. All but 2 cleared completely—one has a mild hemiplegia and one a weakness of one leg. Two patients developed pulmonary oedema on the table and recovered with treatment. Two patients developed urticarial rashes. Fourteen patients in the first 400 suffered a severe drop in blood pressure but only 8 in the next 1000. Six patients had femoral artery problems. In one the tip of a guide wire broke off in the groin and had to be removed surgically. Four patients suffered femoral artery occlusions requiring disobliteration by a surgeon using a Fogarty catheter. One of these patients had had an obvious fall in

blood pressure after left ventricular angiography which showed a large, poorly contracting chamber. Further deterioration occurred after embolectomy. Death occurred within 36 hours of the examination. One patient had severe prolonged haemorrhage. Twenty-five examinations were terminated prematurely (1.7%). Seven because of angina; 5 for persistent electrocardiographic abnormalities; 2 because of pulmonary oedema; 3 after cardiac arrest; 5 because of blood pressure drop; and 3 after embolus. Only 4 of these abandoned investigations were in the last 1000; 2 after a cardiac arrest; 1 because of persistent electrocardiographic abnormalities; and 1 because of a continuing fall in blood pressure. No permanent sequelae resulted from any of these events, other than the patient with the low blood pressure who subsequently died. Failure to pass the catheter into the aorta occurred in 21. This showed little change between 1970 and 1975. Failure to catheterize either the right or left coronary artery dropped abruptly from 16 and 20 per cent in 1970 to 3.8 and 2.7 per cent in 1972 and then gradually to 0.9 per cent and nil in 1975 (Fig. 4). In the last 1000 examinations, the failure rate for catheterization of the aorta was 1.4 per cent, the left coronary artery 0.6 per cent, and the right coronary artery 2.4 per cent. Thus successful catheterization of both coronary arteries was achieved in 95.6 per cent.

Discussion

The data on which Petch *et al.* (1973) and Adams *et al.* (1973) based their conclusions that Sones'

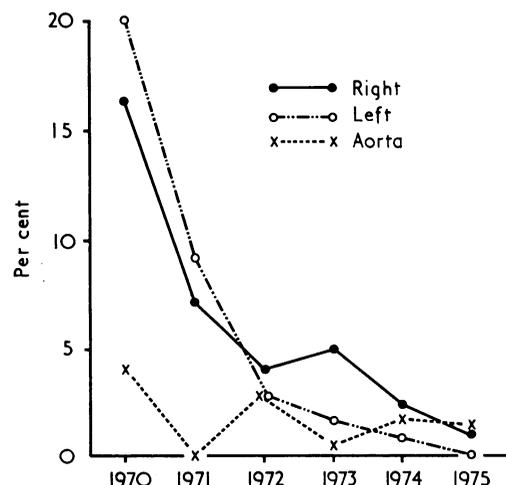


FIG. 4 Failure to enter individual vessels expressed as a percentage of the number attempted each year.

method of coronary angiography is safer than Judkins' are open to a different interpretation. In Adams' series, the centre doing the most femoral coronary angiograms completed 1183 in the two years with a single death. The centre doing approximately the same number of brachial aortic angiograms (1437) also had one death. The mortality rate of these two groups is not significantly different (0.08% and 0.06%). Fifty-six hospitals in this series did less than 50 angiograms each by the femoral route in the 2 years with a mortality of 2.4 per cent but the highest mortality rate of any group of hospitals undertaking Sones' method was 0.5 per cent. Sones' method requires the performance of brachial arteriotomy. This will tend to be undertaken only by trained operators.

Seldinger's technique does not require any such obvious expertise and, in consequence, is frequently attempted by the relatively inexperienced and untrained. Difference in operator ability could also have determined the method used in the National Heart Hospital series (Petch *et al.*, 1973). The fall in the mortality rate between our first 400 and the next 1000 confirms the importance of training and experience. It has been our recent practice to have a trainee operator assisted by one who is fully trained until the learner has become entirely competent. The supervising instructors must be gowned and gloved ready for action, should the learner have difficulty. Difficulty includes delay in entering either artery. The improvement in the complication rate has paralleled the reduction in time taken for each examination. Mean screening times for investigations do not reflect the increase in speed which has been acquired over the years because of the larger numbers of patients being restudied after surgery recently (Fig. 2). These may involve entering up to 4 grafts and even (occasionally) searching for one that has blocked, in addition to catheterization of the native vessels and a left ventricular angiogram.

Although the cases which are now subjected to coronary angiography include patients who are less seriously ill than formerly, the lower complication rate cannot only be a reflection of the lesser severity of the coronary disease, though this must be important. In 1975 the lumen of more than two-thirds of all vessels catheterized was reduced to less than half its original size. Of the last 1000 studies, 564 were on patients who had later (or previously) had a cardiac operation. A further 13.2 per cent had ventricular functions too poor for operations to be undertaken or were primary cardiomyopathies. Only 4 per cent had normal studies. The 264 not operated on include some who are still on the waiting list for operation. The low

incidence of complications associated with the Seldinger procedure is attributed to careful attention following the original instructions (1953). That is, when possible, only the anterior wall of the artery is punctured and the needle inserted sufficiently low that should the back wall be transfixed, the rear hole is below the inguinal ligament and capable of occlusion by compression. Most important, no force must be used in the passage of the catheters which should flow smoothly and easily. A normal arterial pressure must be recorded at all times other than during actual injections. Should the pressure drop, the catheter must be withdrawn from coronary or femoral artery immediately—even though there may have been difficulty in entering the artery.

Conclusion

Coronary angiography by Judkins' technique is a safe procedure when performed by experienced operators. Operators should not be in charge of coronary catheterization until they have proved themselves to be competent during a period of close supervision. During this period of supervision a completely competent operator should be acting as assistant and prepared to take over should the need arise. Taking over from the learner should not be delayed but should occur at the first hint of difficulty. Units would no longer be justified in starting coronary angiography unless they have a fully experienced person in charge. One would expect such a person to have at least 2 years' experience of coronary angiography and a minimum of 200 angiograms to their credit.

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