Experience with systemic heparinization during cardiac catheterization by brachial arteriotomy

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Experience with systemic heparinization during cardiac catheterization by brachial arteriotomy has been investigated by a prospective study. In 253 catheterizations no complications attributable to heparinization occurred. The incidence of impaired (2.4%) and absent (1.6%) radial pulses after catheterization was lower than in some series. The majority of complications were related to local trauma at the site of catheter introduction and were related to the type of catheter used. The incidence of post-catheterization occlusion requiring thrombectomy was significantly lower for those with systemic heparinization than for those where heparin was omitted or reversed, though the numbers involved were small. We conclude that systemic heparinization is a useful and safe technique during cardiac catheterization and can help to reduce the incidence of local thrombosis.

The co-operative study on cardiac catheterization investigated the complications associated with cardiac catheterization and concluded that patients on anticoagulants were at increased risk from this procedure (Swan, 1968a). However, heparin in moderate doses is usually administered locally as a routine part of left heart catheterization when performed by brachial arteriotomy (Sones, 1970; Sewell, 1965; Walker *et al.*, 1973), and since 1968 we have used full systemic heparinization for routine left heart catheterization. We have considered it safe and helpful in reducing the incidence of arterial occlusion caused by distal thrombosis. In order to study the role of systemic heparinization more fully, a prospective study was carried out.

Patients

During a 10-month period from June 1972, 253 arteriotomies were performed in 250 patients over 12 years of age having routine diagnostic retrograde left heart catheterization. During this period a further 23 arteriotomies were performed, but these have been excluded from the present analysis because insufficient details of follow-up were available. However, none of those excluded was known to have had complications.

Of 250 patients in the study, 113 had rheumatic heart disease, 66 ischaemic heart disease, 39 congenital heart

disease, and 32 miscellaneous cardiac conditions. At the conclusion of the study period 105 had been discharged to be followed at their referring hospital and 23 had died. Of the remaining 122, 107 were examined at follow-up at least one month (mean 8.5 weeks) after catheterization. At that time the presence of symptoms in the catheterized arm was elicited by direct questioning.

Methods

Two hundred and forty-six (98.4%) of the procedures were performed by 5 operators and details of technique varied only slightly. Heparin in a dose of 100 units/kg body weight was given through a venous catheter before the artery was opened. However, in 8 patients heparin was contraindicated because of a dissecting aneurysm of the aorta (one patient) or because there was severe aortic stenosis and direct left ventricular puncture was anticipated. In a further 9 patients the effects of heparin were reversed during the procedure by administration of protamine in a dose of 10 mg/kg intravenously before performing a percutaneous arterial or left ventricular puncture. Otherwise no protamine was given. Before closure of the arteriotomy the presence of good proximal and distal flow was confirmed. A Fogarty catheter was used in 3 instances in an attempt to improve flow. Closure of the arteriotomy was performed using one or two horizontal mattress sutures or interrupted sutures of 000000 Ethiflex[®]. In most instances the vein was similarly repaired.

At the time of catheterization details of administration of heparin or protamine, the number of arterial catheter changes, the duration of the procedure, and any complications associated with arteriotomy were recorded.

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All patients in the study were seen, usually by the same observer, on the first or second day after catheterization. Details of peripheral pulses were recorded using a classification of ++++=increased, +++=normal, ++=reduced, +=just palpable, and o=absent, the non-catheterized arm being used as a control in view of the wide variation in peripheral pulses associated with varying clinical conditions. Where the control arm had had a previous radial cannula at the time of surgery, classification was based on the amplitude of unaffected pulses. The presence of bruising, haematoma, bleeding, or inflammation was recorded using a scale of +=slight, ++=moderate, and +++=severe.

Results

Arm pulses

For the purposes of this study all assessments were made between 24 and 48 hours after catheterization. The findings, therefore, include the results of intervention where this occurred. The findings on examination are shown in Table 1. One patient (0.4%) had both absent brachial and radial pulses. In all other patients brachial pulses were satisfactory, 92.9 per cent being classed as normal, 2.0 per cent slightly reduced, and 4.7 per cent slightly increased.

Three other patients had an absent radial pulse and in a further 6 this was considerably reduced. The remaining patients had a satisfactory result being classed as normal (79.1%), slightly increased (9.0%), or slightly reduced (7.9%).

Between the time of catheterization and examination 5 patients had had thrombectomy by Fogarty catheter. In them thrombus formation appeared to be the major problem, with no evidence of significant arterial damage. Of these 5 patients, 1 patient received no heparin and 1 received protamine. The difference in incidence of thrombosis between the heparinized (3/236) and non-heparinized/protamine group (2/17) was statistically significant ($P < 0.01$). All had satisfactory pulses at the time of examination.

One further patient had undergone resection of a damaged portion of artery with end-to-end anastomosis in addition to Fogarty thrombectomy. At examination pulses were satisfactory.

Complications of arteriotomy resulted in impaired radial pulses in 6 patients and an absent radial pulse in 4 patients. Arterial resection and anastomosis was required in one patient. In this group of 11 patients, 9 had had a special catheter used during coronary arteriography. This catheter was used in 57 other cases but tended to cause arterial trauma during introduction and resulted in some difficulty with arterial repair on 6 occasions.

Of the 2 cases with complications where this

TABLE 1 Findings on examination on day 1 or 2 after catheterization

<i>Haematoma</i>			<i>Bruising</i>	
	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>
	o 230	90.9	190	75.1
	+ 21	8.3	52	20.6
	++ 1	0.4	11	4.3
	+++ 1	0.4	—	—
	Total 253	100.0	253	100.0

<i>Radial pulse</i>			<i>Brachial pulse</i>	
	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>
	o 4	1.6	1	0.4
	+ 6	2.4	—	—
	++ 20	7.9	5	2.0
Normal	+++ 200	79.1	235	92.9
	++++ 23	9.0	12	4.7
	Total 253	100.0	253	100.0

TABLE 2 Findings on follow-up examination on average 8.5 weeks after catheterization

<i>Radial pulse</i>			<i>Brachial pulse</i>	
	<i>No.</i>	<i>%</i>	<i>No.</i>	<i>%</i>
	o	1		0.9
	o	(7)		(6.5)
	+	5	I	0.9
	++	3	I	0.9
	+++	86	4	3.7
Normal	+++	86	100	93.6
	++++	5	I	0.9
Total			107	100.0

The values in parentheses indicate patients who had percutaneous radial cannulation at some time after brachial arteriotomy.

catheter was not used, one patient received no heparin and one received protamine. This was not statistically significant.

This group of 11 patients tended to have difficult catheterizations as reflected by the increased average number of arterial catheters used (4.1) compared to the other patients studied (1.8). The average duration of the procedure for these 11 patients was 66 minutes compared to 58 minutes for the other 242 studied (not significant).

Bleeding (Table 1)

Slight bruising (20.6%) or swelling due to minimal haematoma formation (8.3%) was not uncommon. Extensive haematoma formation causing distress occurred in 1 patient (0.4%). Moderate bruising

occurred in 11 patients (4.3%), usually without haematoma formation, and appeared to arise from the venous rather than arterial repair in most instances.

No persistent bleeding or other complications attributable to heparinization occurred. Following reversal of heparin with protamine, 4 left ventricular punctures and 5 percutaneous arterial catheterizations were performed without difficulty.

Follow-up examination

Of 107 patients seen for review at least 4 weeks (mean 8.5 weeks) after catheterization, 1 patient had acquired an absent brachial and radial pulse but had no symptoms. Both pulses had been palpable though the radial pulse was impaired at the earlier study. At catheterization in this patient the brachial artery was small, protamine was given, and the study was completed by percutaneous femoral catheterization. In the patient with previously absent brachial and radial pulses these had both reappeared, though they were faint. In a further 3 patients with previously absent radial pulses, all had reappeared. In 7 patients the radial pulse was absent after percutaneous cannulation at cardiac surgery, the pulse before this presumably having been satisfactory. The remaining 95 patients (88.8%) showed no significant changes in the findings between the first and second examination.

Eleven patients (10.3%) admitted to symptoms in the catheterized arm but in only 3 of these was there any abnormality of limb pulses. None of the symptoms were severe enough to interfere with normal use. Eight patients had intermittent local discomfort such as some tingling in the arm, not sufficient to cause spontaneous complaint except in one patient, in whom clinical and radiological examination was normal. One patient developed an ulnar nerve lesion which was thought to be unrelated to catheterization.

Discussion

The popularity of the brachial arteriotomy approach is encouraged by studies which show that complications of coronary arteriography are lower for the Sones brachial arteriotomy technique than the Judkins percutaneous femoral approach apart from local arterial problems (Chahine, Herman, and Gorlin, 1972; Adams, Fraser, and Abrams, 1973). These continue to cause concern. The reported incidence of occlusion after brachial arteriotomy is influenced by the degree and type of follow-up (Swan, 1968b) as well as technical factors relating to the procedure itself (Demany, Tambe, and Zimmerman, 1972; Sewell, 1965; Goldberg, O'Reilly, and

Chaithiraphan, 1972; Ross, 1968). Several studies with careful follow-up report reduced or absent radial pulses in from 10 to more than 25 per cent of cases (Chahine *et al.*, 1972; Gau *et al.*, 1970; Machleder, Sweeney, and Barker, 1972; Hale and Jefferson, 1963; Jeresaty and Liss, 1968), and a recent report emphasizes the functional impairment and symptoms that can result from this (Machleder *et al.*, 1972). Other groups report more satisfactory results with an occlusion rate of less than 1 per cent (Adams *et al.*, 1973; Demany *et al.*, 1972).

One recent report indicated that the type and strength of heparin used might be an important factor, the weaker porcine gut heparin being associated with an increased incidence of arterial occlusion (Goldberg *et al.*, 1972). In the Sones technique the local installation of approximately 3000 units of heparin to the distal artery is advocated to inhibit thrombus formation though this probably spreads systemically to give mild anticoagulation as well (Walker *et al.*, 1973). Hale and Jefferson (1963), however, advised a much higher dose of 2 mg/kg to avoid thrombus formation though their incidence of occlusion was relatively high in spite of this. Recently studies have shown a reduced incidence of arterial occlusion after percutaneous arterial catheterization when heparin is used (Walker *et al.*, 1973; Wallace *et al.*, 1972). However, in the absence of a controlled trial, the part heparinization plays in the end result of brachial arteriotomy remains uncertain, and concern regarding its safety persists. In the present series the incidence of arterial occlusion causing an absent radial pulse was 1.6 per cent and a significantly impaired pulse occurred in a further 2.4 per cent. Occlusions occurring at the end of catheterization and immediately thereafter with subsequent satisfactory result have not been included in these figures, as thrombectomy by Fogarty catheter is considered a routine part of the arteriotomy procedure when necessary. These cases amounted to 2 per cent of the total. The incidence of complications compares favourably with other series with similar follow-up (Campion *et al.*, 1971), but the use of systemic heparinization has not resulted in an unusually low incidence of complications and other factors may be involved.

Demany *et al.* (1972) were impressed with the reduction in occlusion which occurred after adoption of a meticulous arteriotomy repair, and though Fogarty catheters were used in about 7 per cent distal pulses were subsequently absent in less than 1 per cent. Review of the 10 cases with impaired or absent pulses in our series indicates that difficulty with the arteriotomy repair was an important factor in at least 6 of them. This was associated with multiple catheter changes, and possibly the use of a

special catheter which tended to result in local trauma. Since this experience, the use of an introducer has been helpful in preventing local arterial damage.

This study was not designed as a controlled trial of heparinization and the number of patients not receiving heparin was small. However, in spite of the small numbers the higher incidence of thrombosis when heparin was omitted or reversed was statistically significant ($P < 0.01$). It appears, therefore, that the use of systemic heparinization may result in a reduced incidence of arterial occlusion from thrombosis, but the avoidance of arterial trauma is important in obtaining good results after brachial arteriotomy.

This study confirms that symptoms frequently do occur when brachial arteriotomy results in impaired arm circulation (Machleder *et al.*, 1972), but symptoms also occur which appear unrelated to the blood supply of the arm and present as mild local discomfort. The incidence of symptoms related to ischaemia emphasizes that all efforts should be made to obtain satisfactory blood flow and as Fogarty thrombectomy usually gives a good result this should always be performed if arterial occlusion is suspected.

The present experience confirms other reports that the use of systemic heparinization in catheterizations is a safe procedure (Walker *et al.*, 1973; Wallace *et al.*, 1972). No bleeding episodes occurred and it did not preclude the use of percutaneous techniques when necessary provided protamine was given.

Heparin may protect against thromboembolic complications of catheterization and none occurred in this series or over the 5 years that heparinization has been used. An added advantage of the method is the absence of catheter clotting which can be a risk to the patient as well as an irritation to the operator.

In conclusion this study has shown that systemic heparinization in routine cardiac catheterization can be used safely. It may contribute to a low incidence of arterial occlusions following the procedure, and when these do occur they are usually associated with local trauma to the vessel and difficulty in arteriotomy closure.

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