To those who have been responsible for the establishment, maintenance, and development of the centre progress has often seemed too slow and to lag far behind needs. The recommendation of the advisory council of the Head Injuries Rehabilitation Trust was that so far as possible the funds required for what should be acknowledged as a part of the National Health Service should come from the State, and it can be said with due gratitude that the State has emerged with much credit.

In writing this article I am but the scribe of many others, without whose imagination, patience, devotion, support, and guidance there would have been nothing to write about. I am confident that those that are not mentioned by name will agree with my expression of thanks particularly to Miss J. E.

Drake, secretary, and Mr. S. S. Harkness, treasurer, of the Head Injuries Rehabilitation Trust; Mrs. N. Kimmitt and Mr. H. F. Kinchin, respectively occupational therapist and manager at the work centre; Mr. P. P. Lockhart, group medical social worker; Mr. G. Myers, secretary of the South Birmingham Hospital Management Committee, and his successor, Mr. P. J. Roys; Mr. H. Proctor, surgeon, and Mr. M. B. Rickett, administrator, of the Birmingham Accident Hospital; Dr. Keith Young, deputy administrative medical officer of the Birmingham Regional Hospital Board; and the administrative and nursing staff of the Royal Orthopaedic Hospital (the Forelands) as well as other members of the advisory council of the Head Injuries Rehabilitation Trust and its subcommittees.

Hospital Topics

Femoral Artery Complications after Diagnostic Procedures

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Summary

Of 36 cases of arterial complications after femoral artery puncture 11 were excessive haemorrhage and 25 femoral artery occlusions. Soft arteries are more likely to tear than atheromatous ones, and this had occurred in 9 of the 11 patients. A high puncture, soft arteries, and a low cardiac output are important factors predisposing to thrombosis.

An aggressive policy is recommended for treatment of both conditions.

Introduction

Catheterization or even simple needle puncture of the femoral artery may cause haemorrhage or occlusion. Seidenberg and Hurwitt¹ reported 26 such complications, one of which resulted in amputation. They recommended early operation in all cases of iatrogenic arterial occlusion. McGraw² reported five major complications, one of which resulted in amputation of the leg—and another in the death of the patient. Bolasney and Killen³ reported 33 cases with no loss of life or limb, and emphasized that early operation was always indicated in these patients. Slaney and Ashton⁴ reiterated that when the pulse disappears after arterial injury a diagnosis of arterial spasm should not be made, and that early exploration is indicated.

Thirty-six cases of femoral artery complications after diagnostic procedures are reviewed here. The complications were of two types, haemorrhage and occlusion.

Haemorrhage

There were 11 patients who bled sufficiently from their femoral puncture sites for a surgical opinion to be sought. Of these, nine were patients with heart disease who bled after cardiac catheterization, one was a child with hypertension who had undergone a selective renal arteriogram, and only one was an atherosclerotic patient who bled after a femoral arteriogram through a simple needle puncture. Only two of the 11 patients were hypertensive. Only one, a 6-year-old boy with a ventricular septal defect, required a blood transfusion, and he stopped bleeding after nine hours.

Two patients required operation. One, a woman of 51, bled profusely from the moment the catheter was withdrawn. Pressure over the artery was ineffectual in slowing the flow. She was operated on almost immediately and a large retroperitoneal haematoma was found, with bleeding from the external iliac artery well above the inguinal ligament. The other was a girl aged 14 with hypertension. A haematoma formed around the common femoral artery which completely occluded the pulse, so the haematoma was evacuated and the puncture site in the common femoral artery was sutured. All the others stopped bleeding after pressure over the artery for a period of an hour or so, but the one arteriosclerotic patient bled intermittently for three days.

Arterial Occlusions

A total of 25 cases consisted of 14 females and 11 males. Of the former, 11 were suffering from heart disease and were being investigated by cardiac catheterization, and the other three who underwent Seldinger aortograms were suffering from polycythaemia, atherosclerosis, or Raynaud's phenomenon. Of the 11 males, one was suffering from polycythaemia, four from heart disease alone, four from atherosclerosis alone, and two from atherosclerosis and heart disease. Except for two of the patients with atherosclerosis alone, who underwent a needle puncture of the femoral artery, all were subjected to catheterization.

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In three of the female patients, who had had external iliac punctures, over 15 minutes' pressure was needed over the artery to arrest bleeding, and occlusion occurred after this. In none of the other case notes was this sort of information recorded.

SYMPTOMS

Seventeen patients had no symptoms; the other eight complained of rest pain or claudication.

SIGNS

All 25 patients had a cold limb with no femoral pulses. A 63-year-old man with atherosclerosis was noticed to have pregangrenous changes 10 days after a Seldinger aortogram.

DELAY IN TREATMENT

Only seven patients were treated within six hours of arterial occlusion and one within 12 hours. Four were subjected to two days' delay and, apart from one who presented after six months for treatment, the rest were subjected to up to three weeks' delay before operation. An initial diagnosis of "arterial spasm" had contributed to the delay in some cases.

TREATMENT

Four patients were not operated on. One was a girl of 12 with mitral incompetence, who remained symptom-free although one femoral artery was occluded, and was not referred for treatment. One was a Yugoslavian woman aged 43 with aortic stenosis and incompetence who returned to Yugoslavia without one of her femoral pulses but without symptoms. Two males with multiple valve lesions were thought to be suffering from "arterial spasm" and were not referred until after several weeks of severe claudication. Operation on their femoral arteries was deferred until after cardiac surgery.

Heparin 10,000 units intravenously was given to all those patients whose occlusion was of shorter standing than 24 hours.

OPERATIVE FINDINGS

Three patients were found to have extensive proximal and distal thrombosis. Two of these were men aged 58 and 63, both of whose arteries had been occluded for over a week and both of whom needed Gritti-Stokes amputations. The third patient was a man of 72 with polycythaemia. It was impossible to clear his arterial tree of thrombus and he died soon after exploration. The other 18 cases were treated by operation, with good results in 17. In seven of these the puncture was in the external iliac artery, well above the inguinal ligament. Five of these were females with very small soft arteries, one was a man with congestive cardiomyopathy, and only one was a man with atherosclerosis. In all these cases the clot was confined to the external iliac artery. There was no distal thrombosis.

In six patients the puncture was in the common femoral artery. Two of these were patients with heart disease and small arteries who were found to have intimal flaps with proximal thrombosis only, and the third was a man with atherosclerosis who also had a flap and proximal thrombosis only. The fourth was a man with valvular heart disease and severe atherosclerosis. At the site of the puncture in the common femoral artery, the atheroma was shattered and the superficial femoral artery was found to be thrombosed down to the popliteal artery where there

was a loose piece of atheroma which had embolized. The profunda femoris was patent. The other two cases were the right and left legs of a man of 50 with aortic stenosis who underwent bilateral Seldinger studies. At operation six hours later he was found to have intimal flaps in both common femoral arteries, with proximal thrombosis in one and proximal and distal thrombosis in the other.

A woman aged 50 with heart disease was found to have sustained a puncture of her superficial femoral artery. There was no flap but the artery was thrombosed distally.

In the other nine cases it is not known where the artery was punctured, but in only five of them was there distal thrombosis. Two of these sustained amputations and the third one died soon after an unsuccessful exploration. The patient who died had polycythaemia and the other four all had severe atherosclerosis.

OPERATIVE PROCEDURE

In six of the seven patients with external iliac punctures and proximal thrombosis only, thrombectomy was performed with a Fogarty catheter, any tags of intima were carefully trimmed away, and the arteriotomy was closed with a patch. The arteriotomy was always made to include the puncture in the vessel. In the seventh patient who had severe atherosclerosis, a thromboendarterectomy was performed on the common and external iliac arteries. In all these cases the results were excellent with return of the pulses.

In the six cases with common femoral punctures, three had intimal flaps which were trimmed away, and proximal thrombosis which was cleared with a Fogarty catheter. The arteriotomies were closed with vein patches. In the man with shattered atheroma and a popliteal embolus, the superficial femoral artery was cleared with a Fogarty catheter, the common femoral artery rebored—and the arteriotomy closed with a patch. The other two cases which occurred at the same time in the right and left legs of the same atherosclerotic patient were both treated by trimming away the flaps, performing thrombectomy with a Fogarty catheter, and closing the arteriotomies with vein patches. This was successful on the side with proximal thrombosis only but on the other side, where there was also distal clot, rethrombosis occurred resulting in claudication.

Three patients had distal thrombosis which it was impossible to clear, resulting in two amputations and one death. Of the remaining five patients, one with atherosclerosis had distal thrombosis and was treated with a common femoral rebore and distal thrombectomy by Fogarty catheter, which gave a good result. Another three had proximal thrombectomies and closure with a vein patch, and the fifth, who presented with intermittent claudication and a six-month-old occlusion, was treated with a vein graft to bypass her common femoral artery.

Discussion

Review of these cases brings to light several factors which seem to predispose to haemorrhage or occlusion after arterial puncture. These can be listed as: (1) the condition of the artery; (2) the size of the artery; (3) the cardiac output; (4) the position of the puncture; and (5) polycythaemia.

Of the 11 patients who bled excessively, only two were hypertensive so it is unlikely that hypertension predisposes to this complication. Only one was atherosclerotic so this can be discarded as a predisposing factor. Nine of these patients were cardiac invalids with soft, normal arteries so probably this is important. A soft artery is more likely to tear and the puncture hole enlarge when a catheter is manipulated through it, than a tough atherosclerotic artery. Only two of these patients came to operation. One a girl aged 14 had soft arteries and a haematoma compressing the common femoral artery. The other was a patient with a puncture in the external iliac artery above the

inguinal ligament, which could not be controlled by digital pressure. The external iliac artery turns sharply backwards just above the inguinal ligament and external pressure cannot be brought to bear on it (fig. 1). Furthermore it is surrounded only by the loose extraperitoneal tissues which, unlike the tissues in the femoral triangle, do not exert any resistance to bleeding.

FIG. 1—External iliac artery turning backwards above inguinal ligament so that a puncture in it cannot be controlled by direct pressure. A = Aorta, R.C.I. = Right common iliac artery, L.E.I. = Left external iliac artery. Pr.F. = Profunda femoris artery.

The position of the puncture site is known in 13 of the patients with thrombosis and of these, seven punctures were above the inguinal ligament. Of the 25 patients with arterial occlusions, 16 (64%) were cardiac invalids without atheroma and one other was a young woman with small arteries and Raynaud's phenomenon. It seems that a high puncture, soft arteries, and a low cardiac output are important factors predisposing to thrombosis after arterial puncture. A soft, small artery is easily compressible, unlike an atheromatous one which, because of the calcium in its wall, is sometimes difficult to occlude even with an arterial clamp. Bleeding from a high puncture is difficult to control so there is a tendency for the operator to press on harder and for a longer period than he would on a lower puncture and this will tend to occlude the artery. The low cardiac output will also tend to allow occlusion of the vessel, which will thrombose proximally. If the inferior epigastric and the deep circumflex iliac vessels originate above the compressed area and are of good size, the thrombosis will only extend as high as their origins. If, as is sometimes the case, they are not large enough to provide an adequate run off, thrombosis will extend up to the origin of the internal iliac artery. Thrombosis will tend not to extend more distally than the common femoral artery because of the collateral circulation via the profunda femoris. Only where there is severe atherosclerosis will the collateral circulation be inadequate, and in this series five of the six patients with distal thrombosis had severe atherosclerosis; the sixth had polycythaemia. Polycythaemia is a potent cause of thrombosis and arterial catheterization should be avoided in these patients.

In six patients the common femoral artery had been punctured and in all of these an intimal flap was found. In one the cause of thrombosis was an embolus of atheroma which had lodged in the popliteal artery. Four of these patients were atherosclerotic and two suffered from heart disease. In this series atherosclerosis does not seem to be an important predisposing factor in thrombosis after arterial puncture and when thrombosis occurs it is due to a flap or an embolus (fig. 2). When it does happen, however, it is more likely to spread distally and to result in amputation. The two patients in this group who came to amputation were arteriosclerotic with widespread thrombosis.

FIG. 2—Femoral arteriogram showing a flap of atheromatous intima raised by needle.

Seventeen of the patients reviewed had no symptoms, in most cases because they were at rest in bed. In spite of this lack of symptoms, if the femoral pulse becomes impalpable after an arterial catheterization, the patient should be heparinized to limit propagation thrombosis and the artery explored as soon as possible. This aggressive policy is particularly needed in atherosclerotic patients, for the danger of distal thrombosis and subsequent amputation is much higher in this group.

The artery should be exposed at the groin and the puncture site found. An arteriotomy is made to include the puncture site and to extend above and below it into undamaged artery. Proximal thrombus is removed with a Fogarty catheter and the flow rate assessed. If the flow is poor due to atheromatous narrowing, it is best to rebores the iliac artery to produce good flow. One of the atherosclerotic patients in this series who had proximal and distal thrombosis was treated by thrombectomy alone, after which the artery rethrombosed; this may well have been prevented by reborers the iliac artery.

If there is distal thrombosis, this must be cleared with a Fogarty catheter and in these cases it is very important to perform an operative arteriogram to make sure that all the thrombus is removed, for brisk retrograde bleeding can occur from collaterals even when the main trunk is occluded more distally. If it proves impossible to clear the distal arteries via a femoral arteriotomy then the popliteal artery should be exposed and a Fogarty catheter passed upwards to clear the popliteal artery and downwards to clear each calf artery in turn.⁶

When the thrombus is cleared and there is a good flow from above, attention is turned to the local lesion in the artery. If there is a flap of intima this should be carefully trimmed away. If the artery is otherwise healthy, then the arteriotomy is closed, using a vein patch to avoid constriction. When the vessel is atheromatous it can be rebores locally and sutured, which saves the trouble of using a patch. The wounds are closed in layers with interrupted sutures, and suction drainage is continued for 24 hours. Heparin is given before and during the operation but not after. If there is good flow in the vessels after operation,

thrombosis will not occur. If the flow is poor, heparin will not help.

Prevention of most of the complications from femoral artery puncture could probably be achieved by the following precautions. (1) Never catheterize an artery in a patient with polycythaemia. (2) Puncture the common femoral artery, not the external iliac. (3) Do not use excessive or prolonged pressure to arrest bleeding, particularly in patients with small, soft arteries and a low cardiac output. (4) If the femoral pulse becomes impalpable, give intravenous heparin and arrange for exploration of the artery as an emergency, even in the absence of symptoms.

We are grateful to Mr. Peter Martin for allowing us to study his patients and to Professor R. B. Welbourn, for reading and criticizing this paper.

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Medical History

Medical History of British Columbia: Some Aspects*

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A hundred years ago there was nothing in Vancouver of man except an occasional Indian trail winding through the great trees, ten feet across at their base and towering up as high as the present buildings. And a hundred years before that, this magnificent province was not even on the map. In 1776 when Captain Cook landed on the west coast of Vancouver Island, he brought with him the first doctors, other than the native shamans, that this area had ever seen. They were British trained. Dr. William Anderson, the senior, was already sick and soon to die of tuberculosis in Alaska. William Ellis, the surgeon's mate, a botanist and an artist, was the first doctor to practise in this area. With some pride and at the risk of causing a little parochial disorder among my British Columbian colleagues I should point out that he was trained at Saint Bartholomew's Hospital.

Beginnings

In the early 1790's, when Captain Vancouver explored these waters thoroughly for the first time and when Alexander McKenzie struggled overland to Bella Coola, this great country began to open up. It is still amazing to me that as recently as 130 years ago, the colossal area stretching from Alaska in the north, right down to California in the south, was virtually ruled for the Hudson's Bay Company by one man—a doctor. For twenty years Dr. John McLoughlin, a Canadian whose grandfather had brought a Highland regiment to Canada with Wolff, was the emperor of all the west. If our ancestors had paid a proper attention to his reports and not regarded this whole area as a wilderness of rocks and Christmas trees, suitable only for the trapping of animals, and if Dr. McLoughlin himself had not used the British resources of the Hudson's Bay Company to

feed and succour the starving American overlanders of Oregon, Canada might now be in a possession of the whole coast, probably including California. Whereas this used to be a matter of regret, watching the development of California from this north, I think that it has since become a subject of relief.

The first doctor to settle down here and practise medicine was John Sebastian Helmcken, trained at Guy's Hospital. He sailed around the Horn in 1850 with a group of emigrants to the recently founded settlement of Victoria. His house is still standing and in it are some of his medical records and the original chest of medications he brought with him. He later became the first Speaker of the Legislature and he was responsible more than any other man for taking British Columbia into confederation with the rest of Canada. The brevity of our history was made startlingly apparent to me soon after I arrived in Victoria. I was asked to see a dear old lady in her 90's, dying of heart failure. I was told she was the first graduate nurse of the hospital. After a little medication her confusion appeared to clear a little; she rallied, looked at me and said, "Dr. Helmcken, I'm glad you have come."

A hundred years ago in Europe, Paris had barely survived its siege. Gladstone and Disraeli were struggling for control of the huge Empire, the growing nation of Canada in the East hardly recognized the existence of the West—a state of affairs we sometimes think has not altered a great deal. At that time there were in British Columbia, only 9,000 settlers, of whom eight were doctors, and still in Vancouver, there was nothing except the great silent forest. At the bottom of Hastings Street there were two timber mills and a handful of men working in them but nothing more. Victoria was well established, as was Westminster. The first doctor to visit patients in this area was Dr. Arthur Black, who practised in New Westminster and was a Member of Parliament for that city. Dr. Black was a Scot; a Crimea veteran; he did his medical training in London and in Melbourne, Australia.

In 1871 at the age of 38, he was called out at night to attend a drunkard who had attempted suicide at the Hastings Mill. Riding through the forest his horse slipped into a ditch, rolled on him and killed him. Both the horse and the drunkard survived. Whatever social conclusions you wish to draw from that, it was a very discouraging start for night calls.

* Based on the Presidential address given at the combined Annual Meetings at Vancouver on 18 June (see *B.M.J.*, 7 July, p. 40).

Victoria, British Columbia

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