

MEDICAL PRACTICE

Occasional Survey

Arterial Surgery in Intermittent Claudication

J. K. WATT, G. GILLESPIE, J. G. POLLOCK, W. REID

British Medical Journal, 1974, 1, 23-26

Summary

The results of a survey of 302 operations in 277 patients during 1959-70 are presented, and an additional 69 operations during 1971 are included in the mortality figures. Operative mortality (1968-71) was 0.9% in 113 aortoiliac operations and nil in 96 femoropopliteal operations.

Immediate patency rates on dismissal from hospital exceeded 95%, and the five-year patency rate for aortoiliac operations was just over 70% and for femoropopliteal operations 60%.

Introduction

Successful reconstructive surgery can restore to normal the walking ability of patients with intermittent claudication and achieve lasting improvement in many cases. Boyd¹ and Bloor² showed that only about 18% of untreated patients deteriorate to the stage of gangrene, and the principal indication for operation is therefore relief of claudication itself.

In an attempt to assess the value of arterial surgery in intermittent claudication a series of 302 operations in 277 patients has been surveyed. These were performed in the years 1959-70 and the minimum follow-up period is one year.

Peripheral Vascular Unit, Glasgow Royal Infirmary and Belvidere Hospital, Glasgow

J. K. WATT, CH.M., F.R.C.S., Consultant Surgeon
G. GILLESPIE, M.D., F.R.C.S., Consultant Surgeon (Present address: Victoria Infirmary, Glasgow)
J. G. POLLOCK, M.B., F.R.C.S., Consultant Surgeon
W. REID, M.B., F.R.C.S., Consultant Surgeon

Of the 228 patients alive in 1971 97.4% attended for examination and interview. Three lived too far away to travel and the necessary data were obtained from the patient and the general practitioner, and only three patients were untraced. Of the latter, information from the case record was available in two patients for four years and one patient for two years post-operatively. Information as to the cause of death was known in every case and information concerning graft patency at death was available in most instances.

Indications for Operation

Reconstructive surgery, either bypass surgery or thromboendarterectomy, was performed in fit patients who had arterial occlusion with a good outflow tract and the prospect of a return to normal or nearly normal walking if surgery was successful. Patients suffering from ischaemic rest pain or tissue necrosis were excluded from this series, as were patients with abdominal aneurysm in association with intermittent claudication.

Thirty-nine patients with severe aortoiliac stenosis or occlusion associated with a distal femoropopliteal occlusion had aortofemoral bifurcation grafting performed with or without sympathectomy because of the possibility that further extension of the aortoiliac lesion might precipitate gangrene. These patients could not expect complete relief from their claudication since part of the femoropopliteal segment remained occluded. Similarly, eight out of 38 patients undergoing unilateral aortoiliac grafting and one out of 29 patients undergoing aortoiliac thromboendarterectomy had associated femoropopliteal occlusion.

Results

Altogether, 302 operations (247 in men, 55 in women) were performed in 277 patients. Only three patients (one man, two

women) were diabetic. The mean age for all patients was 51.3 years (S.D. \pm 6.9), with a range of 26-68 years.

Operations have been grouped into four categories in table I: (1) aortofemoral or aortoiliac bifurcation grafting; (2) unilateral aortoiliac, aortofemoral, or iliofemoral grafting; (3) aortic, iliac, or aortoiliac thromboendarterectomy; and (4) femoropopliteal operations. The number of operations in each category is listed by year and the increasing frequency of operations undertaken for claudication is shown.

TABLE I—Number of Grafts Performed Yearly

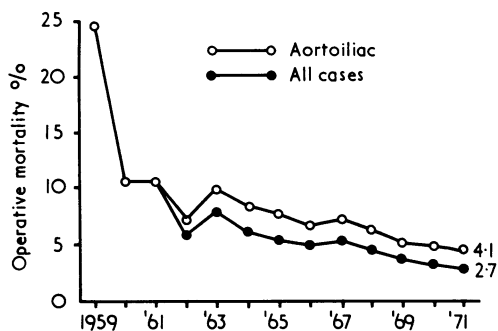
Year	Bifurcation Grafts	Unilateral Grafts	Thromboendarterectomy	Femoropopliteal Grafts	Total
1959	2	2	—	—	4
1960	—	3	2	—	5
1961	2	7	—	—	9
1962	4	5	2	2	13
1963	5	3	1	6	15
1964	3	4	1	7	15
1965	6	6	5	15	32
1966	14	2	7	7	30
1967	15	1	6	17	39
1968	16	—	2	23	41
1969	25	4	—	25	54
1970	20	1	3	21	45
Total	112	38	29	123	302

In 1971 there were 30 bifurcation grafts, 8 unilateral grafts, 4 thromboendarterectomies, and 27 femoropopliteal grafts—a total of 69 operations.

OPERATIVE MORTALITY

Nine patients died during operation or within 28 days of operation, giving an overall mortality rate of 3% (1959-70). Seven deaths occurred in 112 patients undergoing bifurcation grafting, none in 38 unilateral grafts, one in 29 aortoiliac thromboendarterectomies, and one in 123 femoropopliteal operations.

The cumulative mortality rate for all cases with aortoiliac operations is shown in the graph. The downward trend is evident and illustrates the improvement in patient care and management which has taken place over the years.



Cumulative mortality rates in 371 operations for intermittent claudication (1959-71)

Sixty-nine patients operated on during 1971 (table I) are included in the mortality figures in the graph but are not included in the follow-up. During this year there was one death from cardiac failure in 42 aortoiliac operations and none in 27 femoropopliteal operations.

The striking improvement over the years is evident when the mortality figures for 1959-67 (aortoiliac operations 108, mortality rate 7.4%; femoropopliteal 54, 1.9%; all cases 162, 5.6%) are compared with figures for 1968-71 (aortoiliac operations 113, mortality rate 0.9%; femoropopliteal 96, nil; all cases 209, 0.5%). The figures for 1959-71 were 221, 4.1%; 150, 0.7%; and 371, 2.7% respectively.

CAUSES OF OPERATIVE DEATHS

Two deaths in the early part of the series from excessive haemorrhage occurred in patients where knitted grafts had been used (woven Dacron grafts are now used almost exclusively). One patient died in 1963 due to tubular necrosis, but since the introduction of mannitol or frusemide to maintain urine output no further renal complications have occurred. There were three cardiac deaths, a hazard in this type of surgery, one precipitated by reoperation for bleeding from a suture line. The remaining three deaths were from pulmonary embolism, bronchopneumonia, and septicaemia—hazards in any type of major surgery, which cannot be wholly prevented.

CAUSES OF LATE DEATHS

Forty patients died between operation and follow-up in 1971. Most of these (26) died from coronary thrombosis, three during the first year, and the mean survival time from operation to death was four years. Six patients died from other vascular causes—cerebrovascular accident (three), cardiac failure (one), and mesenteric thrombosis (two). One patient developed occlusion after aortoiliac thromboendarterectomy and died during subsequent aortofemoral bifurcation grafting. One patient died three years after operation when he developed graft occlusion and bilateral gangrene. Five patients died from carcinoma of lung, and one from pulmonary tuberculosis.

PATENCY RATES

Bifurcation Grafting.—A total of 112 bifurcation grafts were performed in 112 patients, 94 of which were aortofemoral and 18 aortoiliac. There were seven operative deaths (6.3%) and 15 late deaths in this group. Altogether, 105 patients left hospital and 104 (99%) had patent grafts on dismissal. The immediate patency rate fell to 98.1% at the end of one year and gradually declined thereafter until, five years after operation, the patency rate had fallen to 73.9%. Of the 94 aortofemoral bifurcation grafts 65 were sutured to the aorta end-to-side, and in 29 patients the aorta was divided and the graft sutured end-to-end to the proximal aorta. Comparison of the subsequent patency rates of the two types of anastomosis in the 89 survivors (table II) shows a higher patency rate with end-to-end suture but the difference is not statistically significant in this series (P varied from 0.1 to 0.3).

TABLE II—Comparative Patency Rates of End-to-side and End-to-end Aortic Anastomoses

Patency at	End-to-side		End-to-end	
	No. of Patients	Grafts Patent	No. of Patients	Grafts Patent
Dismissal ..	61	60 (98.4%)	28	28 (100%)
1 year ..	60	59 (98.3%)	28	28 (100%)
2 years ..	47	41 (87.2%)	19	18 (94.7%)
3 years ..	25	20 (80.0%)	17	16 (94.1%)
4 years ..	13	9 (69.2%)	10	9 (90.0%)
5 years ..	8	5 (62.5%)	6	5 (83.3%)

Unilateral Grafting.—Thirty-eight unilateral grafts, either aortoiliac (10), aortofemoral (20), or iliofemoral (8) were performed in 37 patients. There was no operative mortality in this group, and eight patients died before follow-up. Immediate graft failure occurred in two patients, one of whom required amputation, and 36 (94.7%) left hospital with patent grafts. A gradual decline in patency occurred thereafter—from 91.7% at the end of one year to 71.4% at five years. Anastomosis of the proximal end of graft to the side of the common iliac artery was performed in two patients, but neither graft remained

patent for long, and the proximal end of unilateral grafts is now sutured end-to-side to the aorta or end-to-end to the divided common iliac artery in such a way as to preserve the internal iliac artery flow if possible.

Aortoiliac Thromboendarterectomy.—Twenty-nine operations were performed on 29 patients. One patient was re-explored because of bleeding and died from cardiac failure on the following day. Twenty-eight patients left hospital and 27 (96.4%) arteries were patent on dismissal. The one-year patency rate was 96.1% and the five-year rate was 81.8%. However, there were only 11 patients who had been operated on for five years or more.

Femoropopliteal Grafting.—A total of 123 operations were undertaken in 110 patients, of whom 12 had bilateral femoropopliteal operations. One patient had a successful re-graft one year after the initial graft was lost owing to infection. Of the 12 bilateral grafts only five patients had both grafts patent at follow-up (mean duration 2.6 years). One patient died in hospital from septicaemia and one developed gangrene and required immediate amputation. Of the remaining 121 operations, 115 (95%) were patent on dismissal. Various types of operation were performed, the commonest being femoropopliteal bypass saphenous vein grafting (72 operations). Thromboendarterectomy through a long arteriotomy incision was performed in the first five operations of this series but all thrombosed within three months and this technique was discarded. Thromboendarterectomy through multiple incisions, each closed by a vein patch, was performed in 19 patients, proximal thromboendarterectomy with short vein bypass was performed in 10 cases,³ and thromboendarterectomy with the insertion of a long vein strip was performed in nine cases. The long-term patency of bypass vein grafting was superior to any of these other methods. The patency of bypass vein grafts declined rapidly from 91.6% in 71 patients at dismissal to around 60%, though the number of patients with grafts at four and five years is small (12 and 10 respectively). Thromboendarterectomy of the common femoral artery has been performed in six patients, the first being in 1965, and all but one remained patent. Profunda femoris thromboendarterectomy has been performed in two cases (in 1969 and 1970), and both remained patent at the time of writing.

POST-OPERATIVE COMPLICATIONS

Aortoiliac.—In the earlier aortoiliac grafts one patient required operation on the 10th day for gangrene of gall bladder, and another developed cholecystitis and required cholecystectomy during convalescence. It is now routine to check the gall bladder for stones at operation, and three patients in this series had cholecystectomy performed at the time of arterial surgery. Three patients required re-operation soon after surgery because of intestinal obstruction (one) and haemorrhage (two). Eight developed deep vein thrombosis, of whom three developed pulmonary infarcts, and one died from massive pulmonary embolism. Ten patients developed wound infections, but none developed infection involving the graft. Late complications were incisional hernia, false aneurysm at the junction of graft and common femoral artery, and intestinal obstruction. About 70% of patients had an uninterrupted recovery and were dismissed home on the 11th to 19th postoperative day.

Femoropopliteal.—The most serious complication of these operations was infection, which led to the death of one patient and loss of the bypass vein graft in three. Fortunately amputation was not necessary, and they reverted to their preoperative claudication distance. Minor wound infection occurred in 15 other patients. Postoperative swelling of the leg of a mild nature was often seen without positive evidence of deep vein thrombosis and the swelling gradually disappeared with bed elevation and firm bandaging. Minor pulmonary embolic incidents occurred in two patients. One had a non-fatal coronary thrombosis, and

one bypass vein graft developed a late false aneurysm in the groin.

WORK RECORD

An attempt was made to assess the effect of arterial surgery on the working ability of the patients. Contrary to expectations most were able to work before operation, though many had difficulty in travelling to and from work, and others had been forced to change the nature of their work. A number of patients who were unable to work because of their claudication were able to resume work after operation, but a disappointing few made no effort to resume remunerative employment after restoration of normal walking ability. Though the effects of successful grafting on the working capacity of patients was often disappointing, there was no doubt that the well-being of those who had a successful operation was usually transformed and their gratitude is shown by the high percentage follow-up achieved.

IMPOTENCE

The effects of aortoiliac surgery in curing or in causing impotence were known in 104 male patients. Seventy-one (68.3%) were unaffected by operation, two (1.9%) were impotent before but normal after surgery, 25 (24%) were normal before operation and impotent thereafter, and four patients (3.8%) complained of loss of ejaculation after surgery. There was no apparent difference in the effects of operation when aortoiliac and aortofemoral grafts were compared, when end-to-end and end-to-side anastomoses were compared, and patients undergoing thromboendarterectomy showed results similar to that of bypass grafts.

Discussion

Since the introduction of saphenous vein grafts by Kunlin,⁴ and synthetic Dacron and Teflon grafts by de Bakey and his colleagues,⁵ the frequency and scope of arterial surgery has grown, and vascular surgeons in all major centres now treat successfully a wide variety of conditions. In the surgical treatment of intermittent claudication there is still a divergency of views between those who restrict operation to patients with severe claudication and those who are prepared to operate in all cases where the lesion is technically suitable for surgery.

In the present series patients experiencing a restriction of their walking capacity sufficiently severe as to make them seek medical advice and in whom there was a remediable arterial lesion were offered operation. The results obtained since 1968 suggest that operation can be undertaken with very little mortality risk and with a high degree of success (see above).

The cumulative mortality rates (1959-71: 4.1% aortoiliac and 2.7% for all cases) compare favourably with the rates reported by Szilagyi *et al.*⁶ of 6.5% aortoiliac and 4.3% for all cases. Indeed, most series over the past 10 years report mortality rates of 5-10% for aortoiliac surgery (Hardin,⁷ 8%; Dickinson *et al.*,⁸ 7%; Clarke and Provan,⁹ 8%; Kouchoukos *et al.*,¹⁰ 17.5%; Sanger *et al.*,¹¹ 6%). Our 1968-71 mortality rate of 0.9% for 113 aortoiliac operations, of which 91 were bifurcation grafts, seems most satisfactory.

This low mortality rate is not strictly comparable to most reported rates. Virtually all reported series are "mixed"—that is, they include not only patients with claudication but also patients with ischaemic rest pain and incipient gangrene, and greater surgical risks are justifiable in the avoidance of amputation in the latter. However, Sanger¹¹ reported a mortality rate of 2.8% in 36 patients undergoing aortoiliac surgery for claudication alone. The 0.9% mortality rate for aortoiliac operation in 1968-71 in the present series is undoubtedly due to several

factors—for example, case selection, anaesthesia, surgical technique, and postoperative management. There was no rigid upper limit to the age of the patient accepted for operation, but we were reluctant to operate on those over 60 years unless indications for operation were strong and the patient had been passed as reasonably fit by a physician and by the anaesthetist. Case-selection appears to have been reasonably satisfactory in that there were only four cardiac deaths during 1959-71, and only two non-fatal coronary episodes in the postoperative period. However, we have little doubt that the margin of safety can be critically reduced by untoward incidents at operation which produce serious bleeding and hypotension, and we have tried to improve our surgical technique so as to minimize blood loss.

Patency rates in this series are encouraging in that 70% of aortoiliac grafts and 60% of femoropopliteal grafts were patent after five years. The high patency rate (82%) for aortoiliac thromboendarterectomy agrees closely with the 89% five-year patency reported by Pilcher *et al.*¹² This high patency rate can be explained by case selection, since this procedure was usually undertaken only when the segmental occlusion was short, the lesion stripped easily, and the vessels elsewhere were relatively healthy. In this context it is of interest that comparison between thromboendarterectomy and bypass grafting in patients with comparable extent of aortoiliac occlusion has been shown by Kouchoukos *et al.*¹⁰ to give almost identical five-year patency rates. In general, however, we prefer to undertake bypass grafting when severe atherosclerotic lesions extend below the iliac bifurcation.

We found relatively little difference in immediate and long-term patency rates between the first and second halves of the series, but in 1971 all 68 (41 aortoiliac, 27 femoropopliteal) grafts were patent on dismissal. This is encouraging for the future but the factors affecting the long-term patency are still outwith our control.

Graft failure before dismissal from hospital is due to failure in case selection, faulty technique, or the use of inadequate graft material. We now prefer aortofemoral to aortoiliac grafting. The lower end of the graft is inserted high in the common femoral artery to avoid the effects of hip flexion on the graft, and the inguinal ligament is partially divided to avoid compression of the graft. No serious complications due to ischaemia of the pelvic organs have occurred and postoperative hernia alongside the graft has not materialized. The 13 mm by 6.5 mm bifurcation graft has been discarded as unsatisfactorily narrow, several having undergone early thrombosis.

There was an interesting group of six patients (five women, one man) in whom the arterial lesion was an aortic stenosis proximal to a virtually normal aortic bifurcation and in whom the distal arteries were patent and relatively free from atherosclerosis. Excellent restoration of blood flow was obtained by thromboendarterectomy with or without the insertion of a Dacron patch and only one has subsequently developed further occlusion.

Femoropopliteal bypass vein grafting remains a problem and the results depend to a large extent on the size and suitability of the saphenous vein. Though Linton and Darling¹³ found 66 of 76 veins (87%) suitable for bypass grafting, we have found that many veins divide in the middle or lower thigh and the lower portion does not dilate to the 4 mm which is probably the minimum necessary for success.^{13, 14} In 10 cases we performed proximal thromboendarterectomy with a short vein bypass from the lower end of the "cored-out" femoral artery to the popliteal artery but the success of this type of graft has been variable. In femoropopliteal bypass grafting for claudication we feel that it is essential to find a saphenous vein of good quality and to exclude patients who do not have a good popliteal artery below the occlusion.

We are also reluctant to insert a graft below the level of the knee joint except in cases of gangrene. Bilateral femoropopliteal grafting should probably be undertaken only in exceptional

circumstances—for example, in young patients with good saphenous veins and healthy popliteal arteries.

An alternative to bypass vein grafting is the operation of profundaplasty. Two patients in the present series have had lasting benefit from profundaplasty and the special place of this operation has been well reviewed by Martin and his colleagues.¹⁵

Despite the nature of arterial surgery serious postoperative complications are relatively few. The most serious complication is graft infection leading to separation of the graft with resultant loss of graft or life or limb. We use cloxacillin (500 mg six-hourly) routinely, beginning before operation and continuing for seven days, and have had no infective graft complications in the aortoiliac cases. Infection occurred in four femoropopliteal grafts, however, leading to death from septicaemia in one patient and the loss of the graft in the other three, fortunately without loss of limb.

Only two patients with aortoiliac lesions had normal sexual function restored by operation and 27.8% became impotent for the first time after surgery. This accords with the experience of May *et al.*,¹⁶ who found that 34% of patients previously normal became impotent after surgery. They suggested that this might be caused by a reduction in pelvic blood flow produced when the anastomosis of the synthetic graft was made below the level of the external iliac artery. However, analysis of their data shows no statistically significant difference in the incidence of postoperative sexual impotence in patients whose grafts were anastomosed below or above the external iliac artery.

In our own series, the incidence of impotence appears to be evenly distributed among all types of aortoiliac operations and it seems probable that interference with autonomic nerve pathways during dissection is likely to be the crucial factor in producing sexual deficiencies after surgery.

Arterial surgery can restore normal circulation to a limb, but the presence of atherosclerosis means that by the end of five years some patients will have died from cardiovascular causes, some will have experienced a non-fatal coronary thrombosis, and some will have developed graft occlusion or arterial occlusion elsewhere.

Nevertheless, the most striking feature of this review was the physical and mental well-being of those patients with patent grafts. Their restoration of vigour could not have been accomplished by any other means. Provided that operation can be undertaken with minimal risk of life and that patency rates in excess of 70% at the end of five years can be achieved, operation for intermittent claudication seems fully justified in fit patients.

We wish to express our appreciation of the valuable help of the junior medical and nursing staff who contributed to the management of the patients during 1959-71, and to the secretarial staff of the unit who helped to organize the survey and prepare the manuscript.

References

- 1 Boyd, A. M., *Angiology*, 1960, **11**, 10.
- 2 Bloor, K., *Annals of the Royal College of Surgeons of England*, 1961, **28**, 36.
- 3 Cockett, F. B., and Maurice, B. A., *British Medical Journal*, 1963, **1**, 353.
- 4 Kunlin, J., *Revue de Chirurgie*, 1951, **70**, 206.
- 5 de Bakey, M. E., Cooley, D. A., Crawford, E. S., and Morris, G. C., *Archives of Surgery*, 1958, **77**, 713.
- 6 Szilagyi, D. E., Smith, R. F., Elmquist, J. G., Gangales, A., and Elliot, J. P., *Archives of Surgery*, 1965, **90**, 617.
- 7 Hardin, C. A., *Surgery*, 1964, **55**, 617.
- 8 Dickinson, P. H., McNeill, I. F., and Morrison, J. M., *British Journal of Surgery*, 1967, **54**, 764.
- 9 Clarke, R. J., and Provan, J. L., *British Journal of Surgery*, 1969, **56**, 250.
- 10 Kouchoukos, N. T., Levy, J. F., Balfour, J. F., and Butler, H. R., *Archives of Surgery*, 1968, **96**, 628.
- 11 Sanger, P. W., Robicsek, F., Daugherty, H. R., Gallucci, V., *Surgery*, 1968, **64**, 359.
- 12 Pilcher, D. B., Barker, W. F., and Cannon, J. A., *Surgery*, 1970, **64**, 359.
- 13 Linton, R. R., and Darling, R. C., *Surgery*, 1962, **51**, 62.
- 14 Hall, K. B., *Acta Chirurgica Scandinavica*, 1965, **129**, 33.
- 15 Martin, P., Renwick, S., and Stephenson, C., *British Journal of Surgery*, 1968, **55**, 539.
- 16 May, A. G., de Weese, J. A., and Rob, C. G., *Surgery*, 1969, **65**, 41.