AORTOBIFEMORAL BYPASS FOR AORTO-ILIAC OCCLUSIVE DISEASE IN THE POPULATION OF KWAZULU-NATAL: AN IN-DEPTH ASSESSMENT

BY

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PREFACE

The study that is the basis of this dissertation was carried out in the Vascular Unit of the Department of Surgery, University of Natal, Durban, South Africa under the supervision of Professor J.V. Robbs. The Vascular Service of the University of Natal serves the Durban Metropolitan Hospitals which serves the entire Province of Natal. It is a busy unit which serves large numbers of the different population groups in this region with socio-economic and socio-cultural differences. The different population groups studied were Blacks (Negro), Indians (Asian) and Whites (Caucasians).

Aortobifemoral bypass is now an established operation for aorto-iliac occlusive disease. It is a major operation which should be performed when one is certain of acceptable morbidity and mortality.

This is an overview of the controversies surrounding this operation. The conclusions are based on a prospective evaluation of aortobifemoral bypass in 492 patients studied over a period of 8 years from 1985 to 1993.

ACKNOWLEDGEMENTS

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INTRODUCTION

Chronic aorto-iliac occlusive disease is commonly manifested by progressive intermittent claudication which may further progress to ischaemic rest pain, ulceration or gangrene (Figures 1 and 2). No known medical treatment will reverse the process once the disease has developed.

Aortobifemoral bypass (AFBG) is now well established as the optimal operative management for aorto-iliac occlusive disease[1] and, in the past two and a half decades, substantial progress has been achieved in the application of this procedure in clinical practice. Advances in angiography and, more recently, the development of a variety of non-invasive testing methods have led to more accurate diagnosis and localisation of the occlusive process. At the same time, improvements in materials for prosthetic grafts, surgical techniques, intra-operative anaesthetic management and postoperative care have generally led to excellent results with a steady reduction in operative mortality[1].

Aortobifemoral bypass using synthetic grafts was introduced by DeBakey in 1953[2,3,4] as an alternative to endarterectomy in cases where there was long segment involvement. The original description places the aortic anastomosis somewhere along the length of the infrarenal aorta but not juxta-renal [2,3]. Even in the early development of this operation the surgeon had a choice between end-to-end and end-to-side proximal aortic anastomosis, and the decision depended entirely on individual preference.

Numerous subsequent reports have been made indicating the effectiveness of reconstruction by this technique[4]. The mortality rates have declined from 9% to 5% or less and early

(A)

(B)

FIGURE 1:

Illustration showing an ischaemic ulcer on the leg (A), and on the big toe (B).

(A)

(B)

FIGURE 2:

Illustration showing (A) gangrene involving the left big toe, and (B) gangrene involving all four medial toes with surrounding plantar fasciitis.

functional or patency rates have increased from 88%to 99%[4]. Reported long term follow-up observations indicate survival of 24% to 71% depending on age at time of operation and year of reporting[4]. Although in the past the distal anastomoses were placed in the common femoral artery behind the inguinal ligament, in current practice, distal anastomoses are placed at the common femoral bifurcation[5].

It is an almost universal view that peripheral arterial disease occurs rarely in the Black population. Little or no mention is made of the problem in various textbooks dealing specifically with practice of internal medicine, surgery and pathology in this population group[6,7,8]. Grobbelaar[9] in 1974 reported 26% of 70 Black patients in Kalafong Hospital (South Africa) with peripheral arterial disease. In 1985 Robbs[10] in this institution demonstrated in a study of 494 black patients that atherosclerotic peripheral arterial disease is an established disease in Blacks. He concluded that the disease pattern is similar to that in Whites and Indians and that it constitutes a major clinical problem in this population group. The only study comparing the result of aortobifemoral bypass in Black and White patients was by Reddy et al[11], also from this institution, who found no significant difference between the two groups. Part of this study compares the outcome of aortobifemoral bypass in Black, Indian and White patients with special reference to presentation, complications and patency rates.

A large number of patients with peripheral arterial insufficiency are diabetic[10-15]. No study has evaluated the efficacy of aortobifemoral bypass in diabetics and non-diabetics and the present report attempts to address this problem.

Many studies have shown a male preponderance in chronic arterial insufficiency including aorto-iliac disease[4,16,17] but no study has been dedicated to gender differences.

There are few reports that address the problem of young patients requiring peripheral vascular operations including aortic bypass[18]. In our own practice we have dealt with a significant number of patients presenting for treatment before the age of 40 years and these will form the focus of a specific study.

The problem of wound and graft sepsis was a major drawback in the original bypasses[2,3] but, now that systemic peri-operative antibiotic prophylaxis for vascular reconstructive surgery has become a well established principle, these complications have decreased in frequency[2,3,19].

Patients with aorto-iliac occlusive disease sometimes present with critical ischaemia[12]. Successful use of femoral to distal bypass in this clinical situation has been widely addressed[20,21], but little has been written about the role of aortobifemoral bypass in this context. Fears have been expressed regarding the danger of prosthetic aortic graft sepsis due to ascending infection in the lymphatics in the presence of infected extremity lesions[22-25]. In addition, aortic bypass surgery is a major undertaking and one would be reluctant to submit a patient to major surgery without the expectation of a high success rate coupled with an acceptable mortality. In a previous study from this unit[19], we have demonstrated that the infected extremity lesion does not influence the incidence of wound or graft sepsis in these patients. It has also been clearly shown[13] that preservation of the knee joint following major amputation is important from the point of view of rehabilitation which justifies the use of proximal bypass procedures to facilitate healing of a more distal amputation level.

Complete occlusion of the juxtarenal aorta is an uncommon finding in patients presenting with arterial insufficiency of the lower limbs. It is seen in 0.1% of autopsies[26] and 3-8% of patients presenting with aorto-iliac occlusive disease[27,28,30]. Aortic imaging in these patients can only be achieved by translumbar angiography or intravenous (i.v.) digital subtraction angiography (DSA) or retrograde catheterisation of the axillary or brachial artery. It is not always easy to assess femoral "run-off" by means of angiography in view of the fact that femoral vessels may not be visualised due to low velocity blood flow. While the place of aortobifemoral bypass in the treatment of aorto-iliac occlusive disease is well recorded in the literature, very little is written regarding its role in the presence of total infrarenal aortic occlusion.

Distal anastomoses in aortobifemoral bypass are usually placed on the common femoral bifurcations. "Run-off" under these circumstances comprises the superficial femoral artery (SFA) and the profunda femoris artery (PF). If the SFA is occluded, however, the graft is laid onto the origin of the PF artery, and the latter becomes the sole "run-off". There is general agreement that in occlusions of the SFA the PF takes over the function of the main channel supplying the muscles of not only the thigh but, in addition, the leg and foot of the affected extremity[31]. The literature is scant, however, with regard to the efficiency of the PF in practice.

A number of studies have focused on the controversy of end-to-end and end-to-side proximal aortic anastomosis[5,32,33]. However, in these studies the surgeon randomly placed the proximal anastomosis at any site along the length of the infrarenal aorta, and no studies have focused

on the specific site of placement of the proximal anastomosis or at possible criteria for choosing the type of anastomosis i.e. whether end-to-end or end-to-side.

Some surgeons prefer using proximal end-to-end anastomosis in aortobifemoral bypass while others obtain comparable results with proximal end-to-side anastomosis[1,14]. The end-to-end anastomosis has the following theoretical advantages: (1) There is less turbulence at the anastomosis; (2) the graft does not protrude anteriorly against the duodenum; (3) the graft limbs are less likely to be kinked; and (4) the distal aorta, the most common site for aneurysms and a potential source of emboli from ulcerated plaque, is excluded[14]. The postulated advantages of an end-to-side anastomosis on the other hand are as follows: (1) The operation is technically simpler; (2) the inferior mesenteric artery may be more readily preserved; (3) in case of graft occlusion, there may be sufficient flow through the iliac arteries to prevent acute loss of extremities; and (4) some patients may be at special risk of impotence following the end-to-end anastomosis due to disturbance of iliac blood flow[14]. The criteria for doing either anastomosis are, however, not clearly defined and an assessment of the patency rates for both types of anastomosis is scant in the literature. We have a specific protocol for approaching this problem. The decision is made at operation based on the disease status of the aorta. A section of this study is designed to compare end-to-end and end-to-side proximal aortic anastomosis with special reference to patency rates and postoperative complications based on these criteria.

The Dacron® bifurcation graft has been tested over the years and provides the gold standard for use in aortobifemoral bypass and aneurysm surgery[2,3]. Dacron® bifurcation grafts were used in the vast majority of the patients in the study. While a small proportion had teflon

grafts inserted, no study has to date emerged comparing the different types of graft and the numbers in this series are too small to make meaningful analysis.

AIMS OF STUDY

1. Document the outcome of aortobifemoral bypass in patients treated in the Vascular Service for aorto-iliac occlusive disease.
2. Compare the pattern of distribution of arterial disease, clinical presentation and early results of aortobifemoral bypass in Black, Indian and White patients.
3. Compare the early results of aortobifemoral bypass in diabetics and non-diabetics.
4. Assess the effects of gender differences on the outcome of aortobifemoral bypass.
5. Compare the early results of aortobifemoral bypass in patients in different age groups.
6. Evaluate the efficacy of aortobifemoral bypass as a limb salvage operation.
7. Evaluate the role of aortobifemoral bypass in the presence of total juxtarenal aortic occlusion.
8. Evaluate the importance of the profunda femoris artery as sole "run-off" in aortobifemoral bypass.
9. Evaluate the choice of the proximal anastomosis in aortobifemoral bypass (end-to-end vs end-to-side).

METHODOLOGY

The vascular service in the Surgery Department at the University of Natal provides a metropolitan service and treats Black, Indian and White patients on both an inpatient and an outpatient basis. A proforma (see figure 3) is completed on all patients admitted to hospital for evaluation and the information stored in a computer database.

Operative Risk Assessment

All patients are admitted to hospital and fully evaluated clinically. They are then submitted to an investigative protocol which is performed routinely in this unit and includes the following.

Cardiac assessment.

All patients have a resting electrocardiogram (ECG) performed and, if necessary, a stress exercise ECG. A thallium-persantin scan is used if patients cannot exercise. An echocardiogram is performed if there is a history of angina pectoris in order to assess ventricular function. Invasive cardiac testing is not routinely done in any of these patients unless clinically indicated.

SURNAME: FIRST NAMES:

I.P.NO: RACE: HOSPITAL:

O.P.NO: SEX: FIRST ADMISSION:

AGE: REPEAT ADMISSION:

DATE OF ADMISSION / / DATE OF DISCHARGE HOME / /
SUMMARY DATE: / / CWD: / /

SUMMARY NUMBER:

REFERRING DOCTOR:

REFERRING HOSPITAL:

STREET: CITY: PROVINCE: CODE:

D I A G N O S I S

GENERAL CATEGORY

A	TRAUMA	F	THORACIC OUTLET SYNDROME
B	OCCLUSIVE LARGE VESSEL ACUTE	G	CONGENITAL
C	OCCLUSIVE LARGE VESSEL CHRONIC	H	VENOUS OCCLUSION
D	OCCLUSIVE SMALL VESSEL (DIGITAL)	I	NO DEMONSTRABLE VASCULAR DISEASE
E	ANEURYSM	J	PREVIOUSLY WORKED UP ADMITTED FOR ELECTIVE SURGERY

A N A T O M I C A L L O C A T I O N

CEREBROVASCULAR [1]

	R	L
Carotid: Internal	2	3
Common	8	9
Vertebral: proximal	10	11
Brachiocephalic	16	
Aortic arch	17	

	R	L
External	4	5
bony canal	12	13

	R	L
Bifurcation	6	7
distal	14	15

FIGURE 3:

First page of the proforma used for all vascular patients.

Respiratory function.

All patients have chest radiography. Respiratory function tests including forced vital capacity (FVC) and forced expiratory volume in one second (FEV_1) are also performed so as to assess the patients' respiratory reserve.

Renal function.

Plasma urea and electrolytes as well as creatinine are measured routinely and, in most patients, creatinine clearance is performed. We do not regard renal function as significant in influencing outcome as it has been shown from this unit that renal complications are rare following aortic surgery[34].

General.

Other general investigations include fasting blood sugar measurements, full blood count. More recently, blood lipid profiles have been obtained and, where necessary, immunological screening tests are carried out. Patients are then placed in risk category according to the criteria for cardiac risk index as described by Goldman[35]. The criteria are summarised in Table I.

TABLE I

Criteria for Cardiac Risk Index

Criteria	Points
History	
Age > 70 years	5
Myocardial infarction in previous 6 months	10
Physical Examination	
S3 gallop or jugular vein distension	11
Significant valvular aortic stenosis	3
E C G	
Rhythm other than sinus or presence of premature atrial contractions on last preoperative ECG	7
Premature ventricular beats > 5 per minute at any time	7
General Status	
Po_2 < 8kPa or Pco_2 > 6.5 kPa; Serum K^+ <0.97 mmol/l or HCO_3 < 20mmol/l; Urea > 8.0 mmol/l or Creatinine > 265.0 μmol/l Signs of liver disease or patient bedridden from non cardiac causes	3
Operation	
Intraperitoneal, intrathoracic or aortic	3
Emergency operation	4
Total	**53**

Po_2 = partial arterial oxygen pressure; Pco_2 = partial arterial carbon dioxide pressure; HCO_3 = acid base deficit.

There are four grades according to the number of points scored, the maximum score possible being 53. Scores are as follows: grade I - less than 6 points; grade II - 6 to 13 points; grade III - 14 to 25 points and grade IV - 26 to 53 points.

Two local studies[34,36] have shown that this cardiac risk index is a valuable predictor of operative risk in our own practice.

Localisation Studies

Routine non-invasive investigations include segmental pressure measurements and velocity wave form analysis at the level of the common femoral artery in the groin using continuous wave doppler ultrasonography. Angiography which may be conventional (Figure 4) or, more recently, digital subtraction aortography (DSA) (Figure 5) is routinely performed by the intra-arterial technique. Where there is total aortic occlusion intravenous digital subtraction aortography is performed. Other options include thoracolumbar angiography or retrograde cannulation of the axillary or brachial arteries.

The Operation

Prior to aortic surgery all patients have their abdominal wall, groins and lower limbs scrubbed with hibitane scrub daily for three days before operation. A bed is reserved in the intensive care unit for postoperative high care monitoring and ventilation where necessary.

Procedure

The operation is performed under controlled anaesthesia comprising thoracic epidural and standard general anaesthetic techniques. The groins are explored as a first step in order to assess femoral "run-off" (Figure 6). The common femoral artery and its branches on each

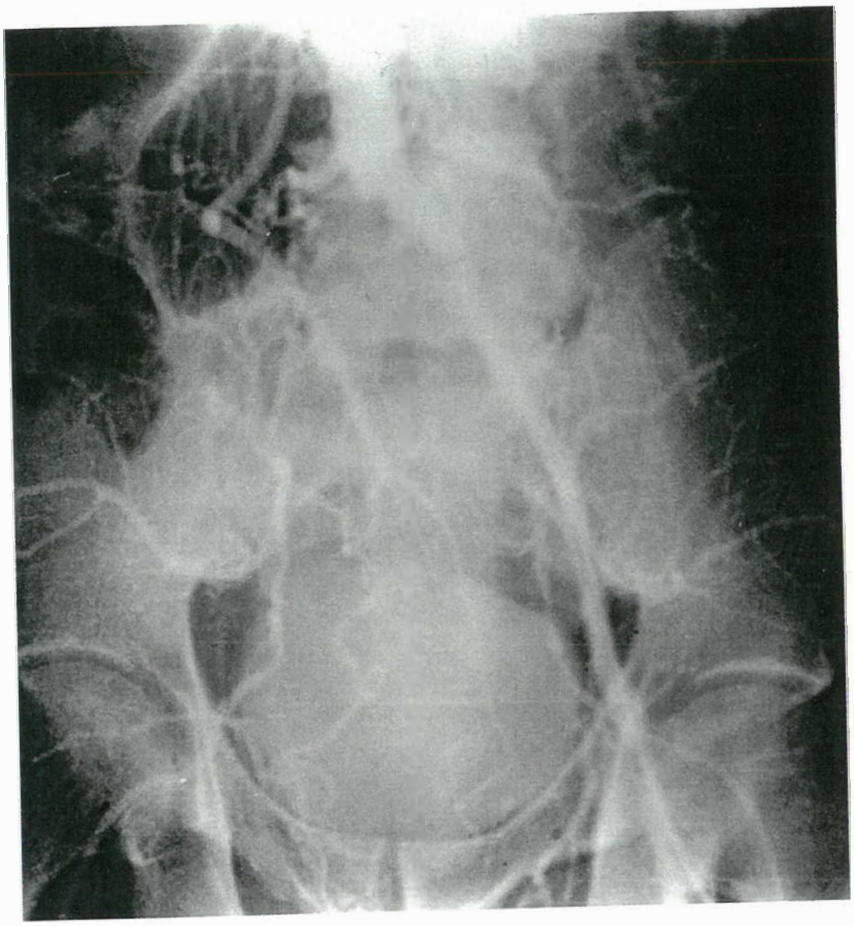

FIGURE 4:

This shows an angiogram of a patient with aorto-iliac occlusive disease. Note cut-off of flow at the aortic bifurcation.

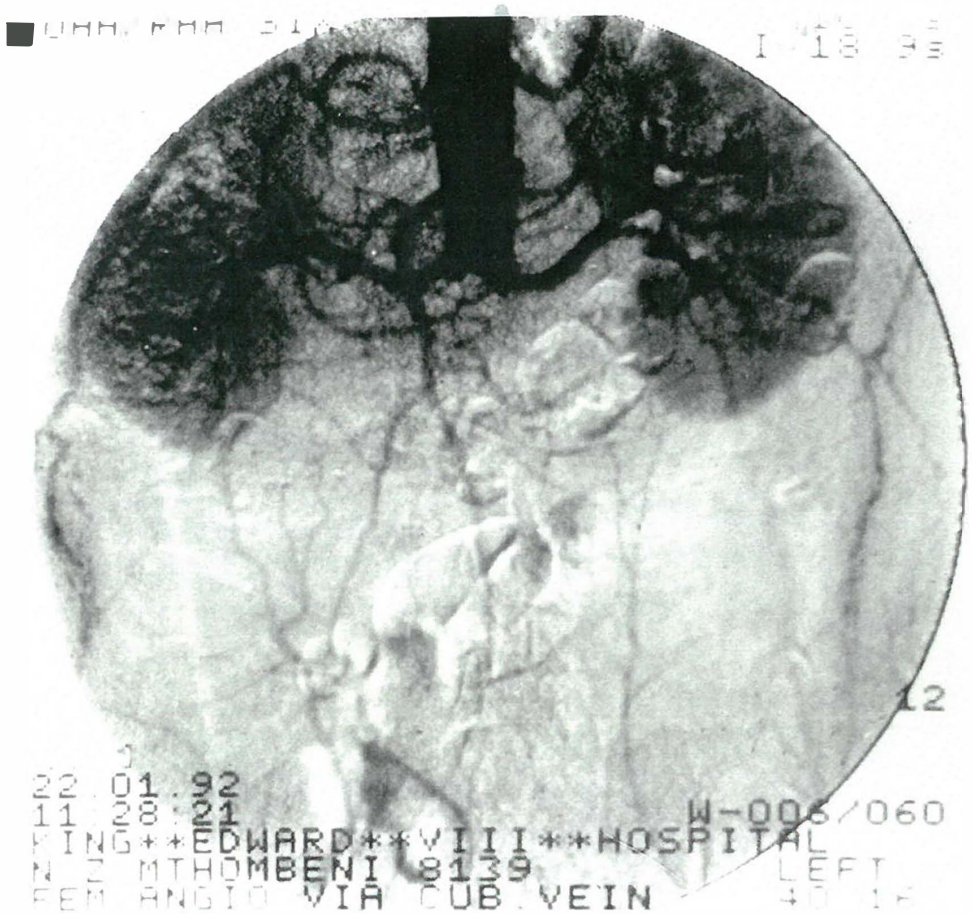

FIGURE 5:

An angiogram (DSA) of a patient with total infrarenal aortic occlusion. Note complete cut-off just below the renal orifices.

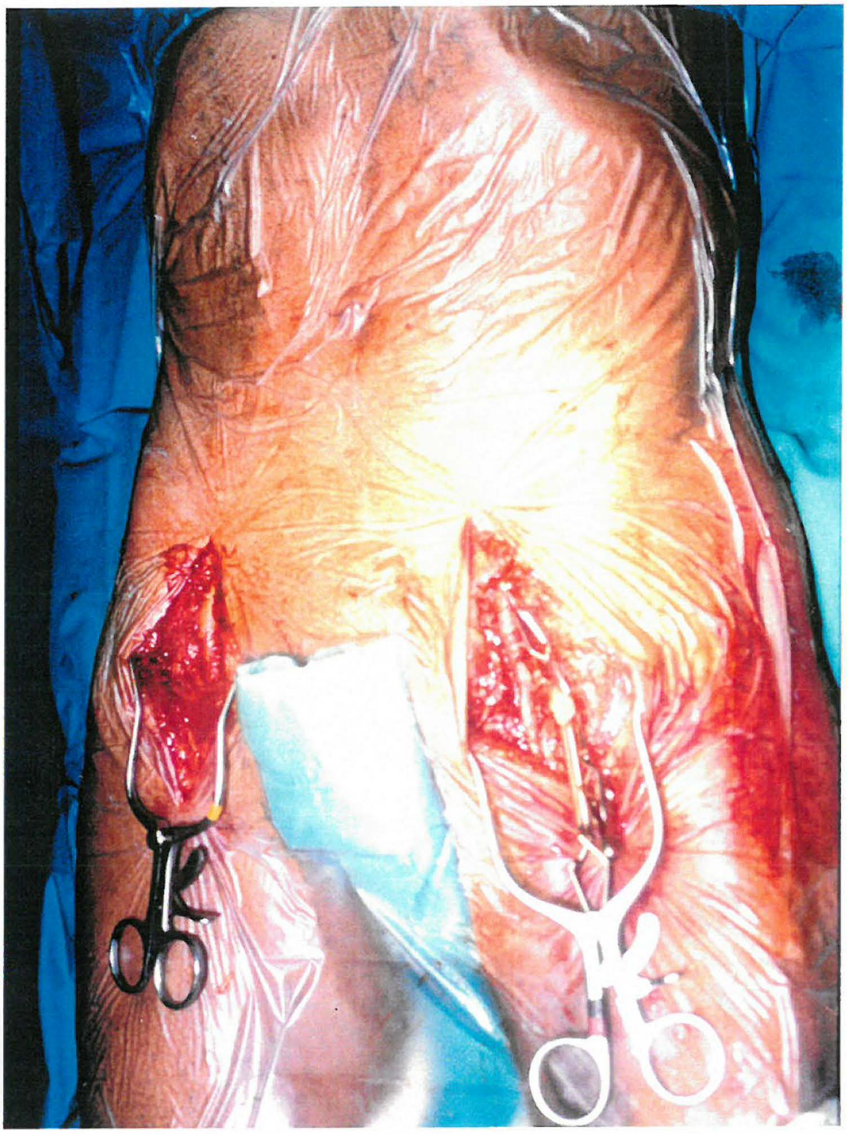

FIGURE 6:

Groins are explored first.

side are examined for the presence of disease. If the superficial femoral artery is occluded the profunda femoris artery is prepared to act as "run-off" and, if the ostium of the PF is stenosed, thromboendarterectomy of the area is performed.

Before commencement of the abdominal aortic component of the procedure, the aorta is inspected for the presence of disease and a decision made as to the type of anastomosis. If it is relatively disease free an end-to-side anastomosis is performed (figure 7). If the aorta is diseased, i.e. if it is aneurysmal, stenosed, or contains loose atheromatous plaque or is completely occluded, then the aorta is transected and endarterectomised and irrigated free of debris prior to the performance of an end-to-end anastomosis (figure 8).

A standard aortobifemoral bypass is carried out using a bifurcation graft with the proximal anastomosis placed on the juxtarenal aorta. The anastomosis is either end-to-side or end-to-end as described. Distal anastomoses are placed end-to-side on the common femoral bifurcations with local thromboendarterectomy where indicated (Figure 7). If the superficial femoral artery is occluded then the graft is laid onto the profunda femoris artery (Figure 9).

In patients with total aortic occlusion the steps prior to the commencement of the abdominal procedure were as described. On exploration of the aorta, the primary site of atherosclerotic occlusion in every case was found in the segment of the aorta distal to the inferior mesenteric artery with thrombosis of the infrarenal aorta up to the level of the renal artery (Figure 10)

Prior to aortic cross-clamping diuresis is induced by the infusion of mannitol (0,5g/Kg) as a means of renal protection. A suprarenal clamp is then applied, the renal arteries controlled

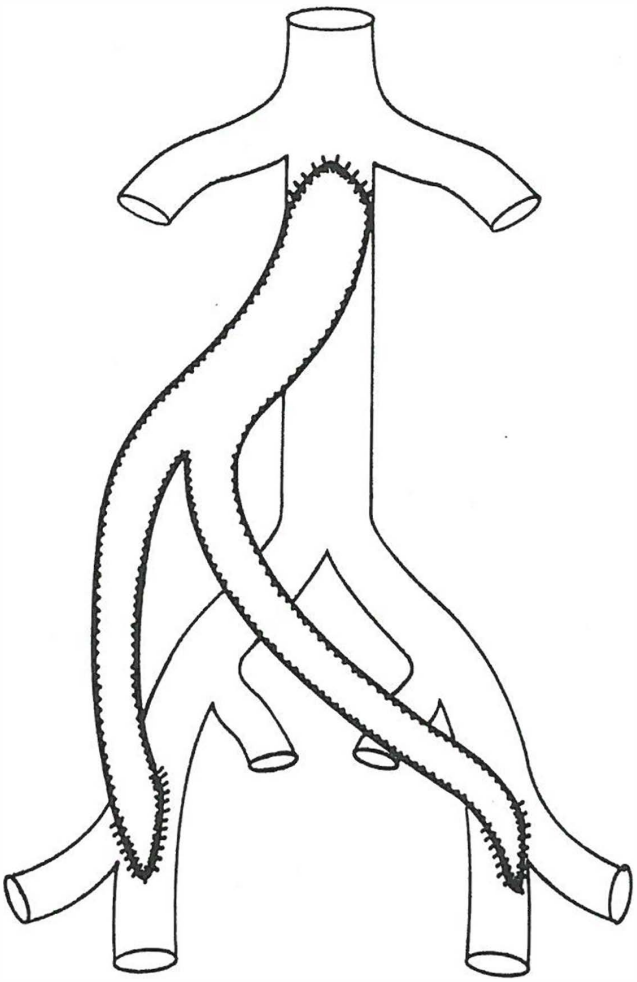

FIGURE 7:

An end-to-side proximal aortic anastomosis with distal anastomoses placed at the common femoral bifurcations.

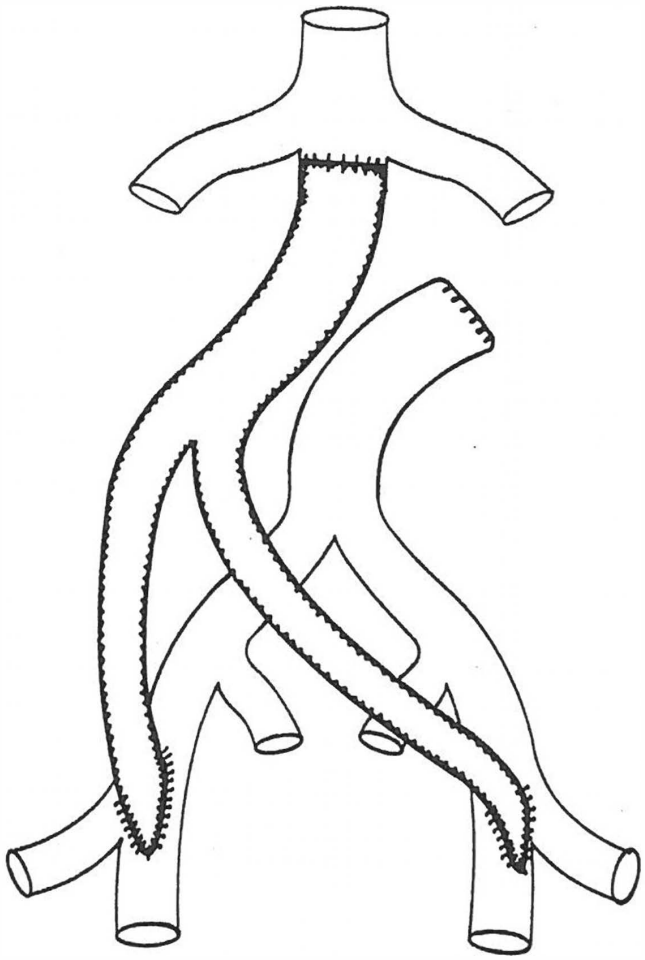

FIGURE 8:

An end-to-end proximal aortic anastomosis. The infrarenal aorta has been transected.

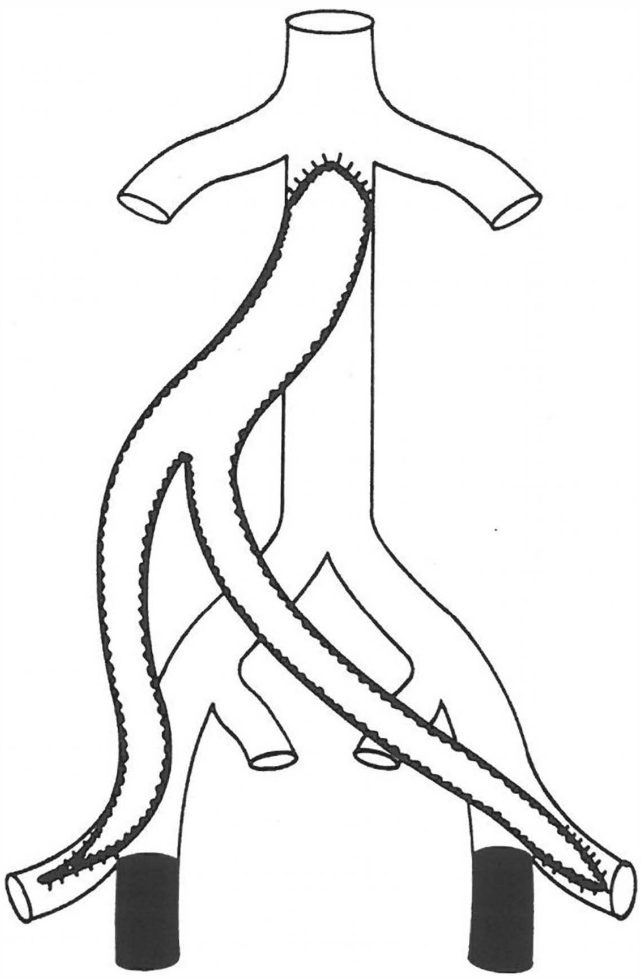

FIGURE 9:

Distal anastomoses in a patient with occlusion of the SFA. The anastomoses are laid onto the P.F.

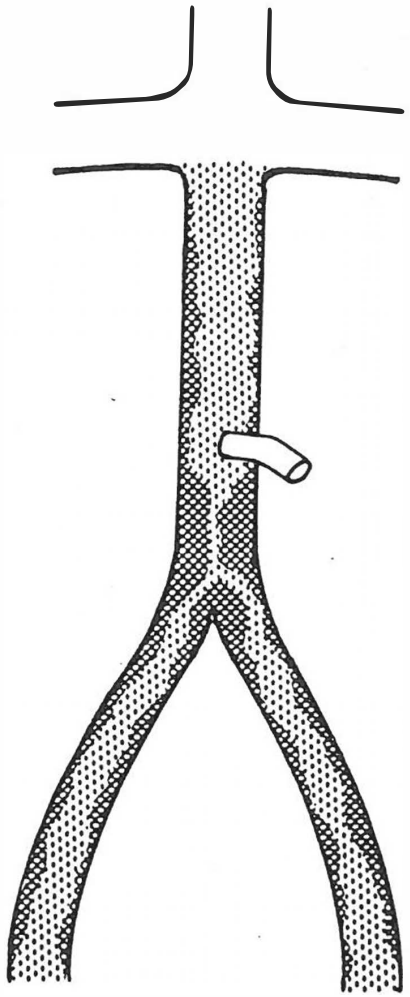

FIGURE 10:

The occluding atherosclerotic plaque situatied in the segment of aorta below the inferior mesenteric artery and thrombosis of the rest of the infra-renal aorta.

and the aorta divided just below the renal arteries. A vertical aortotomy is then made between the renal vessels. In most cases it is possible to retract the left renal vein, but in a small number of patients it is necessary to ligate it in order to gain adequate access. The aorta as well as the orifices of the renal arteries, where necessary, are thrombectomised under direct vision. Thereafter a standard bifurcation graft is inserted with the proximal anastomosis placed obliquely between the renal arteries and made end-to-end to the juxtarenal aorta (Figure 11). The average duration of suprarenal aortic occlusion is 20 minutes, ranging between 10 and 35 minutes.

Concomitant digital amputation is performed where necessary. All patients receive broad spectrum peri-operative antibiotic therapy. In most patients who undergo surgery, a report on the histological examination of the arterial lesion is obtained.

Follow-up

After discharge from hospital all patients are given follow-up appointments at the Vascular Clinic at intervals of 1 month, 3 months, 6 months and then twice yearly for an indefinite period. In addition, all major amputees are referred to the Amputee Rehabilitation Clinic for assessment by a group comprising a vascular surgeon, physiotherapist, orthotist and social worker, for purposes of long-term rehabilitation. Patients in the present study have been assessed for a maximum of 5 years.

Statistical Analysis

The Chi-Squared method was used for statistical analysis in this study and, where numbers were small, the Fischer's Exact Test was used.

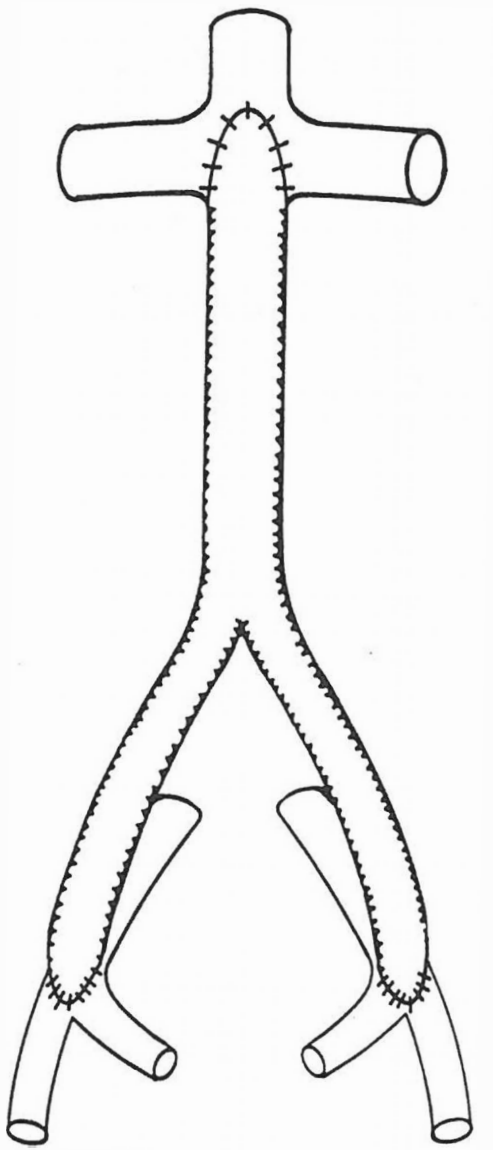

FIGURE 11:

An end-to-end anastomosis placed between the origins of the renal arteries.

PATIENT PROFILE

Overview

The patients evaluated in the study were referred to the Vascular Service with occlusive disease affecting the aorto-iliac segment, all of whom were deemed suitable for surgery. There was a total of 492 patients who underwent aortobifemoral bypass during this period. There were 418 males and 74 females giving a male to female ratio of 5.6:1. Ninety five per cent were cigarette smokers. Their ages ranged between 27 and 89 years with an average of 57.3 years (Table II). Four hundred and fifty two patients were over the age of 40 years.

TABLE II

PATIENT PROFILE

Total	492
Male	418
Females	74
M:F ratio	5.6:1
Age (years) : Range	27-89
: Average	57.3

Profiles of the different population groups are shown on Table III.

TABLE III

Profiles of different population groups (n=492)

		Blacks	**Indians**	**Whites**
Totals		224(46%)	80(16%)	188(38%)
Age (years)	- Range	26-79	35-70	38-89
	- Average	54.3	55	62.5
M : F Ratio		23:1	18:1	2:1

There were 224 Blacks, 80 Indians and 188 Whites. The average age for the Blacks and Indians (54 and 55 years respectively) was lower than that for Whites (62.5 years). The male to female ratio was highest among Blacks and lowest among Whites with that of the Indians falling in-between.

The overall clinical presentation is shown on Table IV and that in the different population groups is shown on Table V.

TABLE IV

Clinical presentation (n = 492)

	n	%
Claudication	255	51.8
Rest pain	74	15
Necrosis (digital gangrene)	105	21.3
Ulcer	58	11.8

Two hundred and fifty five patients (52%) presented with claudication, 74 (15%) with rest pain without necrosis. Necrosis involving one or more toes occurred in 105 patients (21%) and 58 (12%) presented with an ischaemic ulcer on the foot or leg.

The presentation in the different popuation groups is shown in TableV.

TABLE V

Presentation in the Different Population Groups

	Blacks (n=224)	**Indians (n=80)**	**Whites (n=188)**	**p-value**
Claudication	80(36%)$^{+}$	48(56%)	128(68.1%)*	<0,0001
Rest pain	30(13%)	11(13.75%)	33(17.6%)	
Digital Gangrene	77(34%)$^{+}$	13(16.25%)	15(8.0%)*	0.005
Ulcer	38(17%)	8(10%)	12(6.4%)	

{ + vs * statistically significant}

More Whites and Indians presented with claudication compared to Blacks and there was a statistically significant difference between Whites and Blacks. There was no difference as far as rest pain was concerned but more Black patients had gangrene than the other groups and the difference between Blacks and Whites was statistically significant. There was no difference as far as ischaemic ulcer was concerned.

Bypass for Critical Ischaemia

Critical ischaemia with threat of limb loss has been broadly defined as persistently recurring rest pain, requiring analgesia for greater than two weeks; or ulceration or gangrene of foot or toes with ankle systolic pressure $\leq$ 50 mmHg or toe pressure $\leq$ 30 mmHg[37,38].

One hundred and fifty one patients were referred with critical ischaemia to the leg as defined earlier. They were offered aortobifemoral bypass as a means of limb or stump salvage and they formed a cohort of patients studied in the early part of the study to assess the efficacy of aortobifemoral bypass as a limb salvage operation. Forty nine patients presented with rest pain without tissue necrosis, 94 with gangrene confined to one or more digits and 8 with necrosis extending onto the forefoot (Table VI).

TABLE VI

Clinical Presentation of Patients with Critical Ischaemia (n=151)

	n	%
Rest pain - no tissue necrosis	49	32
Digital gangrene	94	62
Forefoot gangrene	8	5

Total Juxtarenal Aortic Occlusion

A cohort of the patients in this study were studied to evaluate the role of aortobifemoral bypass in total juxtarenal aortic occlusion. There were 42 patients with complete occlusion of the infrarenal aorta, a prevalence of 8.5%. Twenty eight were African, 39 were male and the ages in the total group ranged between 37-72 years (Table VII). All were cigarette smokers.

TABLE VII

Racial Distribution of Patients with Total Aortic Occlusion (n=42)

Black	28
Indian	11
White	3
M : F Ratio	13:1

The male to female ratio was higher in this cohort of patients than in the entire group. The majority were African. The clinical presentation is shown in Table VIII.

TABLE VIII

Clinical Presentation of Patients with Total Aortic Occlusion (n=42)

	n	%
Claudication	17	40
Rest pain	14	33
Focal necrosis	10	24
Acute thrombosis	1	2
Impotence	6	15.4

Claudication was a common presentation followed by rest pain and focal necrosis. In only 6 patients was a history of impotence elicited.

As a routine the groins were explored as a first step in order to assess femoral "run-off" (vide supra). In 35 patients the superficial femoral and profunda arteries were patent. Seven had only profunda run-off. Local thromboendarterectomy was required in five patients.

Operative risk factors

Operative risk factors are depicted on Table IX.

TABLE IX

Operative Risk Factors (n=492)

	n	%
Hypertension	127	25,8
Ischaemic Heart Disease	58	11.9
Diabetes	48	9.8
Polycythaemia	1	0.2

The commonest risk factor was hypertension followed by ischaemic heart disease and diabetes.

The operative risk factors were also assessed in the different population groups (Table X)

TABLE X

Risk Factors in the Different Population Groups

	Black (n=224)	**Indians (n=80)**	**Whites (n=188)**	**p value**
Hypertension	49(22%)	22(28%)	56(30%)	
Diabetes	10(4.5%)	18(23%)	20(11%)	
Ischaemic Heart Disease	0	13(15%)	45(24%)	
Total Risk	25%*	50%$	50.3%$	<0,0001

{ * vs $ Statistically Significant : Chi-squared method}

Hypertension was the commonest risk factor in all groups. Diabetes was most common among Indians and ischaemic heart disease was most common among Whites. It is interesting that there was no ischaemic heart disease among the Black cohort in this study. The total percentage risk in each population group was derived by taking the number of patients at risk and calculating it as a percentage of the total number of patients. This was smaller among Blacks and higher among both Whites and Indians. This difference between Blacks on the one hand and Whites and Indians on the other was statistically significant. The male to female ratio was lower among diabetics compared to non-diabetics (1.5:1 vs 6:1) suggesting that there were more female diabetics.

RESULTS

Results will be presented according to the following headings:

1.Overview

a. General - i. early

- ii. late

b. Ethnic Comparisons

c. Influence of diabetic status

d. Influence of gender

e. Age group comparisons

2. Specific subgroups

a. Critical Ischaemia

b. Total Aortic Occlusion

c. Occluded Superficial Femoral Artery

d. Proximal Aortic Anastomosis

OVERVIEW

General

Early results

Table XI shows the overall complications occurring within one month of operation.

TABLE XI

Postoperative Complications Within One Month

		n	%
Remote	Death	25	5.1
	Respiratory	21	
	Intestinal obstruction	4	
	DVT	4	
	CVA	2	
	Other	6	
Local	Wound sepsis - Abdomen	9	
	- Groin	11	
	Occlusion	6	

Forty patients died giving a mortality rate of 8%. Twenty one patients had chest infection. Four patients developed intestinal obstruction, four developed deep vein thrombosis (DVT) and two developed cerebrovascular accident (CVA). Other complications were jaundice in three patients, paralytic ileus in two and high output renal failure in one. Superficial wound sepsis occurred in 19 patients, eight in the abdomen and 10 in the groin and at both sites in

one. Six patients developed graft thrombosis of whom four were successfully disobliterated and in two disobliteration was unsuccessful.

Table XII shows the causes of death in the 40 patients who died

TABLE XII

Causes of Postoperative Mortality in 40 Patients within One Month

	Black	Indian	White	Total
Myocardial Infarction	0	3(3.8%)	12(6.4%)	15(63%)
Respiratory Failure	1	0	1	2(8%)
Renal Failure	2	0	1	3(7.5%)
Pulmonary Embolism	0	0	1	1(4%)
Bowel Infarction	1	0	1	2(8%)
Cerebrovascular Accident	0	1	0	1(2.5%)
Aorto-enteric Fistula	0	0	1	1(4%)
Mortality Rate	1.8%*	5%@	8.5%+	

+ vs * $p < 0.005$
+ vs @ NS
@ vs * NS

{ Chi-squared method }

Fifteen patients died from myocardial infarction, 12 of them White, three Indian and no Blacks died of this cause. The other causes of death were few. Whites had the highest mortality rate while Blacks had the lowest. This difference was statistically significant. The differences between Whites and Indians and between Indians and Blacks were not statistically significant.

Of the 48 diabetic patients, four died (8.3%) and, among the non-diabetics, 21 died (4.7%). Thus more patients died in the diabetic group but this did not reach statistical significance (p=0.148).

It was notable that there were no significant differences in early morbidity in the different subgroups.

Late results

Table XIII shows the six month to five year follow-up of all the patients following the operation.

TABLE XIII

6-60 Month Follow-up of 492 Patients Following Aortobifemoral Bypass

	n	%
Occlusion	65	13.2
Graft Sepsis	13*	2.6
Anastomotic aneurysm	16#	3.2

* Two patients developed aorto-enteric fistula
\# Two aneurysms developed in one patient

Occlusion occurred in 65 patients (13.2%). Thirteen patients developed graft sepsis (2.6%). Two of these patients had developed aorto-enteric fistula. Sixteen anastomotic aneurysms developed in 15 patients (two developed in one patient).

The overall, 5 year cumulative patency rate, calculated by life table analysis, is graphically depicted in Figure 12. The overall 5 year patency rate was 86%.

Table XIV shows patients subsequently developing femoral-to-distal disease.

TABLE XIV

Associated Femoral-to-Distal Disease

Present at time of AFBG	3
Developed subsequently	28
Total	31
Surgery	28
Non-operative	3

Thirty one patients had concomitant femoral-to-distal disease. The three patients who had femoral-to-distal disease at the time of aortobifemoral bypass had an additional femoral-to-distal bypass at the same sitting. Twenty eight developed the disease subsequently. Of this latter group, three patients were managed conservatively.

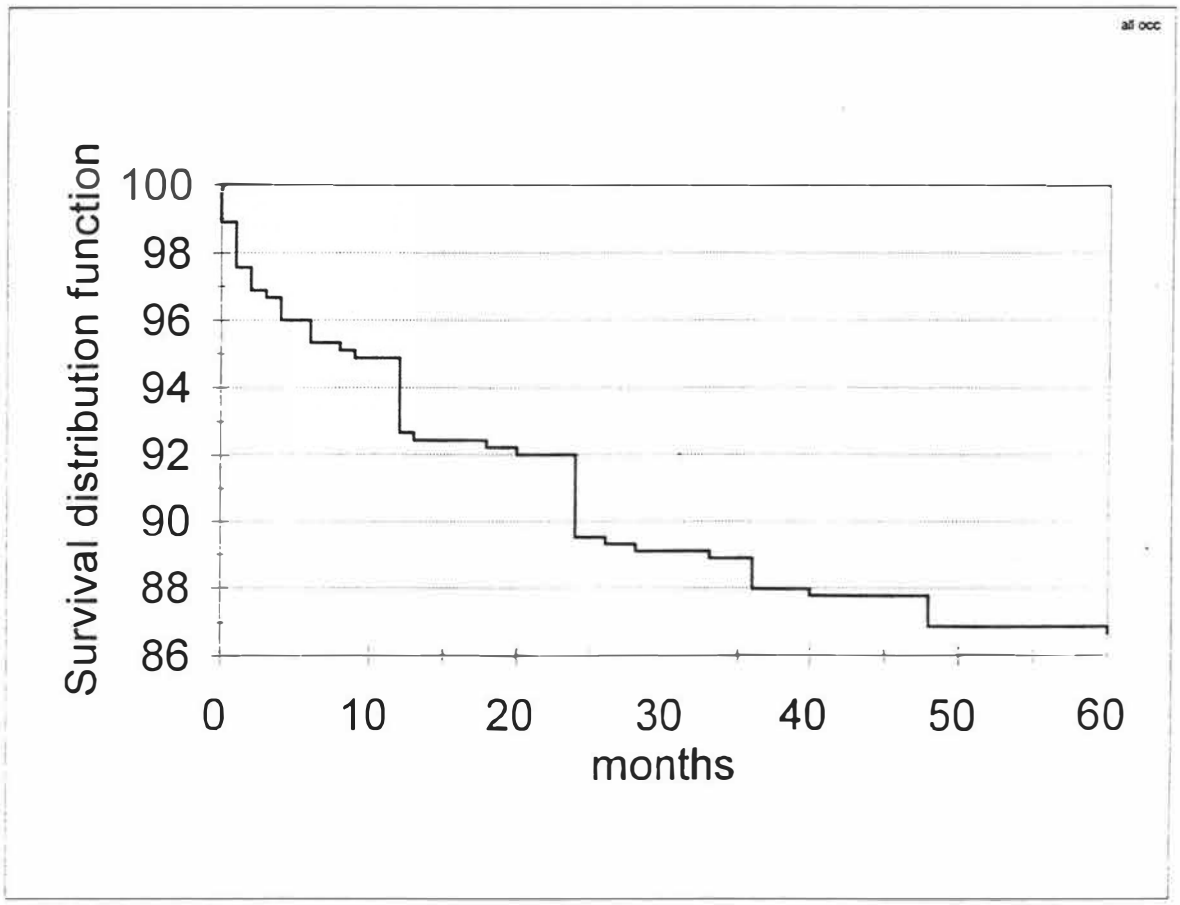

FIGURE 12:

Cumulative patency rates after aortobifemoral bypass using life table analysis.

Ethnic Comparisons

Table XV shows the medium term outcome in all groups

TABLE XV

Outcome of Procedure in Different Groups (6-60 Months)

	Black (n=224)	Indian (n=80)	White (n=188)	p value
Occlusion	18.5%[@]	12.6%[$]	5.1%[*]	#
Sepsis	3.7%	1.4%	1.9%	NS

{@ vs * p=0.0001. @ vs $ p=0.21. $ vs * P=0.09 : Chi-squared method}

The occlusion rate was 18.5% in Blacks 12.6% in Indians and 5.1% in Whites. The difference between Blacks and Whites was statistically significant; that between Blacks and Indians was not statistically significant, and that between Whites and Indians was also not statistically significant. There was no difference between all groups as far as graft sepsis was concerned.

Five year patency rates were also calculated for Blacks, Indians and Whites and are shown in Figure 13. The figure for Blacks was 86%, that for Indians was 87% and that for Whites was 96%. The patency rate for Whites was significantly better than that for Blacks.

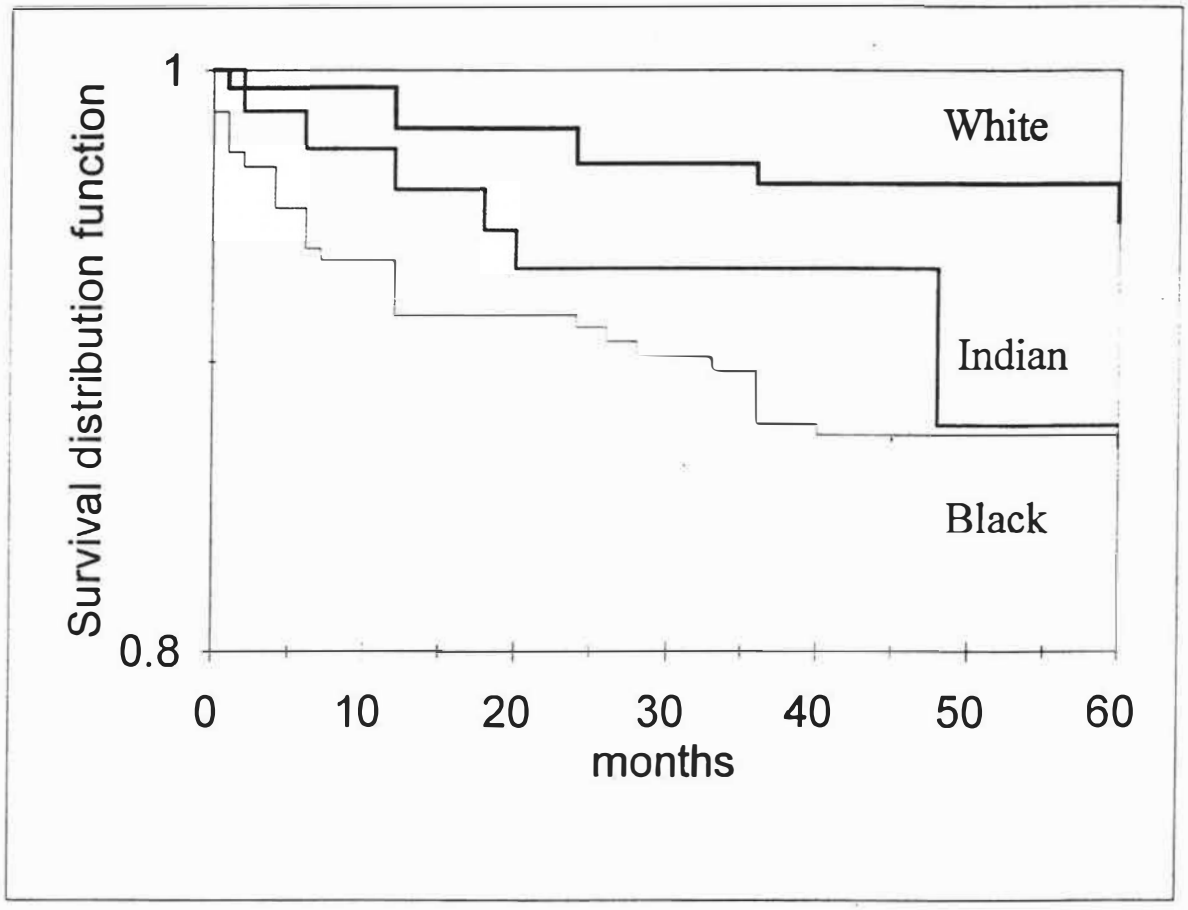

FIGURE 13:

Cumulative patency rates following AFBG in the different population groups.

Influence of Diabetic status

Table XVI shows medium term follow-up among diabetics and non-diabetics.

TABLE XVI

Influence of Diabetes on Outcome (6-60 Months)

	Diabetic	**Non-diabetic**	**p value**
	48	444	
Occlusion	7(14.5%)	58(13.1%)	0.95
Sepsis	0	13(2.9%)	

{ Chi-squared method }

Of the 48 patients with diabetes, seven (14.5%) developed graft occlusion, whereas in the non-diabetic patients 58 (13%) developed graft occlusion. This difference was not statistically significant (p=0.95). It is notable that none of the diabetic patients developed graft sepsis, and, as such, statistics were not calculated to assess statistical significance.

Five year patency rates among diabetics and non-diabetics is shown on Figure 14. The figure for diabetics was 76% while that for non-diabetics was 81%. The difference is not statistically significant.

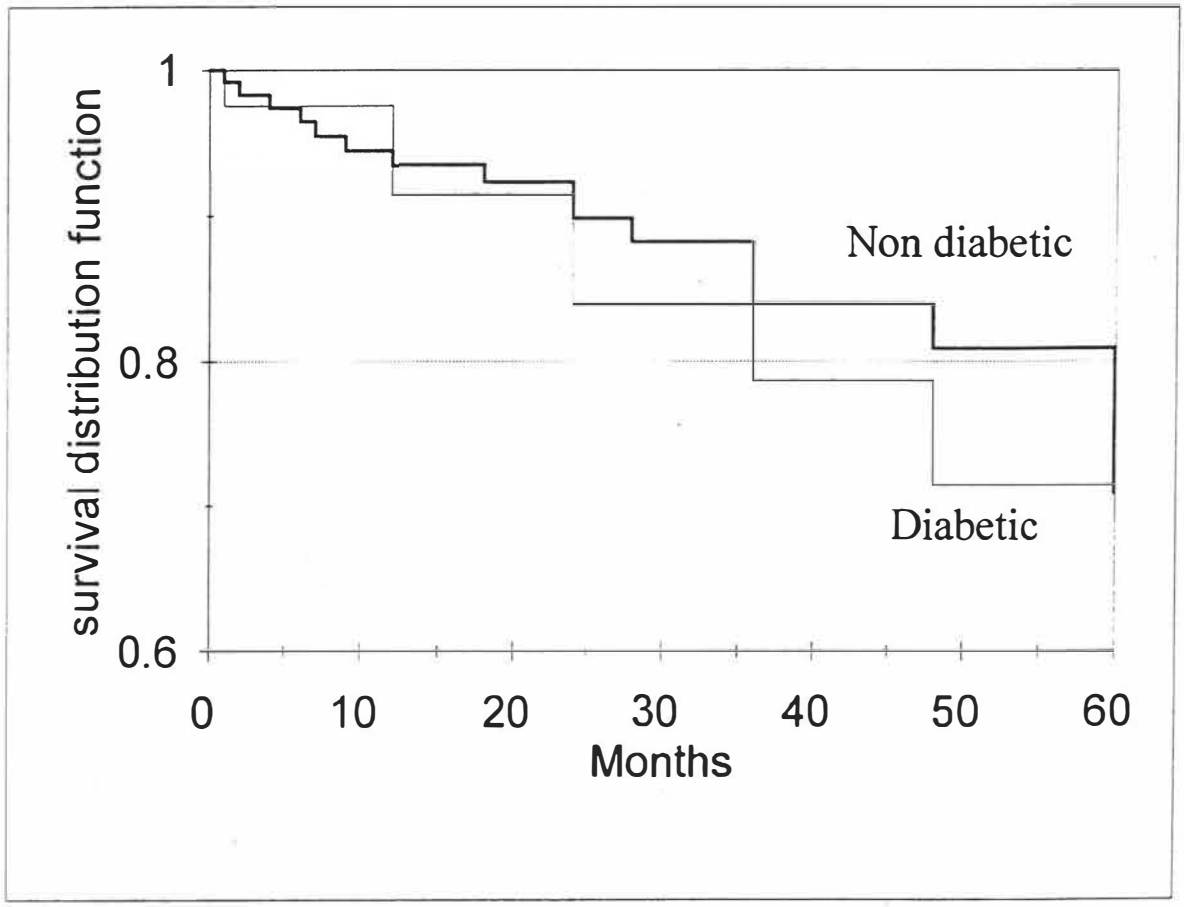

FIGURE 14:

Cumulative patency rates between diabetics and non-diabetics.

Influence of Gender on Outcome

Table XVII shows the outcome of the procedure in males and females.

TABLE XVII

Influence of gender on Outcome (6-60 months)

	Male	**Female**	**p value**
Total	418	74	
Occlusion	60(14.4%)	5(6.7%)	0.076

Chi-squared method

Sixty out of 418 males (14%) developed graft occlusion and five out of 74 females (6.7%) developed occlusion. The disease seemed to be more aggressive in males. The difference was not statistically significant.

Age Group Comparisons

Table XVIII shows differences between those under the age of 40 and those over the age of 40.

TABLE XVIII

Influence of Age on Outcome (6-60 months)

	≤ 40	> 40	p value
Totals	40	452	
Occlusion	9(22.5%)	55(12%)	0.07

{ Chi-squared method }

The graft occlusion rate was higher in the younger age group (23% compared to 12%) but this did not reach statistical significance.

Five year patency rates for patients over 40 years of age and those under 40 years of age are shown on figure 15. The older patients had a patency rate of 86% and the younger patients had a patency rate of 62%. This did not reach statistical significance.

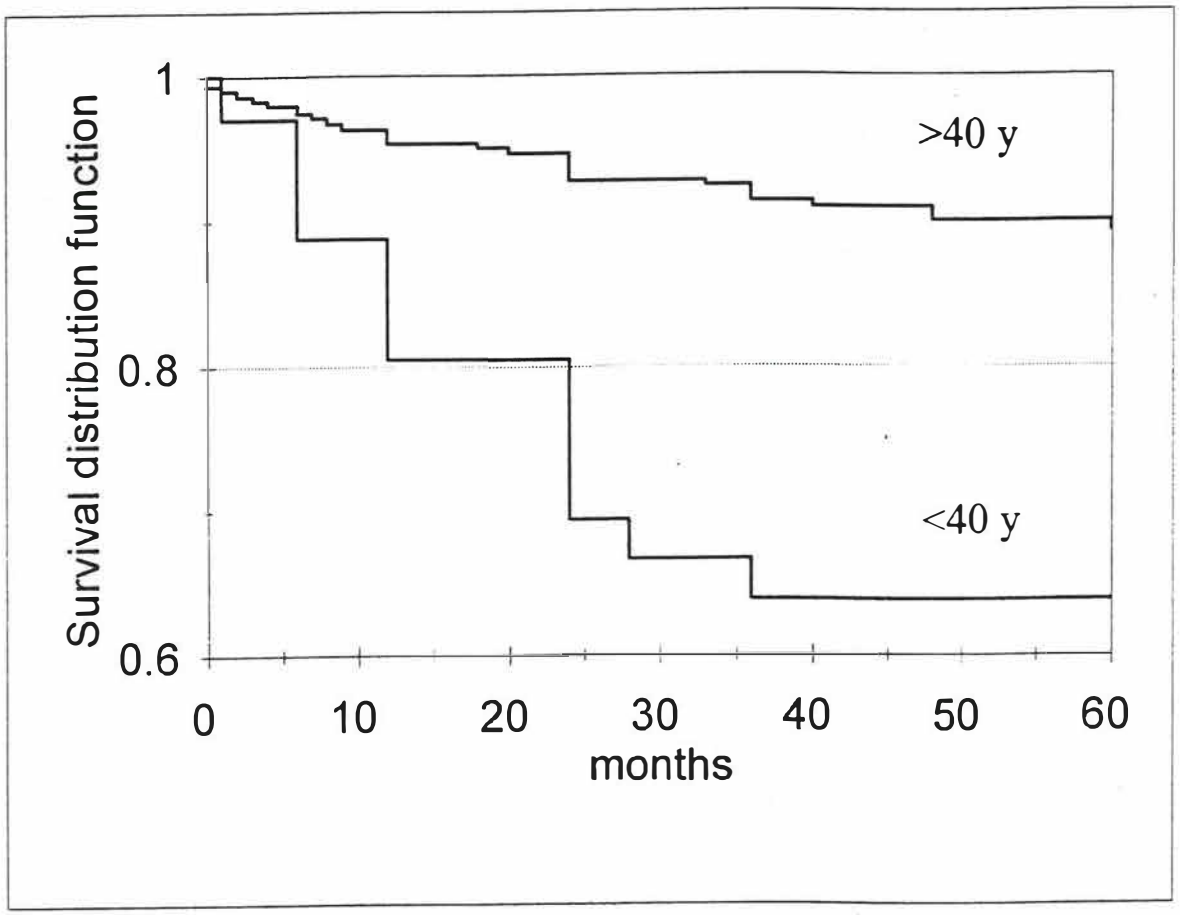

FIGURE 15:

Cumulative patency rates between patients under 40 and those over 40 years of age.

SPECIFIC SUBGROUPS

Bypass For Critical Ischaemia

The acute morbidity in this subgroup was not significantly different from the general morbidity. There was no graft sepsis but 7 patients (4.5%) developed superficial groin wound infection. Three patients (2%) developed graft occlusion. Two of these patients, had a distal intimal flap with thrombus which was successfully corrected at operation. One had severe "run-off" problems and surgical correction was not possible. The patients were then divided into two subgroups. Group I comprised those patients presenting with rest pain and those with focal digital gangrene. This group was submitted to aortobifemoral bypass with concomitant digital or transmetatarsal amputation when necessary. Group 2 comprised those patients in whom a guillotine-type below-knee amputation became mandatory before surgery in view of ascending infection or when the extent of necrosis on the foot made local amputation impracticable. The objective in this group was to obtain healing of the stump at the below-knee level. One hundred and thirty patients were allocated to group 1, while group 2 comprised 21 patients. Table XIX shows the outcome of the bypass procedure in respect of limb or stump salvage in the 6-60 month follow-up period. In group 1, eight required a major proximal amputation (6.2%); six of these stumps healed below the knee but two required revision to the proximal thigh. In group 2, three patients (14.3%) required proximal above knee revision and the total limb salvage was 89.4%.

TABLE XIX

Medium Term Limb/Stump Salvage

	Group 1		Group 2		Total	
	n	%	n	%	n	%
Total no of patients	130		21		151	
Major proximal amputation	8*	6.2	3+	14.3	11	9.3
Limb/stump salvage	117	90.0	18	85.7	135	89.4

* 6 below - knee
\+ 2 above - knee

Of the 11 patients in whom the original aim of limb or stump salvage failed, the aortic graft remained patent in eight. The reason for failure was assessed as being inadequate distal vessel patency as concomitant distal bypass was not considered feasible (Table XX).

TABLE XX

Reason for limb/stump salvage failure within one month of operation

	Group 1	Group 2	Total
Graft Patent - Inadequate distal run-off	6	2	8
Graft Occlusion	2	1	3
Total	8	3	11

Table XXI summarises the 2-5 year follow up of patients discharged with a salvaged limb or below-knee stump. Of the 117 patients in group 1, 12 were lost to follow-up (11.2%) of the 105 available for assessment, seven developed progressive distal disease in the presence of a patent aortic graft with recurrent critical ischaemia. All were re-evaluated with a view to

femoral-to-distal bypass. In three of these patients no further salvage procedure was possible and primary below-knee amputation was performed; in four femoro-distal bypass was successful. Group 2 comprised 18 patients of whom almost one third (27.7%) were lost to follow-up. Of the 13 available for assessment none have had proximal amputation. Only 2.5% of the total of 118 patients available for assessment have required a major proximal amputation.

TABLE XXI

Follow up of patients with salvaged limb/below-knee stump (2-5 years)

	Group 1	Group 2	Total
Total patients entered	117	18	135
Lost to follow-up	12(11.2%)	5(27.7%)	17(12.6%)
Available for assessment	105	13	118
Major proximal amputation	3(2.9%)	0	3(2.5%)
Femoral-to-distal bypass	4(3.8%)*	0	4(3.8%)

* successful limb salvage

Total juxtarenal aortic occlusion

The acute morbidity in this cohort of patients was similar to that in the general morbidity. None of these patients developed renal failure. Two patients developed superficial wound sepsis, one in the groin and the other in the abdomen. Two patients developed graft occlusion. In one patient this followed embolisation which was successfully disobliterated. In the other, attempted disobliteration of the thrombosed segment was unsuccessful and was most likely due to inadequate distal "run-off". The patient eventually required a major amputation.

able XXII summarises the 6-60 month follow up of patients discharged with a patent aortic graft.

TABLE XXII

Follow-up of patients with aortic bypass for total aortic occlusion (6 months to 5 years)

	n	%
Total patients entered	39	
Lost to follow-up	9	
Available for assessment	30	
Graft occlusion	3	10
Graft sepsis	1*	3
Anastomotic aneurysm	1	3
Femoro-distal disease	2+	6.5

*Major amputation
+ 1 major amputation, 1 successful salvage

Of the 39 patients that were originally discharged with a patent aortic graft, 9 were lost to follow-up. There were no deaths during this period. Three patients developed unilateral graft occlusion due to progression of distal disease, but none of these required a major amputation. In one patient graft sepsis occurred which resulted in high bilateral above knee amputation. One patient developed an anastomotic aneurysm in the right groin which was successfully excised. Two patients developed progressive distal disease in the presence of a patent aortic graft. They were re-evaluated with a view to femoral-to-distal bypass. In one no further procedure was considered possible and a primary below-knee amputation was performed. In the other patient a femoral-to-distal bypass was successful.

Five year cumulative patency rates were calculated by life table analysis and are graphically depicted in figure 16. This shows a patency rate of 95% at 1 year and 78% at 5 years

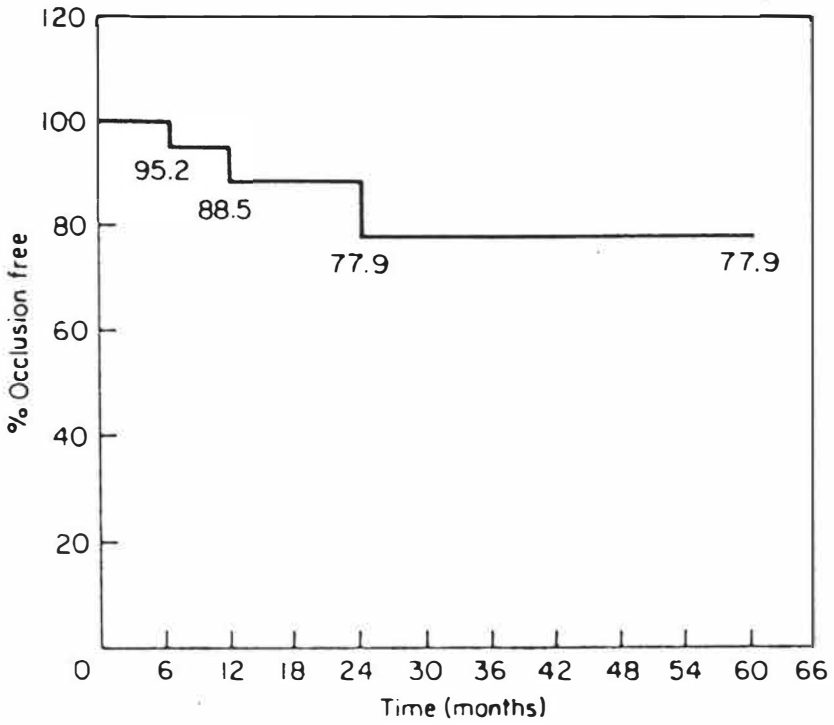

FIGURE 16:

Cumulative patency rates in patients with total aortic occlusion.

The occluded superficial femoral artery

Four hundred and ninety two patients were studied for assessment of the role of the profunda femoris as sole "run-off" in aortobifemoral bypass. As a routine the groins were explored first and the femoral artery and its branches assessed for the presence of disease (vide supra). The distal anastomoses are normally placed on the common femoral bifurcations but where the SFA was occluded it was laid onto the profunda femoris artery.

Ninety three patients were found at exploration to have occlusion of the SFA (19%). Of these, 30 had bilateral SFA occlusion and the other 63 had a unilateral SFA occlusion (Table XXIII)

TABLE XXIII

Distal "Run-off" in 492 patients

Group		No Patients	No Limbs	% Patients
I	SFA patent	399	798	81.1
IIa	SFA both occluded	30	60	6.3
IIb	SFA one occluded	63	126	13.4

The patients were divided into 2 groups. Group 1 comprised patients with a patent SFA, Group II comprised those with occluded SFA. Group II was further subdivided into group IIa with bilateral occlusion of the SFA, and group IIb with unilateral SFA occlusion. There were 399 (81%) patients in group 1, 30 in group IIa (6%) and 63 in group IIb (13%). There were 798 limbs with patent SFA in group I and 63 limbs in group IIb giving a total of 861 limbs with two-vessel "run-off". There were 60 limbs in group IIa with occluded SFA and 63 in group IIb giving a total of 123 limbs with one-vessel "run-off" (Table XXIV).

TABLE XXIV Distal "Run-off"	
	No. Limbs
Two vessel	861
One vessel	123

Table XXV shows the 6-60 month follow-up of patients following aortobifemoral bypass to assess the efficacy of one-vessel "run-off" (PF only)

TABLE XXV 6-60 Month follow up of patients following aortobifemoral bypass		
"Run-off"	**Total Limbs**	**No. Occluded**
Two Vessel	861	64 (7.4 %)
One Vessel	123	18 (14.6%)
{ p = 0.019 : Chi-squared method }		

Sixty four limbs among those with two-vessel "run-off" developed occlusion (7.8%). Eighteen limbs (14.6%) among those with one vessel "run-off" developed occlusion. This difference between the two groups was statistically significant ($x^2 = 0.019$ $p < 0.05$).

Table XXVI shows the number of patients who subsequently developed femoral-distal disease.

TABLE XXVI

Associated Femoral-to-Distal Disease

	Two-vessel "run-off"	**One-vessel "run-off"**
Total No.	27	4
Surgery with AFBG	2	1
Subsequent Surgery	22	3
Conservative	3	0

Among the two-vessel group there were 27 patients who were found to have femoral-to-distal disease. Two had femoro-popliteal bypass at the same time as aortobifemoral bypass. Twenty five developed the disease later and 22 of these had successful femoral-distal bypass and three were treated conservatively. There were four such patients among the one-vessel group. One had femoro-popliteal bypass at the time of aortobifemoral bypass. Three patients developed distal disease subsequently and all three were successfully treated surgically.

Table XXVII shows amputations that were performed because of failure of the aortobifemoral bypass in the two groups.

TABLE XXVII

Amputations due to Failure of Procedure

	n	%
Two vessel "run-off" (n=861)	14	1.7*
Profunda "Run-off" (n=123)	7	5.6+

* vs + p = 0.010 { Fischer's Exact Test }

These figures do not include amputations done pre-operatively because of spreading sepsis and revised subsequent to the bypass. Ther were more amputations in limbs with one vessel "run-off"

End-to-end versus end-to-side proximal aortic anastomosis.

All the patients in this study were used to evaluate the principle of using the disease status of the aorta to choose the type of proximal anastomosis.

Decision was made at operation using the criteria discussed above. Of the total of 492 patients, 166 had an end-to-end anastomosis performed and 326 had end-to-side anastomosis.

Table XXVIII shows early and late occlusion.

TABLE XXVIII

Occlusion Rates According to Proximal Anastomosis

	End-to-End	**End-to-Side**	**p value**
Early Occlusion (< 1 month)	0	6	
Late Occlusion (6-60 months)	9 (5.4%)	56 (17.2%)	0.0001

{ Chi-squared method }

As there were no early occlusions in the end-to-end group, statistics could not be calculated to assess statistical significance. The 5.4% late occlusion rate in the end-to-end group and the 17% in the end-to-side group were statistically significant. Four patients developed graft sepsis in the end-to-end group as opposed to nine patients in the end-to-side group. The rate of sepsis was not statistically significant between the two groups ($x^2 = 0.813 : p > 0.05$). The 5 year cumulative patency rates for end-to-end and end-to-side anastomosis are graphically

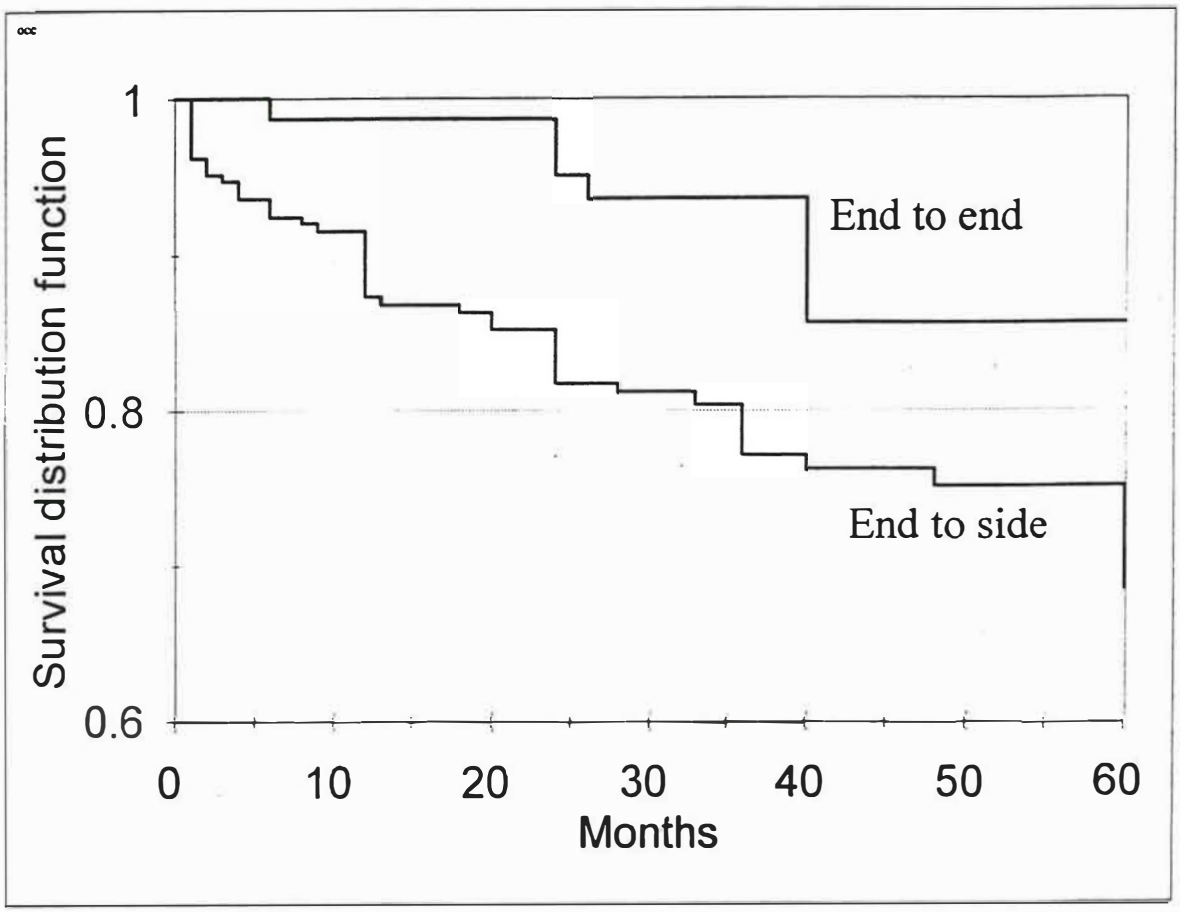

FIGURE 17:

Cumulative patency rates following AFBG in patients with end-to-end and end-to-side aortic anastomosis.

depicted in Figure 17. The 5 year patency rate for end-to-end anastomosis was 83% and that for end-to-side anastomosis was 78%. This difference was statistically significant.

The patients were then stratified according to whether there was single vessel "run-off" (Profunda only) or two vessel "run-off" (Profunda and SFA) and the occlusion rates were again assessed. The patients in each group (end-to-end and end-to-side) were divided into two groups namely, group I and group II. Group I comprised patients with patent SFA's and group II consisted of patients with occluded SFA's. Group II was further subdivided into group IIa (patients with the SFA occluded on both sides) and group IIb (patients with SFA occluded on one side only).

One hundred and thirty patients in the end-to-end group and 269 in the end-to-side group fell into group I. Eleven patients in the end-to-end group and 19 in the end-to-side group fell into group IIa and 25 patients in the end-to-end group and 38 in the end-to-side group fell into group IIb (Table XXIX).

TABLE XXIX

Distal "Run-off" According to type of Proximal Anastomosis

Group		End-to-end		End-to-side	
		Patients	**Limbs**	**Patients**	**Limbs**
I	SFA patent	130(78%)	260	269(83%)	538
IIa	SFA both occluded	11(7%)	22	19(6%)	38
IIb	SFA one occluded	25(15%)	50	38(12%)	76

Thus there were 285 limbs with two vessel "run-off" in the end-to-end group and 576 in the end-to-side group and there were 47 limbs with one vessel "run-off" in the end-to-end group and 76 in the end-to-side group (Table XXX).

TABLE XXX

Influence of Distal "Run-off" on Occlusion rate

"Run-off"	End-to-end		End-to-side	
	Total Limbs	**Occluded**	**Total Limbs**	**Occluded**
Two - vessel	285	8(3%)*	576	54(9%)+
One - vessel	47	1(2%)@	76	17(30%)$

* vs @ p = NS ; * vs + p = 0.0001

@ vs $ p = 0.001 ; + vs $ p = 0.0001 { Chi-squared method }

In the end-to-end group there was no difference in the rate of occlusion between two-vessel "run-off" and one-vessel "run-off". In the end-to-side group the difference in occlusion between two-vessel "run-off" and one-vessel "run-off" was statistically significant. As far as two-vessel "run-off" was concerned there was significant difference in occlusion between end-to-end and end-to-side in favour of end-to-end proximal anastomosis; and as far as one-vessel "run-off" was concerned there was also significant difference between end-to-end and end-to-side in favour of end-to-end proximal anastomosis. Thus this means that there were more graft occlusions in the end-to-side group and,in this latter group, there were more graft occlusions in the patients with one-vessel "run-off" than those with two-vessel "run-off".

DISCUSSION

This is a prospective study of 492 patients who underwent aortobifemoral bypass over an eight year period on the Vascular Service of the University of Natal. It has been possible from this study to make certain conclusions and recommendations.

This study shows that all population groups in Durban are affected by aorto-iliac atherosclerosis alike. Blacks tend to be younger. The highest male to female ratio was among Blacks whereas that among Whites was lowest. There was a male preponderance of 5.3:1. This male preponderance has been shown by previous studies from this institution[12,15] and by others[4,16,17]. The average age was 57.3 years which falls within that reported in other series[16,17,39-41].

The majority of the patients presented with claudication and the second most common presentation was necrosis. More black patients presented with necrosis than Whites and Indians and this picture was also shown by Robbs[10] and Reddy et al[11]. It is our experience that many Black patients present at an advanced stage in the natural history of the disease most probably due to socio-economic factors including transport from home to hospital, fear of losing a job, possibly ignorance and stoicism. We believe this is the explanation for a high rate of necrosis in this group rather than the aggressiveness of disease. Many Black patients also had a threatened limb at the time of surgery compared to their Indian and White counterparts who present mainly with claudication.

It is notable that hypertension was the most common risk factor in this study. Although present, ischaemic heart disease and diabetes were less frequently seen. This trend has been

shown by others[42]. Although the majority of patients were smokers (95%), only one patient had polycythaemia. An interesting finding was the variable differences in terms of operative risk among the groups. Hypertension was the most common risk factor in all groups and it was commonest among Whites. Ischaemic heart disease was also commonest among Whites and was not seen among Blacks in this study. Seftel[43] has reported on the rarity of ischaemic heart disease in South African Blacks and the results of the present study supports this. Why the disease affects coronary vessels less frequently in Blacks remains enigmatic. In the study by Robbs[10] blood lipid profiles were done and the blood levels of triglyceride, cholesterol and high density lipoproteins were low in Blacks. The significance of this, however, was not apparent in that paper as very few patients were studied. Robbs[10] also showed that a higher incidence of arteritis was noted in Blacks and that there was less aneurysmal disease among Blacks.

Diabetes accelerates the progression of atherosclerosis[2] and it is associated with neuropathy which increases the risk of unrecognised foot trauma and infections which may in turn lead to necrotising fasciitis, septic gangrene and major amputations[2]. Grossly and microscopically, the atherosclerotic process in diabetics is similar to that seen in non-diabetic patients with advanced atherosclerosis[2]. In the diabetic, however, it is more widespread and rapidly progressive[2,44-46]. Diabetes mellitus was commonest among Indians in this study. The difference in prevalence of risk factors was also highlighted in the papers by Robbs[10] and Reddy et al[11]. In the former paper it was also apparent that diabetes was common among Indians. The clinical picture was similar in both diabetics and non-diabetics.

Where total risk is considered it is interesting to note that such risk is lower among Blacks and is equal in Indians and Whites. This is probably related to the higher incidence of risk factors among the latter two groups such as diabetes in Indians and ischaemic heart disease in Whites.

There was a mortality rate of 5%. This is high and most patients died as a result of myocardial infarction. A likely reason is that most of these patients were inadequately investigated with regard to cardiac risk owing to the urgency of limb revascularisation which were often done on a semi-emergency basis, and also the inability to perform treadmill stress testing in view of limb pain. In more recent times thallium-persantin perfusion scans have improved this assessment[47]. We have adopted the cardiac risk index as described by Goldman[35] to predict operative risk, and this index has been demonstrated by local studies[34,36] that it is reliable in predicting operative risk in our own practice.The mortality rate reported in different series ranges between 2 and 9%[1,17,19,40,48].

In keeping with the significantly higher incidence of ischaemic heart disease in these population groups, the main cause of postoperative mortality in Whites and Indians was myocardial infarction, which was never encountered in Blacks. Admittedly more patients died in this group and the highest mortality of 8.5% was among Whites.

The 5 year patency was 86% which is in keeping with the reported patency rates in the literature which range from 75 to 95%[1,10,12,15,49]. It is interesting to note that the occlusion rate was lowest among Whites and the patency rate was thus higher in this group while the opposite applied to Blacks.

Major reservations have been expressed in respect of placing prosthetic aortic grafts in the presence of septic extremity lesions. The major consideration under these circumstances was the possibility of graft infection due to pre-existing infection in groin lymph nodes. In a previous study[19], we clearly demonstrated that the infected extremity lesion does not influence the incidence of wound or graft sepsis in these patients. In the present study graft sepsis occurred in only 2.6% of patients throughout the whole period. The reported incidence of aortic graft sepsis ranges between 0.25% and 6%[49]. The wound sepsis that occurred in a larger number of patients (3.9%) was superficial and confined to the abdominal and groin wounds.

The more advanced stage of disease did not adversely influence graft occlusion or sepsis rate in Black patients compared to the other groups. Both mortality and graft occlusion rates were higher among diabetics but these differences did not reach statistical significance. The reason for the higher mortality in the diabetic group is difficult to explain. It is of interest that none of the diabetic patients developed graft sepsis.

The role of gender in the aetio-pathogenesis of atherosclerosis has been extensively evaluated among the causes associated with atherosclerotic disease but there are no papers in the literature that are dedicated to the influence of gender on the outcome of aortic bypass. As was noted in previous studies[4,16,17] there is a male preponderance. A greater proportion of graft occlusions occurred among males when compared to their female counterparts although this did not reach statistical significance. Most of the occlusions were due to poor "run-off" and this trend may suggest a more aggressive disease process among males for reasons which are obscure.

The spectrum of pathology in young patients with chronic arterial occlusive disease include Buerger's disease (thromboangiitis obliterans), atherosclerosis, coarctation of the aorta, fibromuscular dysplasia, radiation fibrosis of the aorta and arteritis. Popliteal entrapment syndrome should also be considered. This study was prompted by the impression that a greater proportion of younger patients were found to suffer from chronic arterial occlusion compared to other series. It is also of interest to ascertain whether the disease was more aggressive in younger patients. An age of 40 years was taken as a cut-of in this study simply for ease of reference as other authors have used the same cut-off[18].

Atherosclerotic occlusive disease in patients under the age of 40 years is distinctly uncommon[18]. DeBakey et al[50] reported an incidence of 1.4%. Other authors have reported a similar trend[50,51]. Forty patients in this study (8%) were younger than 40 years and the occlusion rate following the procedure of aortobifemoral bypass was higher in those under 40 years of age. This, however, did not reach statistical significance and the 5 year patency rate was higher among the older age group. Previous studies of the virulence of atherosclerosis[18,50-53] have found the disease to be rapidly progressive among young adults and the trend in this study tends to support this view.

This study shows that aortobifemoral bypass graft performed in the face of critical ischaemia in patients with aorto-iliac occlusive disease will result in limb or below-knee stump salvage in the majority, with an acceptable mortality and morbidity. In our practice a large proportion of the patients come from the lower socio-economic group and hence tend to present late when critical ischaemia mandates medical attention[10]. Desai et al[13] and Robbs et al[54] from this institution have shown that 25% more patients are ambulant on a below-knee prosthesis

when compared to their above-knee counterparts at any given interval after amputation. This occurs in spite of an active amputee rehabilitation programme through the Amputee Rehabilitation Clinic and serves to emphasize the importance of preserving the knee from the point of view of ambulation on a prosthesis.

With regard to stump salvage, it is difficult to ascertain whether healing would have occurred in any event if primary amputation had been performed. Clinical assessments, such as skin temperature, the amount of bleeding from flaps or muscle at the time of surgery, popliteal pulse status, and investigations such as angiography and doppler studies are unreliable[54]. We have, however, found the appearance of the transected guillotine stump in terms of the generation of healthy granulation tissue to be of value[13]. More recently, transcutaneous oxygen tension measurements at the level of amputation are being increasingly employed in our practice as a predictor of healing[55,56] and, in future studies, we hope to use this to provide more objective data.

In keeping with the general pattern, failure to achieve limb salvage within the first month of operation was largely due to inadequate distal arterial patency[11,57,58] and in only three patients did technical failure contribute to graft occlusion. In 6 of the 8 patients in group 1 who required major amputation due to spreading foot gangrene, the aortic graft remained patent due to profunda femoris "run-off", and it may be postulated that healing would not have occurred at this level if the bypass had not been performed, which improves the salvage rate still further. In the longer term, seven of the patients available for follow-up (6.6%) with limb or stump salvage developed a new episode of critical ischaemia due to progressive distal disease, in the face of a patent aortobifemoral graft, and in 4 of these limb salvage was

possible by means of femoral-to-distal bypass. The major problem with regard to the long term assessment is the 12% of patients lost to follow up. However among the remaining 118 patients, 97% retained the use of the salvaged limb or below-knee stump.

The prevalence of complete aortic occlusion in our practice is 8,5%, a figure which is higher than that previously reported in earlier studies[27,28]. The present study suggests that aortobifemoral bypass graft is feasible in most, if not all, patients who are found to have complete occlusion of the juxtarenal aorta on preoperative angiography. Black patients predominated in this subgroup, although caucasians represented a proportionately larger number of patients (38%) submitted to aortobifemoral bypass during the study period. The reason for this is difficult to establish.

In all patients in this subgroup, the primary site of occlusion was found in the segment of the aorta below the inferior mesenteric artery, with thrombosis of the segment of aorta above this level. The findings in this part of the study are in agreement with those of Deriu and Ballotta[59]. Furthermore, these patients have a chronic atherosclerotic process of insidious progression with a superimposed thrombosis, thus allowing collateral circulation to develop. It is of interest that only six (15.4%) of these patients had a history of impotence.

Angiographic assessment of "run-off" is difficult in patients with total aortic occlusion particularly if the intravenous technique is used, due to slow blood flow. We feel that it is preferable to explore the groins and, if necessary, use intra-operative angiography than to resort to high translumbar aortography, which usually result in extensive retroperitoneal haematoma in the operative field.

Our experience differs from that of Liddicoat et al[60] in that we have found thrombectomy of the aorta and renal orifices under direct vision very helpful, as the thrombus may sometimes be very adherent and not adequately cleared by milking between fingers. In addition, we have had previous experience of embolisation into the renal arteries during juxtarenal aneurysm resection with consequent renal infarction following manipulation in this area. It is not known how frequently silent embolisation into a single renal artery may occur following blind manipulation, as it is certainly not reported in published series whether postoperative renal imaging by isotope scan or angiography is performed as a routine.

The technique of juxtarenal anastomosis reported in this series is a modification of that described by Wylie et al[29]. The average clamp time is no longer than that utilising their technique and obviates the need for an additional suture line. The same technique of aortic anastomosis reported in this series has been previously described and we have found this satisfactory whenever manipulation in this area is necessary, as for example when dealing with juxtarenal aneurysm[61]. No patients in this series developed postoperative renal failure and this compares favourably with the previously reported incidence which ranges from 0-25%.[27,28,59,60] As a routine, when performing aortobifemoral bypass in our practice, whether end-to-end or end-to-side aortic anastomosis is performed, the graft is placed in the segment of aorta immediately below the renal vessels, in view of the well demonstrated progression of the atherosclerotic process in the lower aorta[28,57].

The peri-operative mortality of 4.8% in this cohort of patients is comparable with that in previous series[28,57] where aorto-iliac disease was being considered in general. Furthermore,

the procedure was associated with minimal complications in this series and these results are very favourable compared to others which discuss complete juxtarenal aortic occlusion[28,49].

Five year patency rates in previous studies on aortobifemoral bypass range from 75-95%[1]. Similarly, in an earlier study from our service which compared patency rates in the different racial groups, a figure of 86% was reported over a 36 month period[11] and more recently a 5 year study showed a 93% patency[12]. The 5 year patency rate in the present series was 78%. Although three patients developed graft occlusion in the follow-up period, none of these required major amputation.

A significant proportion of our patients (18.9%) had an occluded superficial femoral artery and the sole "run-off" was the profunda femoris artery. The importance of the deep femoral artery (profunda femoris) as a collateral channel supplying the entire limb in cases of SFA occlusive disease was first reported in 1961 reported by Morris et al[62].

Simultaneous aorto-iliac and SFA occlusive disease has been the main indication for restoring flow by way of the deep femoral artery. There is general agreement that, in occlusions of the superficial femoral artery, the profunda femoris artery is capable of taking over the function of the main channel supplying the muscles of, not only the thigh, but, in addition, the leg and foot of the affected extremity[31]. The literature is scant, however, regarding the efficacy of the profunda femoris artery in clinical practice. Except for its first centimetre, the profunda femoris artery remains surprisingly free of atherosclerotic involvement long after the main arterial channels of the lower extremity have been occluded[21,63-65] and collateral circulation is well developed particularly in cases of chronic occlusion of the SFA[65].

The distal anastomoses in our practice are routinely placed at the common femoral bifurcations. If the superficial femoral artery is occluded, the graft is laid onto the profunda femoris artery. The profunda orifice is carefully inspected and any stenotic lesion dealt with by orifice endarterectomy with or without distal profundoplasty.

Progressive atherosclerosis is an important factor in recurrent lower limb ischaemia[57] and it is thus important that "run-off" should be adequate. Brewster and Darling[39] concluded that a major contributing factor to the improved graft patency rates, in their series, was the routine placement of the distal anastomoses across the profunda origin as a patch angioplasty whenever significant occlusive disease was noted in the superficial femoral artery.

Waibel and Wolfe[31] in Switzerland showed in their experimental study that the profunda femoris artery is the main collateral circulation in occlusions of the superficial femoral artery. They demonstrated angiographically that the diameter of the profunda corresponds to that of a normal superficial artery under these circumstances. Malone et al[40] and, more recently, Charlesworth[66] have further emphasised the importance of profunda reconstruction in maintaining graft patency. Furthermore the importance of the profunda femoris artery as an important collateral to the lower extremity has been described by others[47,62-64,67]

The operative technique in revascularising the deep femoral artery depends on the state of the profunda and the extent of the patient's occlusive disease[65]. Kärkölä et al[65] and Martin et al[68] suggest that, if the PF is patent, the end of the graft can be placed on the common femoral artery. In our unit we place the graft only on the origin of the profunda if the SFA is occluded.

There were more graft occlusions in patients with profunda "run-off" compared to those with a patent SFA (15% vs 7%) and there were significantly more amputations due to failure in limbs with one vessel "run-off".

This study demonstrates that the profunda artery is adequate for "run-off" although the rate of graft occlusion was significantly higher in the limbs with one-vessel (profunda only) than that observed in those with two-vessel"run-off" (PF and SFA). Previous studies have shown occlusion rates of between 8% and 10%[10,15]. The occlusion rate was higher in the group of patients with profunda "run-off". We feel that the practice of using the PF as a sole "runoff" in cases of superficial femoral artery occlusion should be continued and that any occlusion at the orifice of the PF should be disobliterated in order to reach the patent distal vessels although further studies are indicated to assess the efficacy of the profunda femoris artery as sole "run-off".

The preferred method of proximal aortic anastomosis in aortobifemoral bypass for aorto-iliac occlusive disease remains controversial. This study analyzed the results of consecutive series of end-to-end anastomosis and end-to-side anastomosis to determine the median term patency.

The decision to perform an end-to-end or end-to-side anastomosis was governed by the appearance of the aortic segment. We believe that the segment of the aorta that is diseased should be transected and occluded. This avoids the embolisation of the debris down to the distal end of the extremity. It has been our belief that, if the aorta is free of disease, either

anastomosis would suffice but certainly the end-to-side anastomosis takes less time and is easier to perform.

Early occlusion did not occur in the end-to-end group while it occurred in six in the end-to-side group. Statistical analysis could not be performed in these figures.

The late occlusion rate in the end-to-side group was significantly higher than in the end-to-end group but the sepsis rate was not significantly different. The overall 5 year patency rate was significantly higher in the end-to-end group. Distal "run-off" did not influence the rate of occlusion in patients with end-to-end anastomosis but,in those with end-to-side anastomoses, there were more occlusions in patients with one vessel "run-off". Whether the patients had one vessel "run-off" or two vessel "run-off" there were more occlusions in patients with end-to-side anastomosis.

Earlier studies[39.69] reported higher patency rates for the end-to-end anastomosis. However, Melliere et al[32] and Ameli and colleagues[33] have not found any difference in the two anastomoses. In these studies there were no clear indications for either anastomosis. In the former series, the study was retrospective and it is not clear what criteria were used to decide on the proximal anastomosis. In the latter study there was bias for end-to-end anastomosis to be done for aneurysm and the end-to-side was done for occlusive disease. It is also noteworthy that in these studies no mention was made as to where along the aorta the proximal anastomosis was placed. Ameli and associates[33] suggest that there is discrepancy regarding patency in the early and more recent reports, and we support their belief that this

discrepancy is probably the result of more careful selection. Our criteria for selecting the proximal aortic anastomosis are clearly defined.

In his classic paper comparing end-to-end and end-to-side anastomosis Gaylis[5] concluded that the end-to-end anastomosis appeared to be preferable. He demonstrated kinking that may occur in an end-to-side graft. It appears from the present study that the outcome is more favourable with the end-to-end anastomosis.

Conclusions

1. Aorto-iliac occlusive disease affects all population groups alike in Durban and the points of difference are the high operative risk among Whites and Indians, the high mortality rate due to myocardial infarction among Whites, the high incidence of advanced disease among Blacks and the high occlusion rate among Blacks.

2. Although diabetes is associated with widespread and accelerated atherosclerotic disease, it does not affect the outcome of aortic reconstruction nor does it predispose to graft sepsis.

3. It would appear that atherosclerotic disease shows a more aggressive trend in male patients compared to their female counterparts although this did not reach statistical significance.

4. There is a trend towards a more aggressive disease in young patients compared to the older age group.

5. This study has shown that aortobifemoral bypass performed in the face of critical ischaemia in patients with aorto-iliac occlusive disease will result in limb or below-knee stump salvage in the majority of patients. We feel that these results warrant the continued practice of aortobifemoral bypass for limb or stump salvage since this can be performed with an acceptable mortality, morbidity and limb salvage rate in our hands.

6. Angiographic evidence of total aortic occlusion with poor filling of groin vessels does not preclude aortobifemoral bypass. The assessment of "run-off" in the groins should be made operatively prior to embarking upon bypass. The results of aortobifemoral bypass in this subset of patients are excellent in both short - and medium - term.

7. The profunda femoris artery can be used as sole"run-off" although the rate of occlusion is higher in this group of patients compared to their counterparts with two-vessel "run-off". Further studies are required to assess the efficacy of the profunda femoris artery as sole "run-off".

8. This study has also shown that end-to-end proximal aortic anastomosis yields significantly more favourable results when compared to the end-to-side anastomosis. It would appear therefore that the end-to-end proximal aortic anastomosis should be the anastomosis of choice for aortobifemoral bypass.

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