THE USE AND FATE OF LONG PROSTHETIC BYPASS GRAFTS OF THE AORTA

By P. K. Sen

Long prosthetic bypass operations have been utilized for peripheral arterial disease, particularly in the lower limbs, for many years with considerable success (Crawford, DeBakey 1955). The behaviour of such grafts in these locations is well documented and well known (DeBakey et al 1964). However the use of such long prosthetic bypasses in the aorta has been limited and their long term behaviour and results have not been as well or widely studied. This is mainly because of the limited indication for the placement of such long aortic bypasses. Our experience in the management of non-specific stenosing aortitis has provided a rare opportunity for studying the behaviour of such long prosthetic bypass grafts and this communication deals with the observations made by us over a period of 18 years.

The essential pathology of non-specific stenosing aortitis with its accompanying peri-aortitis, dense adhesions and low rupture rate has made aortic prosthetic bypass surgery the surgical management of choice, excisional surgery being both difficult and hazardous. (Thromboendartectomy has also been tried but with poor results). A total of 22 long aortic prosthetic bypasses have been carried out by us with gratifying long term results in many instances.

The presence of impaired flow is the main indication for such surgery, as also is the demonstration of a significant pressure gradient. Most bypasses fall within the conventional types of accepted practice, but certain parameters govern the placement of such grafts. It is most essential that the grafts must be anastomosed to healthy vessels on either side and at a reasonable distance from the affected area. The disease is progressive in nature and graft failures are inevitable if they are sutured to unhealthy vessel walls. Dissection in and around the affected portion (except for the purpose of biopsy or the occasional angioplasty) is not recommended, as the adhesions are often extensive, plastic, and bind down the accompanying venae cavae, other veins, lumphatics and nodes.

Long aortic dacron bypass procedures, using vessels which are comp'etely uninvolved by disease for attachment of the graft, give the best results, and the three types more commonly employed by us are: Thoraco-Thoracic, the Posterior Thoraco-Abdominal ('dorsal' aorta), and the Anterior Thoraco-Abdominal ('ventral' aorta) bypasses.

Thoraco-Thoracic Bypass

This is the best tolerated and has the lowest morbidity rate of these 'long bypass' procedures. In supra-diaphragmatic stenotic disease, if sufficient healthy aorta be'ow the lesion is available above the diaphragm, this would be the operation of choice. (Figs. 1a, 1b). The involvement of the left subclavian artery is indirect evidence of disease in the supra-isthmial region of the descending thoracic aorta, and in such instances one should be very careful during the exploratory thoracotomy and ascertain the quality of the aorta above the obvious lesion. It is best to do the difficult proximal anastomosis—end to side—with an obliquely woven dacron graft, first. The pressures in the aorta above the obstruction are often very high and lateral clamping is difficult. Halothane anaesthesia helps, as also does judicious employment of Arfonad, though in this disease Arfonad does not act as efficiently as it should, particularly in those with involvement of the splanchnic vessels. If needed, cross clamping of a segment of aorta for the end to side anastomosis may be required for a short while and is generally free from risk. Periaortic dissection is always tricky because of matting of tissues, Intercoastal vessels, however, do not cause much trouble for they are often sealed off, and never aneurysmal such as are seen with congenital coarctation in older patients.

The approach is usually through a single postero-lateral thoracotomy, usually through the 5th or 6th rib bed. (Sen et al, 1962). Separate thoracotomies, or resection of the angle of the ribs ('shingling') may be employed to facilitate suturing of the grafts. The thoraco-thoracic bypass is ideal for children, and 3 of our cases now followed for 10, 10, and 4 years have proved that full skeletal growth is possible without compromising the graft, and is well tolerated in the adolescent years of strenuous physical activity (Table I). The graft tends to curve more and lie laterally, at first, but with growth, straightens up considerably and occupies the posterior paravertebral gutter.

TABLE I

RESULTS OF AORTIC BYPASS GRAFTS SURVIVALS: 13 PATIENTS

Patient		Type of bypass	Duration
L.P.	F/8	Thoraco-thoracic	4 years
V.K.	M/8	Thoraco-thoracic	10 years
M.R.	F/5	Thoraco-thoracic	10 years
I.N.	F/29	Thoraco-abdominal Dorsal	10 years
L.C.P.	F/24	Thoraco-abdominal Dorsal	7 years
S.K.	F/18	Thoraco-abdominal Dorsal	6 years
P.N.	F/40	Thoraco-abdominal Dorsal	5 years
S.G.	F/21	Thoraco-abdominal Dorsal	3 years
R.S.	F/12	Thoraco-abdominal Dorsal	6 months
T.R.	M/32	Thoraco-abdominal Ventral	10 years
V.D.	M/17	Thoraco-abdominal Ventral	8 years
I.A.K.	M/28	Thoraco-abdominal Ventral	4 years
M.K.	F/22	Thoraco-abdominal Ventral	1 month

Posterior Thoraco-Abdominal Bypass ('dorsal' aorta)

This is employed in patients with supra and/or infra-diaphragmatic, single or multiple, constrictive lesions of the descending aorta. Side grafts for vascularising branches such as the renal or superior mesenteric may also be needed. The procedure is more traumatic than the purely thoraco-thoracic graft and needs an extensive thoraco-abdominal approach.

Two separate incisions—thoracic and abdominal—without dividing the costal margin, may also be employed and perhaps better tolerated, though a single, oblique, long thoraco-abdominal incision dividing the costal cartilages has proved to be an extremely useful approach, providing excellent exposure. Placement of the graft in the left posterior thoracic gutter intrapleurally poses no problems, but within the abdomen the graft should not be allowed to lie free within the peritoneal cavity. Adhesions occur early and may give rise to intestinal obstruction, erosion of the viscera, or fistulation. The entire abdominal portion of the graft is, therefore, placed retroperitoneally, or as much of it as possible. The spleen is best removed to accomplish this. But more importantly, care should be taken to see that the graft does not directly form a part of the stomach bed. If it does, it should be well wrapped with a free graft of the greater omentum.

The posterior thoraco-abdominal (artificial 'dorsal' aorta) graft is not difficult to place in this manner and

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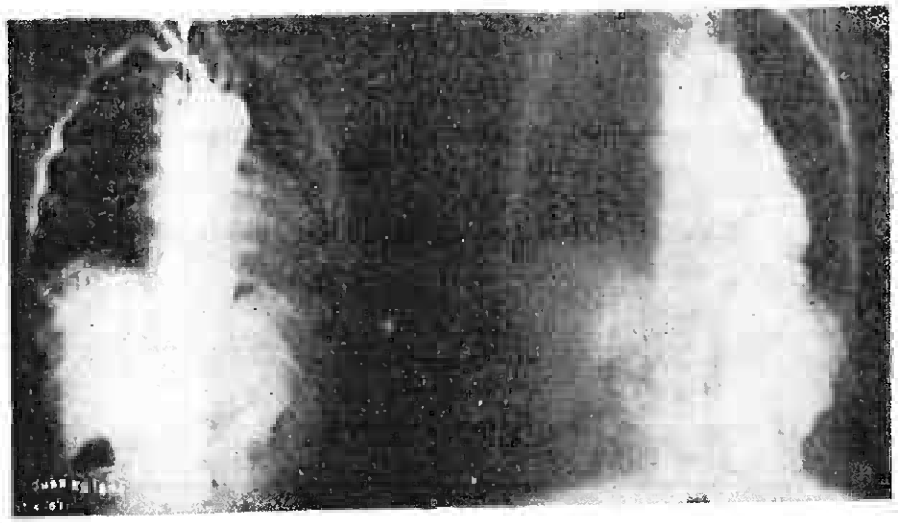
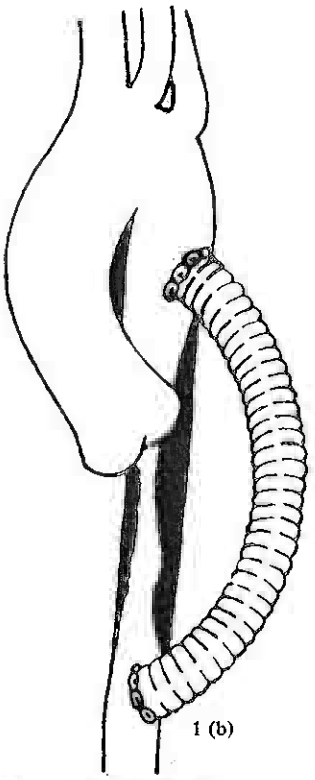
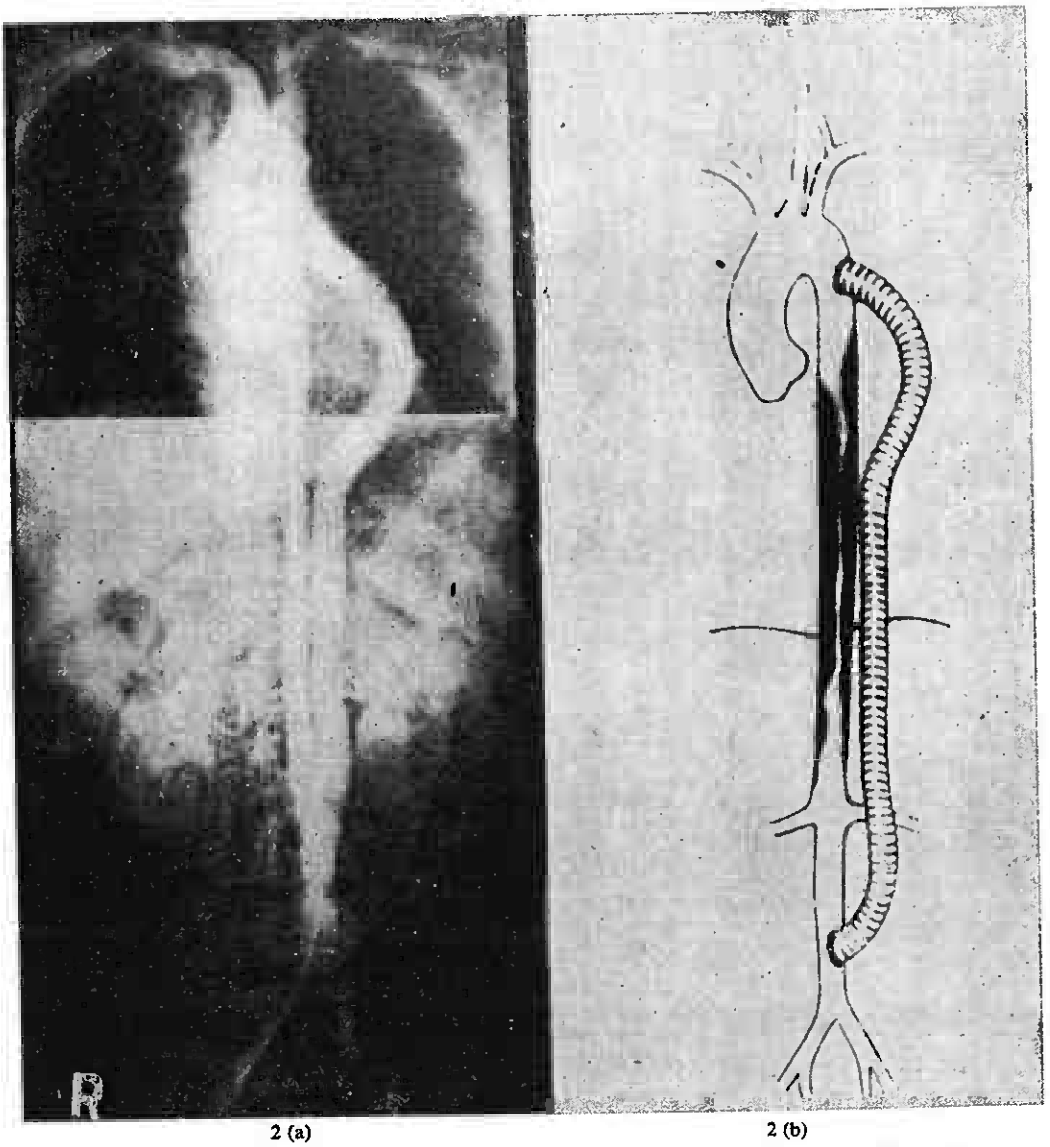


1 (a)



1 (b)

Figs. 1(a), 1(b). Pre and post-operative (6 months) aortogram of Thoraco-Thoracic bypass. Note the decrease in the size of the ascending aorta following relief of hypertension.



2 (a) 2 (b)

Figs. 2(a), 2(b). Posterior thoraco-abdominal bypass ('dorsal' aorta). Composite post-operative angiogram 1½ years after surgery.

long term results have been rewarding. (Figs. 2a, b) Not infrequently, however, extensive disease, involving the descending part of the arch, makes this procedure impossible and therefore, one has to take recourse to the anterior thoraco-abdominal aorto-aortic 'posterior' bypass graft is somehow thempting in such a situation and has been reported by Basu in one of his cases (Basu, 1961). It must be pointed out here that the left subclavian artery gets involved in a large number of these cases sooner or later, and therefore, in such extensive disease, it is best in our opinion, to employ the artificial 'ventral' aorta.

Anterior Thoraco-Abdominal Bypass ('ventral' aorta)

A long midline incision (Fig. 3) is made from the pubis to the suprasternal notch. The abdominal component is usually made first. (Sen et al 1962, 1963). The abdomen explored, the ligament of Treitz divided, the healthy area of abdominal aorta exposed and cleared in order to receive the graft, the feasibility of other collateral vascularisation of any obstructed aortic branches is next decided upon. The thoracic component is then added, extending the incision upwards and splitting the sternum. The pericardium is widely opened longitudinally and the intrapericardial portion of the ascending aorta dissected for the purpose of putting a lateral partial-occlusion clamp. The anastomoses are made, end to side, and a size larger than 12 mm woven dacron graft is not usually recommended. For one thing, a larger graft may compromise cerebral blood supply by draining blood away to the splanchnic pool, and also, the retrosternal, pericardial, and retroperitoneal spaces adapt themselves better to a smaller graft. A larger graft does not seem to be necessary in order to obtain adequate haemodynamic results. The abdominal placement of the graft is most crucial. (Figs. 4a, b, c). The portion which traverses the lesser sac of the peritoneum—the omental bursa—should be either placed behind the posterior peritoneum or tacked down securely, well covered by free omental graft. Any direct contact with the stomach is dangerous, particularly at the lesser curvature of the organ. Erosion of the stomach was caused by the graft at this site in two of our cases with fatal outcome.

Splenectomy, and carrying the graft out through the posterior part of the diaphragm near the aortic orifice enables it to be placed in the retroperitoneum more easily. If need be, the descending colon can be mobilised for the retroperitoneal placement. The graft is then brought medially in for anastomosis to the aorta, above the bifurcation. Additional side grafts may be used for vascularising branches of the aorta. A long Y bifurcation graft can be employed for vascularising the iliac arteries directly, for complete blocks of the abdominal aorta (Fig. 5). A frequent and often troublesome accompaniment encountered during operation is lymphorrhoea and can, on occasion, be dangerously excessive, needing drainage. These long grafting procedures are time consuming but often surprisingly well tolerated. Care taken to control and replace blood and fluid loss during such prolonged procedures is essential to success.

Whenever possible, a 'dorsal' aortic bypass is preferred by us. Creation of a 'ventral' aorta, though unavoidable on several occasions, has been attended with greater morbidity (Table II). Any infection of a midline sternotomy incision overlying the graft poses yet another hazard. However, many of these operations have been very successful (Table I), and with greater experience and modification of technique, the procedure, heroic though it may seem, might be equally tolerated and be as free of complications as other long aortic bypasses. Technically, the 'ventral' aortic bypass is often easier to perform than the 'dorsal'.

These patients with well functioning grafts, are generally doing well, growing and leading a normal life and requiring little medication, except one patient T.R., a male of 32 years. He had developed intestinal obstruction in the immediate postoperative period requiring exploration, division of adhesions and retroperitonealisation of the graft. Over the last 10 years the disease has progressed, involving the superior mesenteric artery and now he has symptoms of abdominal angina.

TABLE II

RESULTS OF AORTIC BYPASS GRAFTS
DEATHS: 9 PATIENTS

Patient	Type	Survival Time	Complication	Cause of Death
S.H. M/19	Aortic Thoraco-Thoracic	1 hour	Haemorrhage from graft (nylon)	Shock
D.R. F/19	Thoraco-Abdominal Dorsal	2 hours	Massive generalised haemorrhage	Haemorrhage & irreversible shock—capillary failure
J.S. F/18	,,	20 days	Secondary haemorrhage from anastomosis	Septicaemia and shock
M.G. F/6½	,,	8 hours	Left ventricular failure	Heart failure
S.S F/32	Thoraco-Abdominal Ventral	1 month	Severe peritonitis	Burst abdomen & septicaemia
R.B. M/26	,,	1 year	False aneurysm at proximal anastomosis rupturing through (R) lung into pleura	Haemothorax and shock
G.D. F/10	,,	8 months	Erosion of stomach by graft, gastric fistula through median sternotomy with osteomylitis of sternum	Massive secondary haemorrhage from aorta near proximal anastomosis
R.C. M/18	,,	3 years	Erosion of stomach by graft. Gastric haemorrhage	Massive gastric bleeding and shock
A.D. F/16	,,	6 hours	Left ventricular failure	Heart failure

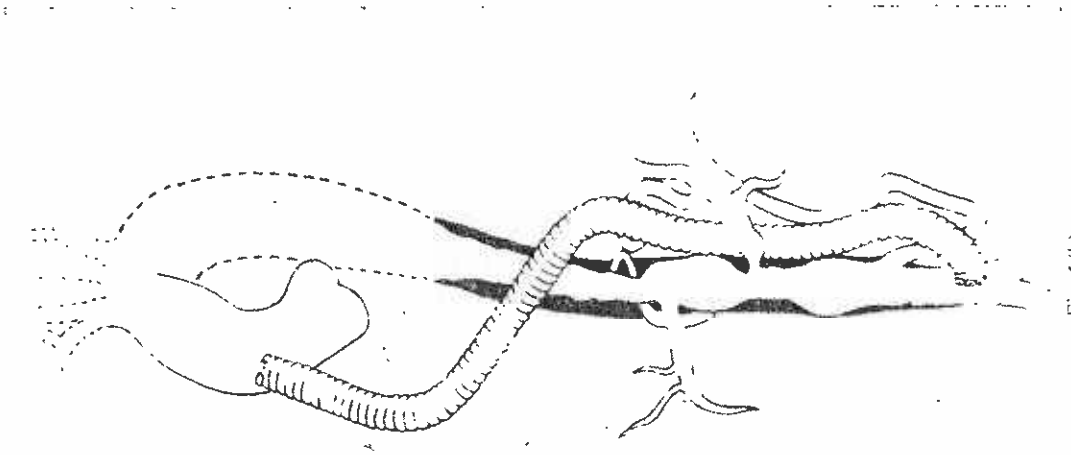


Fig. 4 (b)

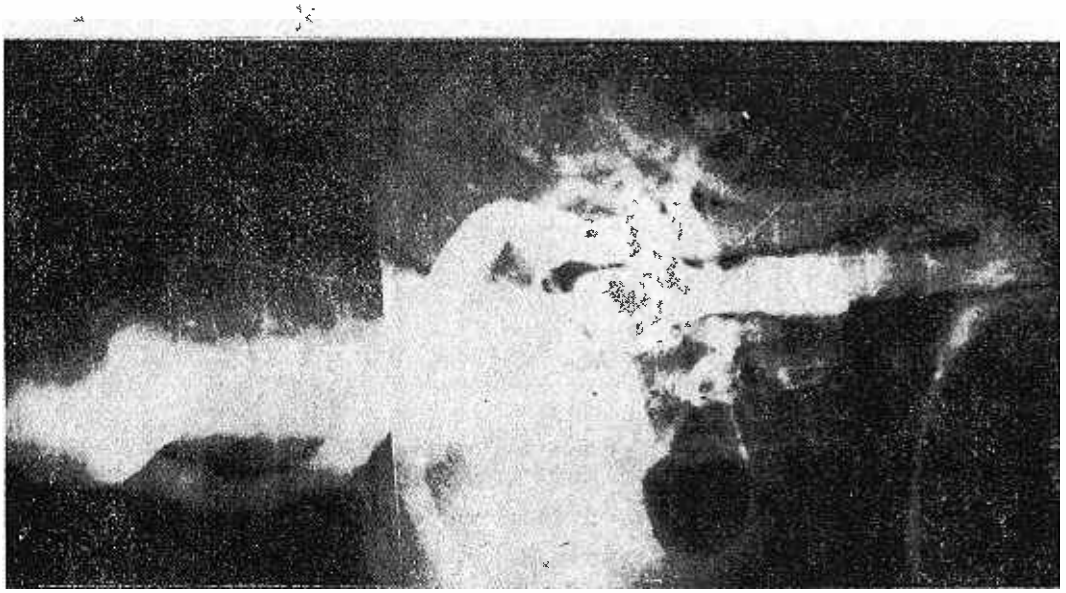


Fig. 4 (a)

Figs. 4(a), 4(b). Anterior Thoraco-abdominal bypass('ventral' aorta). Composite aortogram 3 months after surgery.

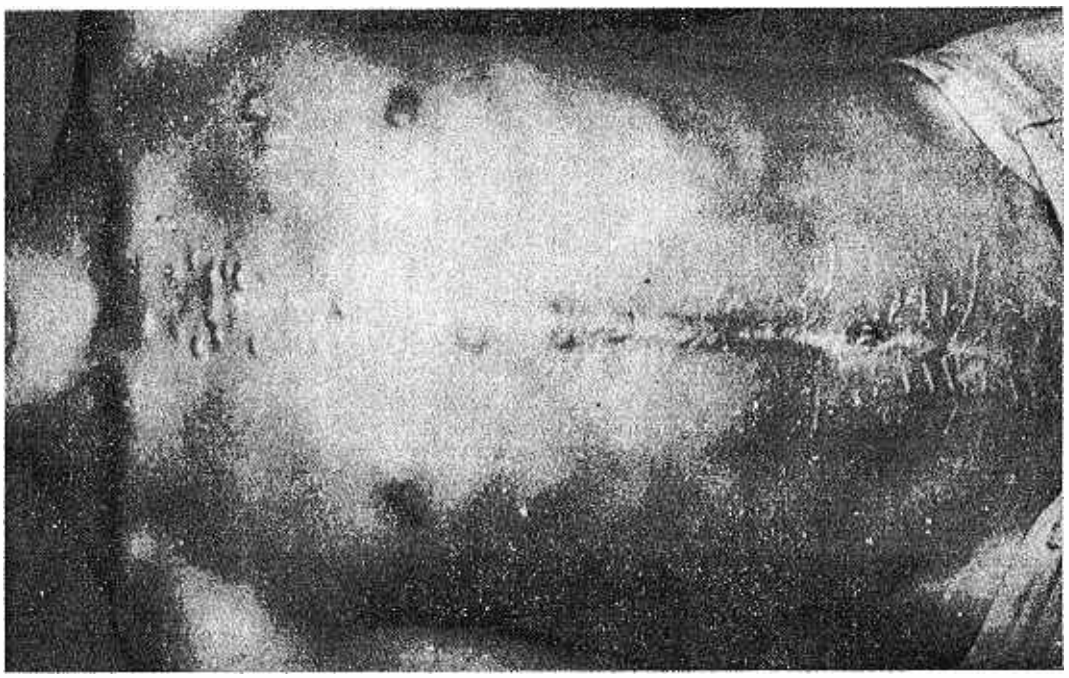


Fig. 3 Scar following anterior aortic bypass ('ventral' aorta).

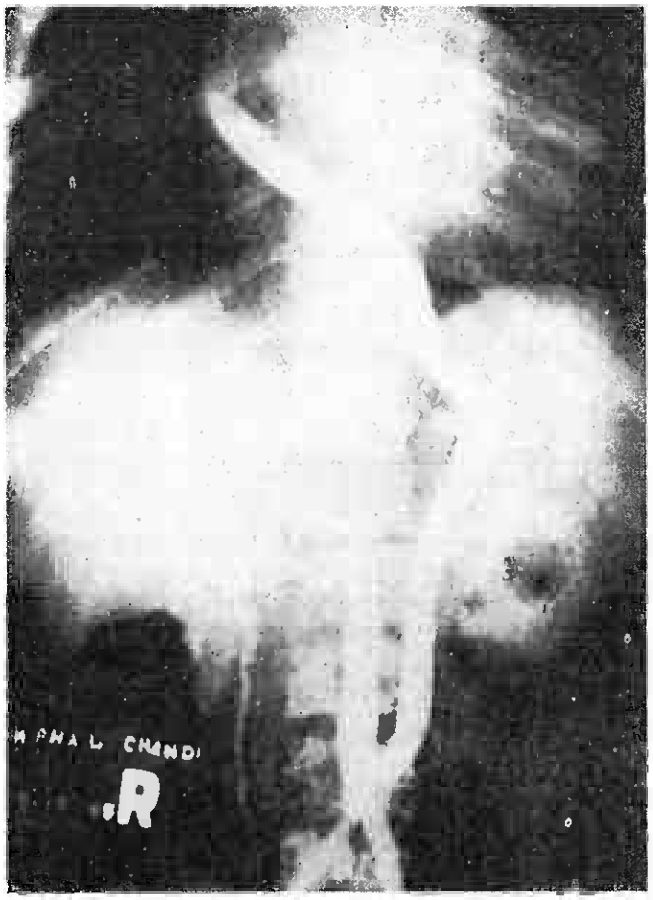


Fig. 4(c). Another case with artificial 'ventral' aorta. Aortogram 18 months after operation, P.A. View. Note retrograde filling of the renal arteries.

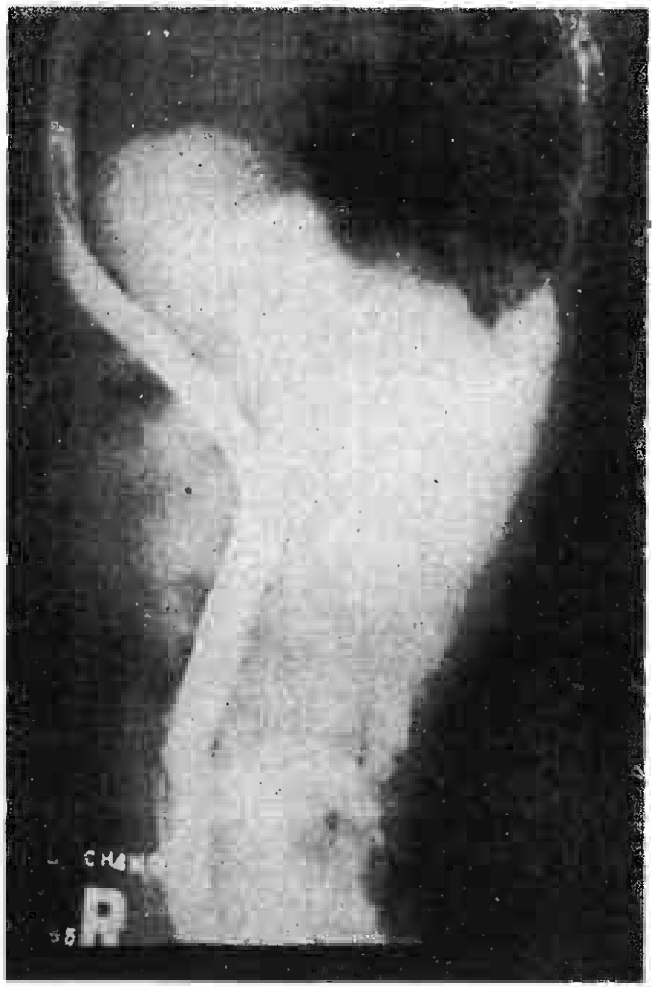


Fig. 4(d). Lateral view of (c). Note para-aortic reproperitoneal lie of the graft in the abdomen

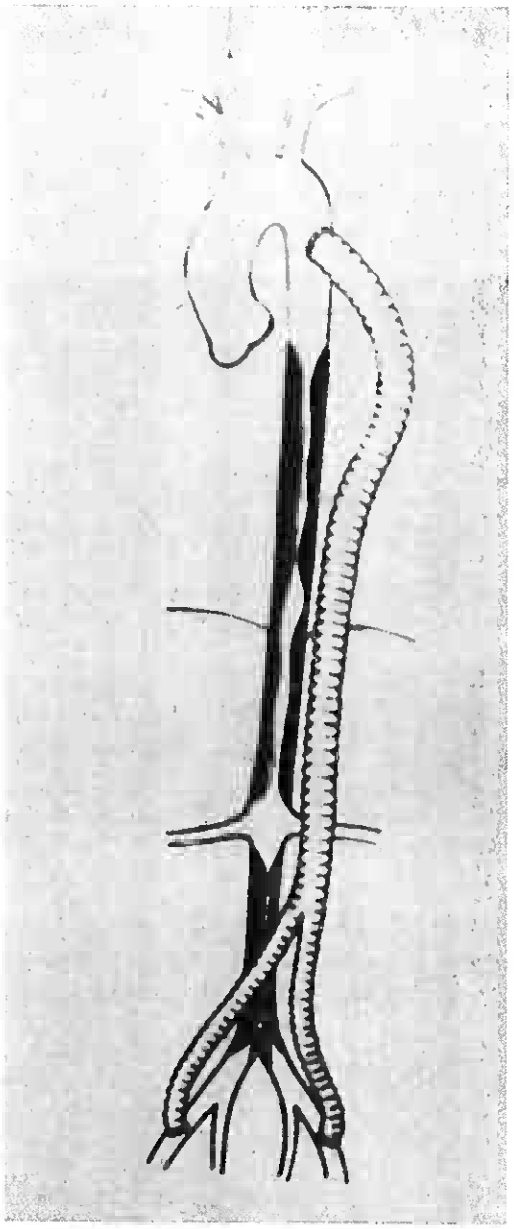


Fig. 5. Long abdomino-thoracic ('dorsal') aortic bypass with dacron 'Y' graft to lilac arteries, as used in J.S. female, 18 (Table II).

Fig. 6(a). Barium swallow 2 months after surgery. Fistula from stomach tracking towards the peristernal stainless steel suture.

CASE REPORT

Gastric fistula and secondary haemorrhage from graft

G.D.A. female child, aged 10 years, underwent aorto-aortic bypass procedure ('ventral' aorta) for extensive aortitis in the descending aorta.

She was readmitted 2 month later for a non-healing sinus over the sternum. The sinus was found to be discharging stomach contents. Barium swallow showed a gastric fistula tracking up by the side of the graft behind the sternum and presenting to the surface through the sternum. Tomogram of the sternum showed a fenestrated bony opening and evidence of osteomyelitis.

At exploration for sudden bout of secondary haemorrhage while in the ward, the bleeding from the upper anastomosis was uncontrollable, the aorta being extremely friable. At autopsy, a large erosion of the posterior wall of the stomach was found close to the dacron graft. The ascending aorta had softened, like cheese cake, and the anastomosis showed no signs of healing. It is postulated that the proximity of the pulsating dacron graft caused this erosion of the stomach. (Panday et al, 1969) (Figs. 6a, 6b).

Fig. 6(b). Autopsy specimen. Gastric fistula produced by dacron graft eroding the lesser curvature of the Stomach. Note the thickened reactive and inflammatory changes at the edges.

CASE REPORT

Gastric erosion and haemorrhage

R. C. male, aged 15 years, underwent a similar 'ventral' aortic bypass operation in August 1965 for extensive aortic constrictive disease. He was doing well and generally asymptomatic until his emergency readmission $3\frac{1}{2}$ years later in a terminal state of shock with massive gastro-intestinal bleeding. Autopsy revealed that he had bled from a gastric erosion but without perforation or fistula formation. The dacron was adherent to the stomach.

These unfortunate experiences have made us extremely conscious of the danger of a 'free' dacron graft within the abdomen. No attempt is therefore spared now to pass the graft retroperitoneally and avoid gross contact with either the free edge of the left lobe of the liver or the lesser curve of the stomach. While technically, and haemodynamically these long bypass operations are immediately satisfactory, long term appraisals are the true indications of their usefulness. In Table I and II these results are set out in summary form. The mortality is acceptable when one recognises the inevitable march of extensive disease to disability and death. Much of the morbidity which we have seen (Table II) is also essentially preventable, and increasing experience should minimise many of these complications. Most of these patients are in poor nutritional states, in addition to suffering from infectious diseases such as tuberculosis. Control of such infections and of any heart failure, restoration of blood protein and haemoglobin levels before surgery are essential to success.

Additional revascularisations, such as renal or mesenteric, can be carried out easily enough, but these do leave such grafts free in the peritoneal cavity, and great care must be taken to fully omentalise them. Lately, we have favoured the use of autogenous vein grafts for this purpose. Dacron grafts at times, excite considerable inflammatory fibrosis and on no account should uncovered dacron graft surface be allowed to present itself in the abdominal cavity. This point cannot be over emphasized. A careful organisation of the length of the graft is also needed, as excess length tends to curve out under pulsatile blood flow, and may dangerously compress and/or erode viscera. Preliminary testing and selection of these grafts are, therefore, absolutely essential. Teflon grafts, which tend to reject tissue adherence may be preferred by some for long aortic bypasses, but we have no experience with this material.

Total occlusion of the descending aorta is uncommon but has been occasionally seen by us in the abdominal aorta. Though gangrene is rare, threatened viability of the legs in such extensively blocked aortae may need some type of axillo-femoral bypass procedure (DeVilla et al, 1966), preferably bilateral. This operation is mainly of temporary value in an emergency but will help check gangrene if successfully performed and tide the patient over until a more definitive and permanent surgical relief can be offered.

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COMMON VENTRICLE

By Donald G. Ritter

Cases of common ventricle (C.V.) were classified according to Hallerman's modification of Van Praagh's. Of the 145 cases, 95 (66%) were male and 50 (34%) were female. The age range was 7 days to 38 years of age (mean 8·4 years). Table I is a summary of the cases reviewed at the Mayo Clinic.

TABLE I

			% With PS	Cases with AS
Type A I	9 cases	(6%)	50	—
A II (92 cases)	14 cases	(10%)	36	—
A III	69 cases	(48%)	45	2
Type C I	6 cases	(47%)	67	1
C II (53 cases)	29 cases	(20%)	76	1
C III	18 cases	(12%)	94	1
	145	100%		

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Slides illustrating the various types of C.V. as well as certain hemodynamic findings will be presented.

The first case of C.V. operated successfully at the Mayo Clinic was a 6 year old boy sent to surgery in 1964 as a VSD without benefit of angiography. At surgery a type C II C.V. was found. A postoperative catheterization with angiography was done in 1972 and the data will be presented.

A second case was operated recently. A 20 year old man in severe failure was diagnosed at cardiac catheterization as having a huge ASD with a large VSD or C.V., complete A-V canal with severe incompetence of both A-V valves. Dr. Gordon Danielson repaired the heart by placing a large patch to a small (2cm) apical remnant of septum. Two Braunwald-Cutter valves were inserted and the atrial defect repaired with the upper portion of the patch. The recovery was rewarding and he continues to improve at home in Italy 3 months after the operation. Preoperation and postoperative data will be presented.

Thus, common ventricle can be an operable lesion including the A type C.V. as shown by Dr. Arai. An exact anatomical and physiological diagnosis becomes mandatory not to exclude C.V. but to include it as a potentially operable entity.