THE SURGERY OF THE ABDOMINAL AORTA AND ITS MAJOR BRANCHES

Lecture delivered at the Royal College of Surgeons of England
on
4th October 1955
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THE SURGERY OF the abdominal aorta has developed at a great rate during the last five years. Before this the only regularly performed operations were reinforcing procedures for aneurysms and aortic embolectomy. Although Astley Cooper had tied the abdominal aorta as long ago as 1818 his patient died, and Croot who reviewed the literature in 1951 found that all the 21 recorded operations performed on the abdominal aorta for aneurysms prior to 1918 had been unsuccessful and that Vaughan (1922) was the first to report survival of a patient after ligature of the aorta for an abdominal aneurysm. Probably the first successful operation on the abdominal aorta was performed by Bauer, who in 1913 successfully removed a saddle embolus from the aortic bifurcation. Our experience consists of 59 resections of the aorta for aneurysm or occlusive disease, and it is upon that that the following conclusions have been based.

ABDOMINAL ANEURYSM BELOW THE RENAL ARTERIES

This lesion, due in nearly every case to arteriosclerosis, carries a grave prognosis. In 1927 Colt analysed a series of 121 patients with an abdominal aneurysm and found that the average duration of life was less than two years from the date the condition was diagnosed, and in 1950 Estes in an analysis of 102 case histories found that 33 per cent. of the patients had died within one year of diagnosis, that only 10 per cent. were alive eight years later, and that the cause of death was rupture of the aneurysm in 63.3 per cent. of those who died. Our experience although smaller agrees with this, and no less than five of our patients have died from rupture of their aneurysm in the interval between their names being placed on our waiting list and operation. It appears that the younger patients are particularly liable to this catastrophe and that the onset of pain may be the warning that rupture is imminent. It is also of interest that many of these patients are relatively young—two of ours were less than 40, and about one-third of our own and recorded cases have been under 60 years of age.

Treatment

In the past abdominal aneurysms have been treated by aortic ligation proximal (Astley Cooper, 1818) or distal (Vaughan, 1922) to the sac, the introduction of wire into the sac (Moore and Murchison, 1864 ; Blakemore, 1947 and Linton, 1951), wrapping with various plastic substances (Poppe,

1949, and Kirklin, Waugh, Grindlay, Openshaw and Allen, 1953), endoaneurysmorrhaphy (Bigger, 1940), and the injection of substances round the aneurysm to promote fibrosis (Berman and Hull, 1952). In our view, none of these methods is effective and it is probably wise to abandon their use ; this opinion is shared by DeBakey and Cooley (1953).

The treatment of choice is excision of the aneurysm and reconstruction with a homologous arterial transplant or a plastic prosthesis. Since 1952 we have resected 33 aneurysms of the aorta and restored continuity in 19 patients with a homologous arterial transplant, 11 with a prosthesis of orlon cloth and three with a prosthesis of polyvinyl sponge. Seven of these patients are dead—three were emergency operations (two for leaking aneurysms and one for a dissecting aneurysm), one died from coronary occlusion, one died because a dissecting aneurysm formed in the arterial transplant four weeks after its insertion, and two were patients with very large aneurysms of the upper abdominal aorta, one of which did not survive the operation and the other died three months later from osteomyelitis of the spine. The other 26 patients are fit and well. The first to resect an abdominal aneurysm and reconstruct the aorta were Dubost, Allary and Oeconomos (1952), and since then many others have performed this operation, the largest experience being that of DeBakey and Cooley (1955) who have resected nearly 300 aortic aneurysms, thrombosis and coarctations.

Selection

With improving results we now believe that nearly every abdominal aneurysm should be excised, particularly if it is producing symptoms or the patient is under 70 years of age. Our oldest patient has been 76, and we now only treat conservatively symptomless aneurysms in elderly patients and those who are considered unfit for an operation which, although still severe for the surgeon, is no more disturbing from the patient's point of view than a partial gastrectomy.

Technique

We prefer a long left paramedian incision and then approach the aorta by dividing the peritoneum to the left of the descending and pelvic colon and displacing those structures to the right, thus exposing the aorta and both common iliac arteries ; as an alternative, very large aneurysms or those grossly adherent to the parietal peritoneum may be exposed directly through the pelvic mesocolon. The two common iliac arteries are next isolated or, if they are diseased, the two external and two internal iliac vessels ; in each case it is important to avoid damage to the accompanying veins. We feel that it is of value to pass tapes around the iliac arteries below the aneurysm at an early stage in the operation so that they can be tightened if it appears that emboli are likely to be dislodged during the mobilisation of the aneurysm. The aorta above the aneurysm is now exposed and isolated. To do this the inferior mesenteric vein is

retracted to the side and the dissection carried round the aorta just below the point at which it is crossed by the pancreas and left renal vein. A tape is now passed round the aorta. It is a fortunate fact that in nearly every case the aneurysm lies either above or below the renal arteries with a relatively normal segment at this level. The next step is to tie the inferior mesenteric artery as close to the aorta as possible and to identify both ureters. The aneurysm is now freed, and particular care must be exercised to avoid injury to the inferior vena cava and especially the left common iliac vein as it crosses behind the aortic bifurcation. By now the aorta will be sufficiently mobile for the surgeon to rotate it from side to side and tie the lumbar arteries, after which the tapes are tightened over rubber tubes or clamps applied and the aneurysm resected. In difficult cases the clamps may be applied before the aneurysm has been freed, and the aorta divided above and turned forwards and downwards so that it is peeled off the vena cava as the lumbar arteries are tied serially. In most patients resection of the aortic bifurcation is necessary. After resection of the aneurysm the aortic and iliac arteries are inspected, the ends of the arteries trimmed, their lumina gently cleared of clot and debris by syringing with saline, and the adventia stripped back so that it does not interfere with the suture line.

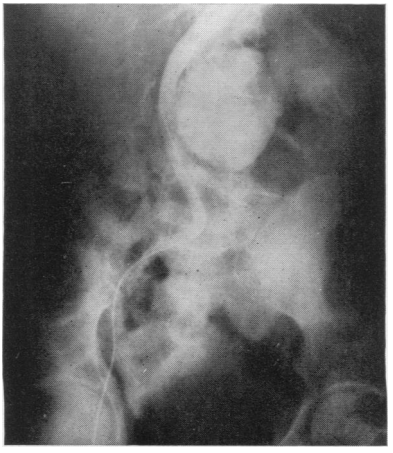

Fig. 1. An aneurysm of the abdominal aorta in a patient aged 42. This had leaked and produced a large extraperitoneal haematoma which contained between one and two litres of blood.

Reconstruction is performed in the same way for the insertion of a plastic prosthesis or a homologous arterial transplant. The proximal anastomosis is performed first, two everting mattress sutures of 0000 silk are inserted at opposite corners and then the anterior layer of the anastomosis ; a continuous over and over suture should be placed between the two stay sutures. The transplant or prosthesis is now turned up and

the posterior layer inserted from behind. The right and then the left iliac anastomosis are next performed, using a similar technique but rotating the vessel instead of turning it up to put in the posterior layer. A plastic prosthesis should be inserted without particular tension but a homologous arterial transplant must be put in under considerable tension if it is not to become redundant when the clamps are removed.

The distal clamps are removed first and the new vessel allowed to fill from below, after which a large pack is placed over the whole field and held firmly in position whilst the proximal clamp is slowly released. At this stage two things are important : the first is to release the proximal clamp either slowly or intermittently and at the same time to give the patient a rapid blood transfusion perhaps containing nor-adrenalin. A marked fall of blood pressure occurs when the clamp is released, probably due to hyperaemia, in the distal portion of the patient and if this is not prevented or corrected at once the patient, who probably has abnormal coronary arteries, may die from relative cardiac ischaemia. The second thing is to leave the pack held firmly over the three anastomoses for at least five minutes unless the blood loss is gross ; this allows the continuous sutures to tighten and is far better than trying to stop small leaks with interrupted stitches.

Closure of the abdomen after any operation on the abdominal aorta must be performed with the greatest care and, in addition to the routine suture of each layer, a series of through and through tension sutures should be inserted. The reason for this is the high incidence of wound dehiscence after these operations probably due to paralytic ileus which itself requires treatment, preferably prophylactically with a gastric suction tube and an intravenous infusion for two or three days.

ABDOMINAL ANEURYSM ABOVE THE RENAL ARTERIES

These patients present a most difficult problem because the aneurysm is nearly always syphilitic, the patient usually has aortic insufficiency and the aneurysm itself may involve the major branches of the upper abdominal aorta. The operation should preferably be performed with the aid of hypothermia because the lower thoracic aorta has to be cross clamped and the resulting temporary ischaemia may result in irreparable damage to the spinal cord or kidneys, the risk of which can be reduced by this means.

The incision, a left thoracoabdominal, follows the line of the ninth rib. The aorta is then approached from the left side by displacing the pancreas, spleen and other viscera forwards. The left renal artery and splenic artery are now isolated and then tapes are passed around the aorta above and below the aneurysm. The origins of the coeliac axis and superior mesenteric arteries are now exposed, and then the appropriate lumbar and intercostal arteries are divided. The right renal artery is now located and isolated either from in front by retracting the superior

mesenteric artery upwards or from behind by rotating the aorta to the right. The aneurysm is now freed, but this may be impossible, in which case the aorta and its branches are clamped, the aneurysm opened and as much of its wall as possible removed. It is important to remove the aneurysm because, if left *in situ,* the remnant frequently becomes infected. The cut ends of the aorta and any of its branches which arose from the aneurysm are now prepared for anastomosing and the vessel reconstructed with a plastic prosthesis or homologous transplant.

It is not known for how long it is possible to cross clamp the lower thoracic aorta before irreparable damage is done to the spinal cord or kidneys either with or without the aid of hypothermia, but our experience of six patients indicates that one hour is safe at a body temperature of approximately 28°C (82·4°F) and that two hours is getting near the danger point. One patient after two hours' occlusion developed signs of a lower spinal cord lesion which gradually recovered. Another point which must be stressed is that these operations take a long time—10 or 12 hours may be needed—and the same applies to those thromboses of the abdominal aorta which have reached the level of the renal arteries.

THROMBOSIS OF THE AORTIC BIFURCATION

Although this condition is mentioned in Allbutt and Rolleston's System of Medicine (1909), Leriche was the first to give a complete description of the lesion and its clinical features (1923 and 1940). He treated it by sympathectomy and aortectomy, but more recently others have restored the blood flow either by the operation of thromboendarterectomy (dos Santos, 1947) or with an arterial transplant (Oudot, 1951 ; DeBakey, Creech and Cooley, 1954) or a plastic prosthesis (Hufnagel, 1955).

The course of this disease without treatment is steadily progressive. At first the symptoms are surprisingly mild but they get steadily worse. Work is usually impossible and, in our view, restoration of the blood flow is the correct procedure because it returns the patient to normal ; in addition there is the possibility that the clot may spread up and occlude the renal arteries (Johnson, 1954).

Technique

In an occasional patient the operation of thromboendarterectomy is justified, but in our view this procedure should be reserved for extremely well localised lesions. Figure 2 illustrates the ideal case—a 46 year old general labourer who was unemployed because his intermittent claudication distance was below fifty yards ; at operation a pedunculated calcified plaque was removed from the right common iliac artery and the patient returned to full work. The majority of patients, however, are best treated by inserting an arterial transplant or plastic prosthesis.

The first stages of the operation are the same as for an adombinal aneurysm but it is not necessary to excise the thrombosed segment, sufficient is removed from each end of the occluded vessels for the

transplant to lie snugly after it has been sutured into position and the remainder left *in situ.*

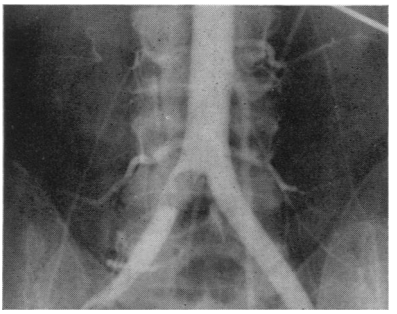

Fig. 2. Localised obstruction of the common iliac artery—the ideal case for the operation of thromboendarterectomy.

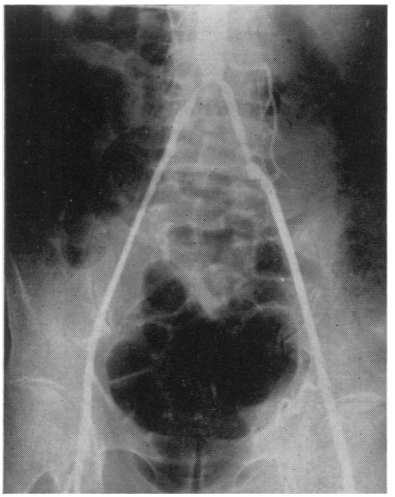

Fig. 3. Occlusion of the lower abdominal aorta and iliac arteries. An early case suitable for the relatively minor procedure of resection and reconstruction of the aortic bifurcation.

On the other hand, *High Occlusions* which have reached the level of the left renal artery require a special technique. We use a full-length left paramedian incision extending from the pubis to the costal margin and operate under hypothermia because the aorta will have to be clamped above the renal arteries and sometimes above the superior mesenteric. The upper end is exposed by incising the peritoneum on the outer side of the descending colon, retracting the descending colon to the right and then retracting the splenic flexure, duodenojejunal flexure, spleen and

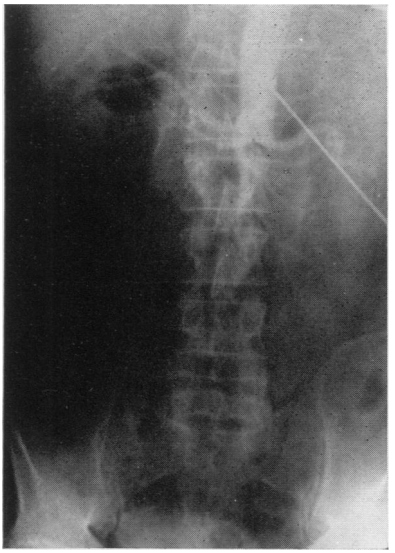

Fig. 4. High occlusion of the abdominal aorta flush with the left renal artery. A major procedure involving cross clamping the aorta above the renal arteries was required to restore the blood flow with an arterial transplant. We think that these patients should be treated surgically in spite of the magnitude of the operation.

pancreas upwards and forwards. This exposes the aorta, left kidney and left adrenal. The inferior mesenteric vein is identified and preserved and the aortic dissection commenced. This is most easily performed by passing a tape around the aorta between the superior mesenteric artery and the coeliac axis, after which the aorta is divided about one inch below the level of the left renal vein ; clamps are unnecessary because it has thrombosed. The end of the distal segment is then closed with two or three sutures and the proximal segment dissected free from the left renal vein and the vena cava. As soon as the proximal stump of the aorta is free from the renal vein it is threaded up behind this vessel and laid in front of it. This makes the dissection of the two renal arteries much easier. These, and the superior mesenteric artery, are carefully isolated, any occluded lumbar arteries are divided and those which are patent are prepared so that they can be clamped with small bulldog clamps during the anastamosis. The next step is to prepare the distal ends in the common or external iliac arteries, after which attention is directed back to the proximal stump. The final preparation of the proximal stump consists of the application of the aortic clamp at the lowest convenient level, the control of all branches below this and then the removal of the clot from the aorta below the renal arteries. This is in fact a thromboendarterectomy of the first one or two centimetres of aorta distal to the renal vessels. The anastamosis is then performed and, after it has been completed, the arterial

transplant or plastic prosthesis is threaded behind the renal vein and the operation completed by performing the two iliac anastamoses.

As an alternative, it is sometimes possible to insert a bypass around an iliac occlusion—Fig. 5 illustrates a good case for such a procedure. This patient, a diabetic aged 40, had suffered from severe intermittent claudication for 11 years. On admission the distance walked before the pain became intolerable averaged 50 yards in spite of the presence of the curious vessel (probably congenitally abnormal) which conducted blood to the left lower limb.

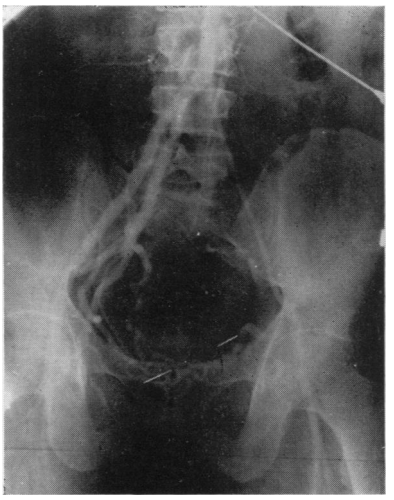

Fig. 5. A good case for a bypass type of reconstruction. In our view this small vessel conducting blood to the left lower limb was congenitally abnormal.

The results of our reconstruction operations on patients with obliterative vascular disease are given in the accompanying table and it will be seen that those patients with aortic and iliac occlusions have on the whole done well.

75 ARTERIAL RECONSTRUCTIONS IN PATIENTS WITH OBLITERATIVE VASCULAR DISEASE

Vessel	Number of Transplants	Thrombosed in Hospital	Thrombosed Later	Patient To-day
Aorta and Iliacs	26 (two died in hospital)	1	1	22
Femorals ..	29	9	6 (plus one dead since discharge)	13
Popliteals ..	15	1	4	10
Others	5	2	2	1

Three have thrombosed another artery since the operation.

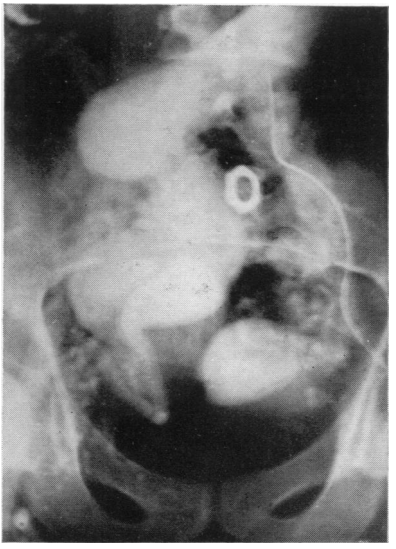

Fig. 6. An arteriovenous fistula between the right internal iliac artery and vein. Note the dilatation of the aorta and iliac arteries proximal to the fistula and the nose cap of the grenade which had wounded him 12 years before.

DISSECTING ANEURYSM

Since the post mortem examination of King George II and the discovery that he had died of a dissecting aneurysm of the aorta this lesion has been recognised as a not uncommon cause of death but a relatively rare diagnosis before death. In general, it attacks two types of patient—first the elderly with grossly abnormal vessels, and second those between 30 and 50 where the split occurs in the intima of an otherwise nearly normal thoracic aorta. It is the second group which it should be possible to save by surgery, and so far we have been unsuccessful. These lesions are nearly always fatal but with better diagnosis, particularly of the site of the split in the aorta, suture of the defect should be relatively easy. An alternative procedure is to transect the aorta distal to the intimal defect and suture the dissected layers of the aortic wall together again, but this does not go to the source of the trouble and is probably of only palliative value.

EMBOLISM

As already stated, Bauer in 1913 successfully removed a saddle embolus from the bifurcation of the aorta, and to-day when the approach to arterial emboli as a whole is more conservative all would agree that emboli lodged at the aortic or iliac bifurcations and in the superior mesenteric artery should be removed if diagnosed sufficiently early and if good facilities exist. In my opinion a major reason for the death of these patients is either a second embolus, usually of a mesenteric artery, soon

after the successful removal of the first or failure to recognise an associate mesenteric embolus at the time a saddle embolus is removed from the aorta.

INJURIES AND ARTERIO-VENOUS FISTULAS

The successful treatment of both injuries and arterio-venous fistulas involving the abdominal aorta or its major branches have been reported. Both are very uncommon, but with modern techniques of resuscitation and vascular surgery more patients should recover if they survive long enough to reach hospital. Figure 6 illustrates an arterio-venous fistula between the internal iliac vessels which was successfully excised.

Fig. 7. A prosthesis of polyvinyl sponge in position after excision of an abdominal aneurysm.

SUMMARY AND CONCLUSIONS

(1) The surgical treatment of two important lesions has been discussed —aneurysm and obliterative vascular disease of the abdominal aorta.

(2) The technical details of the operations recommended for these two lesions have been described.

(3) We have experience of the resection of an aortic aneurysm and reconstruction of the aorta on 33 occasions, and of the reconstruction of the aorta and iliac arteries for obliterative vascular disease in 26 patients.

(4) These operations may take as long as 10 hours in a different case but the results justify the trouble involved.

I wish to thank Mr. H. H. G. Eastcott and Mr. K. Owen who performed several of the operations and who have assisted with the care of the patients.

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