AORTIC ANEURYSMS

Hunterian Lecture delivered at the Royal College of Surgeons of England
on
9th October 1962
by

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THREE THOUSAND YEARS ago Indian healers described, in the Ayurevedic Texts, the swelling and pulsation of blood vessels. They recommended treatment by compression and continued, "If not cured cut open and remove with capsule and sac, and stop bleeding with thermal cauterisation. The surgeon should not operate if the tumour is fixed and immovable, nor if it is big or situated near vital organs". This advice has held for aortic aneurysms until 1952, when Dubost resected an abdominal aneurysm and reconstructed the aorta with a homograft. John Hunter's classical operation for popliteal aneurysm was based on his knowledge of anatomy and collateral circulation, and also his observation of sepsis and secondary haemorrhage resulting from direct surgery on such aneurysms. He operated on five patients, the first in 1786, and it must be noted that four out of the five recovered completely. His pupils soon recognized the advantage of the Hunterian ligation, and this became the standard procedure for popliteal aneurysm. The literature of Hunter's day abounds with graphic descriptions of patients suffering from rapidly enlarging aortic aneurysms, and the subsequent fatal rupture, but it is only in the last 10 years that they have yielded to direct surgical excision and reconstruction.

The subject of this Hunterian lecture is a personal series of 145 patients with aortic aneurysm. The majority of these were admitted between 1957 and 1960 to the Surgical Unit at St. Mary's Hospital, where I had the privilege of undertaking the management and operative surgery, for which I am much indebted to Professor Rob.

TABLE I

145 PATIENTS WITH AORTIC ANEURYSM

Site	*No.*	*Resection and graft*	*Other procedures*	*No operation*
Abdominal aorta . .	96	73 (6)	15 (3)	8
Abdominal aorta (ruptured) . .	32	31 (22)	—	1
Thoracic aorta . .	5	5 (3)	—	—
Dissecting aneurysms	12	—	10 (1)	2
	145	109	25	11

Hospital mortality shown in parentheses.

ABDOMINAL AORTA

Aneurysm of the abdominal aorta was the commonest and affected 128 patients; 32 of these were emergencies with symptoms and signs of

massive haemorrhage. The remainder presented with abdominal pain, dyspepsia, backache or epigastric pulsation.

The aetiology of these aneurysms was athero-sclerosis, with the exception of one mycotic aneurysm. All were below the renal arteries, excepting four which involved the renals and the aorta immediately above. The age of the patients varied from 38 to 79, with the majority in the sixth decade.

The diagnosis is generally easy.

TABLE II

Presenting symptoms	*No. of patients*
Dyspepsia and epigastric fullness ..	37
Epigastric pulsation	30
Lumbar pain	21
Claudication	3
Symptom free	5
	96

The presenting symptom in the majority was a sensation of fullness in the epigastrium, or dyspepsia after meals. This was characterized by the recent onset and the absence of remission such as occurs in peptic ulceration. The post-prandial fullness occurred in the larger aneurysms and is caused by the stretching of the third part of the duodenum over the aneurysmal sac. Throbbing or palpitation occurred in 30 patients and was usually observed by them when lying in bed. Pain in the back, lumbar region or iliac fossa is an ominous symptom and may herald early rupture of the aneurysm. Renal pain due to stretching of the ureter over an abdominal or iliac aneurysm is relatively uncommon and has only been observed on three occasions. Intermittent claudication due to atheromatous occlusion of the femoral vessels occurred in two patients. Peripheral embolus is uncommon when compared with femoral and popliteal aneurysms, on account of relative absence of movement and muscle action in relation to the aortic dilatation. This occurred in one patient. In five patients the aneurysm was first observed at routine medical examination.

Examination shows a mass with expansile pulsation in the epigastrium. If the fingers can be insinuated between the mass and the xiphisternum the aneurysm is almost certainly below the renal arteries. The iliac arteries should be examined for dilatation, and in many cases the lower limb arteries are relatively dilated. If there is any doubt about the clinical diagnosis it is most helpful to examine the femoral arteries, which are nearly always aneurysmal.

Investigation. Straight X-ray of the abdomen shows calcium in the wall of the aneurysm (Fig. 1). Vertebral erosion is uncommon, when compared with the thoracic aorta, since the abdominal aorta is elongated and moves away from the spine. Intravenous pyelography rarely shows hydronephrosis or hydro-ureter, but serial examinations may demonstrate

displacement of the ureters and are of value in assessing increase in size of the sac. Aortogram is seldom indicated, because a Seldinger catheter may disturb blood clot in the aneurysm. If required, a high trans-lumbar aortogram is advised since the neck of the sac is particularly weak at the normal site of needle puncture and haemorrhage may be precipitated. This applies particularly to hypertensive patients.

Fig. 1. Lateral abdominal X-ray showing calcium deposits in aneurysmal sac.

Myocardial function is a most important factor in assessing fitness for operation. Twenty-seven per cent. of these patients had an abnormal E.C.G. and 10 per cent. had angina of effort or myocardial infarction. Ischaemic heart disease does not contra-indicate operation provided the myocardial reserve is adequate.

Renal function is also important since a degree of chronic pyelonephritis is not uncommon in these patients. This is investigated by blood urea and electrolyte estimations, and M.S.U. culture. Urea clearance and urine cell counts (Houghton and Pears, 1957) are performed if malfunction is suspected.

Indications for operation. It has been said that the operation should be performed shortly after the diagnosis has been made. Estes (1950) has shown that 81 per cent. of patients with abdominal aneurysm die within five years, 63.3 per cent. of them with rupture. Although three patients have died of rupture while on the waiting list, operation is not always advised. The uncoiled aorta, or the small fusiform aneurysm, may be kept under careful observation, the size charted and straight X-ray or intravenous pyelogram performed for future comparison. Operation is indicated if there is appreciable enlargement of the sac. Lumbar pain, or pain in the iliac fossa, is an ominous symptom and demands early operation. Operation is also advised for very large aneurysms.

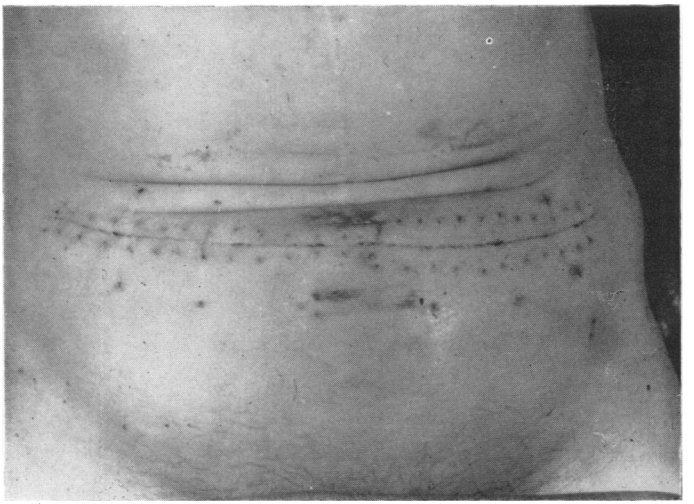

Fig. 2. Transverse abdominal incision for exposure of abdominal aorta.

OPERATIVE TECHNIQUE

Preparation

Six units of blood are cross-matched for the average aneurysm and eight units for large aneurysms. A wide bore intravenous catheter is placed in a forearm vein for intravenous replacement. Blood balance is a necessary aid to replacement therapy. General anaesthesia is employed, although I have witnessed a master surgeon successfully excise and reconstruct an aneurysm under spinal anaesthesia. This, however, is not advised for ordinary mortals like ourselves.

The incision

The transverse incision gives the best exposure, with minimal post-operative ileus and good wound healing (Fig. 2). The left thoraco-abdominal incision is reserved for high aneurysms. The long left paramedian gives

particularly good exposure of the iliac arteries but is associated with considerable post-operative pain and ileus. The retro-peritoneum is incised obliquely to the right iliac bifurcation. The neck of the aneurysm is dissected and a tape passed round the aorta. At this point care must be taken with the left renal vein. In three patients this vein has been anomalous, posterior to the aorta, and injury would result in severe haemorrhage. Dissection may also injure the receptaculum chyli, which lies between the aorta and inferior vena cava. The iliac arteries are then dissected immediately above the bifurcation to external and internal iliacs, to avoid damage to the bifurcation of the vena cava. The inferior mesenteric artery is mobilized and ligated close to the aneurysm to preserve the distal branches. This preservation of collateral flow helps reduce the incidence of ischaemic

Fig. 3. Terylene bifurcation prosthesis for abdominal aortic reconstruction.

colitis. The above manoeuvres are performed with minimal handling of the aneurysm to avoid detachment of thrombus and distal emboli. The aorta is now cross-clamped and Potts or Brock's auricular clamps are most suitable. The iliacs are secured with bulldog or Crafoord clamps and 50–100 mg. heparin infused in the distal portion. The aneurysm may now be handled without fear of detaching thrombus. The lumbar arteries are identified and secured by lateral dissection. Medial dissection is limited to avoid damage to the vena cava. The aneurysm is opened, thrombus evacuated and the sac excised, leaving the portion attached to the vena cava. The prosthesis is then selected and prepared.

Terylene or Dacron are the only prostheses recommended (Fig. 3). The prosthesis is anastomosed to the proximal aorta with two layers of 4.0 silk, and pre-clotted under pressure by temporarily releasing the proximal clamp

and occluding the graft distally. The legs are trimmed to size and anastomosed end to end with the iliac arteries, one layer of 4.0 silk is usually adequate. It is important to avoid excessive slackness in the graft; in one early case, as a result of this, one limb buckled with subsequent occlusion. At re-operation two months later it was possible to shorten the graft, with restoration of flow. Before commercial bifurcations were available the prostheses were fashioned out of terylene cloth sewn on an ordinary sewing machine and then sterilized. This proved very satisfactory pro-

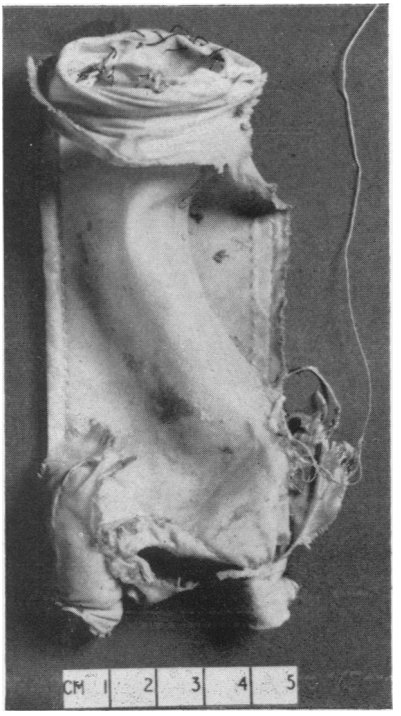

Fig. 4. Ruptured terylene prosthesis due to fatigue of cotton thread.

vided terylene thread was used in the machine. Unknown to us, cotton thread was used to sew one particular graft and it fatigued and ruptured into the duodenum 23 months later (Fig. 4). The patient was sent to hospital just in time and it was possible to excise the faulty graft and replace it with a woven prosthesis, with complete recovery of the patient.

PTFE (*Teflon*) is now considered unsuitable. Two late failures have occurred with this material, secondary to dissection, between the prosthesis and the pseudo-adventitia. In both cases the false aneurysm ruptured into the large intestine with fatal results.

Homografts were used in early reconstructions in this series, but have now been abandoned on account of the late failures. There have been four deaths due to failure, occurring one to three years after operation.

When the prosthesis is in place the suture lines are wrapped temporarily with gauze and the distal clamps removed to confirm the backflow. The proximal clamp is now slowly released and a careful check made on the arterial pressure. Blood loss should be minimal, but any serious loss is replaced rapidly and a fall of pressure countered by temporary reclamping of the aorta. The field should be dry within 3–4 minutes. The wound is closed in layers, using unabsorbable sutures for the rectus sheath and deep tension sutures. Wound dehiscence is not an uncommon complication.

POST-OPERATIVE MANAGEMENT

(1) Gastro-duodenal suction.

(2) Blood pressure and pulse observed half-hourly.

(3) Observe leg pulses.

(4) Fluid and blood replacement.

(5) Daily fluid balance and electrolyte estimation.

(6) Breathing exercises.

(7) The patient can be mobilized on the first or second day, especially if transverse incisions are used.

COMPLICATIONS

Deaths: 3 coronary infarction.

1 pulmonary embolus.

1 thrombosed graft (part technical, part poor outflow).

1 paralytic ileus and uraemia.

Complications: Those of special importance are:

(1) Paralytic ileus.

(2) Peripheral embolus; this occurred in two patients and one subsequently required below-knee amputation after unsuccessful embolectomy.

(3) Wound dehiscence occurred in four patients.

(4) Ischaemic colitis occurred in five patients and resolved with conservative treatment.

Wiring of the aneurysm was performed on 15 patients who were unfit for a major aortic resection by reason of poor myocardial reserve or chronic respiratory or renal disease. At operation between 50 and 200 feet of stainless steel wire is inserted into the sac, the length depending on the size of the aneurysm. Multiple needle punctures are usually required,

the object being to reinforce the walls of the aneurysm, leaving a central channel for blood flow. It is possible to insert too much wire and rupture occurred from this cause on one occasion.

Fifteen patients were so treated. Three died in hospital, two from subsequent rupture and the third from staphylococcal enteritis.

RUPTURED ANEURYSMS

The 32 patients in this group were all desperately ill, presenting with severe oligaemia and systolic blood pressure varying from 100 mg. Hg. to the unrecordable, the majority being between 60–80 mm. Hg. The history of abdominal pain and the finding of a pulsatile abdominal mass confirms the diagnosis. Acute haemorrhagic pancreatitis is the most likely condition to be confused with a ruptured aneurysm. Five patients presented with massive haematemesis and melaena from aneurysm eroding the duodenum.

Immediate operation offers the only hope of survival, and investigation and preparation, other than cross-matching blood, is absolutely contraindicated. One patient died on the way to the operating theatre, leaving 31 for operation. No attempt should be made to raise the arterial pressure above 80 mm. Hg. by rapid transfusion, provided cerebral blood flow is adequate. The reason for this is that the rupture is often sealed by friable clot, and an increased pressure may dislodge it. Also the foot of the bed should not be raised for any prolonged period since, with low arterial pressure, the renal blood flow is reduced, with resultant renal tubular ischaemia.

The patient is anaesthetized on the operating table with the surgical team scrubbed up and ready. The abdominal relaxation from the scoline required for intubation has been known to dislodge the blood clot and cause fatal haemorrhage. The abdomen is opened and the aorta clamped as soon as possible. Two patients died on the table from uncontrollable haemorrhage from a false sac which extended to the diaphragm. The following manoeuvre has saved the day on several subsequent occasions. The pulsating haematoma is opened and the index finger of the left hand used to plug the aorta. Using this as a guide, a clamp can now be placed on the neck of the sac. The aneurysm is then resected and reconstructed as previously described. The blood replacement required in these patients has varied between 2 and 15 litres with an average of approximately 6 litres. A troublesome capillary ooze occurs later in the operation, the so-called " red ink syndrome ". This is caused by the oligaemia, reduced peripheral blood flow and subsequent metabolic acidosis. In controlling this a proportion of fresh donor blood is desirable during the later stages of the operation. Infusion of 2.8 per cent. sodium bicarbonate in sufficient quantity to restore the arterial pH and pCO_2 to normal is also an invaluable form of therapy.

The results are not good, since many of the patients had to travel considerable distances and operation was thereby delayed. In addition to the two deaths during operation, previously described, nine patients died of renal tubular necrosis despite repeated dialyses; five died of coronary thrombosis; two died of pulmonary embolus, and four died of cardio-respiratory failure.

THORACIC ANEURYSMS

I wish to refer only briefly to these, since the operative technique and management are rather specialized and may require cardiac bypass, cardio-pulmonary bypass or deep hypothermia.

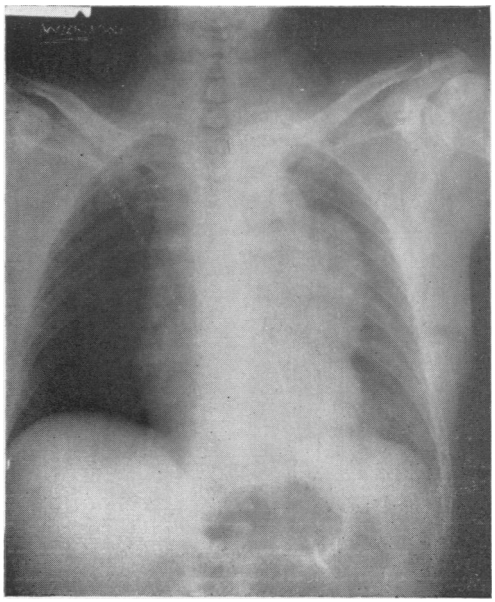

Fig. 5. Chest X-ray of dissecting aneurysm, showing broadening of aortic shadow.

The five aneurysms in this group were syphilitic in aetiology. Three out of five patients with ascending or transverse arch aneurysms died during operation, one from myocardial infarction and two from haemorrhage. The two surviving patients had aneurysms of the distal arch. One patient is alive and well five years after resection and reconstruction, the second one and a half years after operation.

DISSECTING ANEURYSMS

These most frequently commence in the ascending aorta and may extend proximally to the coronary arteries or pericardium or distally to the descending aorta, abdominal aorta or even to the iliacs and femorals.

Twelve patients have been seen and 10 operations performed. The first patient died in hospital while under investigation, a second with chronic dissection was treated conservatively. Ten were operated upon with one death, which occurred from aortic rupture 12 hours after operation. Nine made a complete recovery and eight of these are alive and well up to three years and six months after operation. One died six months after operation, probably from a rupture of the aorta, but there was no post-mortem confirmation of the cause of death.

Diagnosis is not always easy, and aortic dissections should be differentiated from coronary thrombosis. Chest X-ray may show broadening of

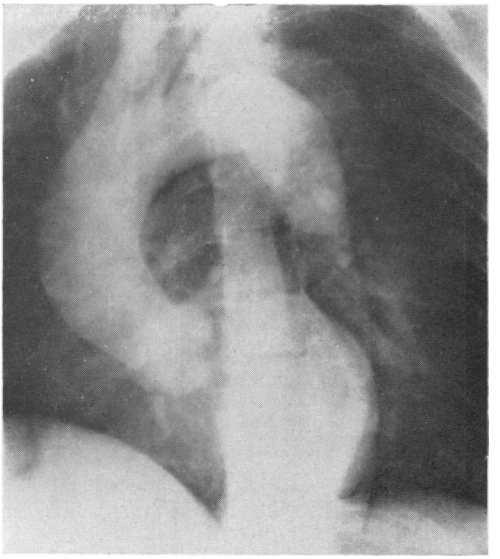

Fig. 6. Ascending aortogram showing dissection of thoracic aorta with double lumen.

the mediastinum (Fig. 5); a haemothorax makes the diagnosis obvious. Ascending aortography is necessary to confirm the diagnosis and show the lower limit of the dissection (Fig. 6).

Operation should be undertaken as soon as the diagnosis has been confirmed. Of the 10 operations, a re-entry ostium was done in eight and a resection and reconstruction in two. The former operation has given particularly good results in our hands in these elderly patients. Hypothermia is not advised for dissections above the renal arteries; it is preferable to restrict the period of aortic occlusion. Clamping the thoracic aorta produces hypertension with the danger of proximal dissection. This is countered with induced oligaemia, by bleeding 500–1,000 ml. of blood into ACD solution. The aorta is then clamped and the decompression performed (Fig. 7).

The following points are most important:

(1) The duration of aortic clamping above the renal arteries should not exceed 20 minutes. This is ample time to perform the operation.

(2) Adequate decompression is necessary, 6 sq. cm. in thoracic aorta and 4 sq. cm. in the abdominal aorta.

(3) The proximal dissection should be flushed free of blood clot.

(4) Secure closure of distal dehiscence is essential.

When the clamps are removed, the blood previously removed is infused intravenously to restore arterial pressure.

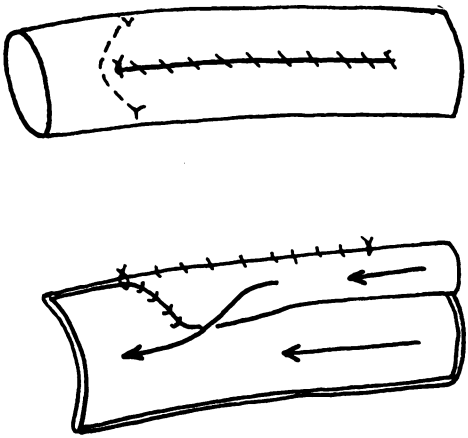

Fig. 7. Decompression ostium for dissecting aneurysm.

In the post-operative period all patients with dissections above the renal arteries show a temporary depression of renal and hepatic function. It is interesting to note that some months after the operation arteriography shows that the inner layer of the dissection expands to match the outer, and not the converse as might have been expected.

RESULTS OF OPERATION

Only those patients operated upon prior to July 1961 have been considered in this series, therefore the minimum follow-up has exceeded one year.

TABLE III

FOLLOW-UP REVIEW 1957–51

Operation	*Total*	*Alive*	*Dead*	
			Aortic rupture	*Other causes*
Aortic Reconstruction (thoracic and ruptured included)	75 (3)	56	7	12
Aneurysm wired . .	10 (2)	3	4	3
Dissecting aneurysm	9	8	1	0

Patients untraced shown in parentheses.

In the first group of aortic reconstructions seven patients died 1–3 years after operation from failure of the prosthesis; five of these were homograft ruptures and since 27 homografts were used this represents a failure rate of nearly 20 per cent. The two others were ruptures following dissection in a Teflon prosthesis, which I have already described, representing a late failure of 12 per cent. The other causes include cardiovascular disease (7), carcinoma of bronchus (2), carcinoma of pancreas (1), uraemia (1), and cause unknown (1). In the wired aneurysms there was a high proportion of aortic rupture. Other causes were coronary thrombosis (2) and cerebral haemorrhage (1). Of the 10 dissecting aneurysms, one death occurred after six months, probably from aortic rupture.

Figure 8 is adapted from Estes's (1950) results and shows approximately the survival rate of resected aneurysms compared with non-resected, and the standard mortality rates.

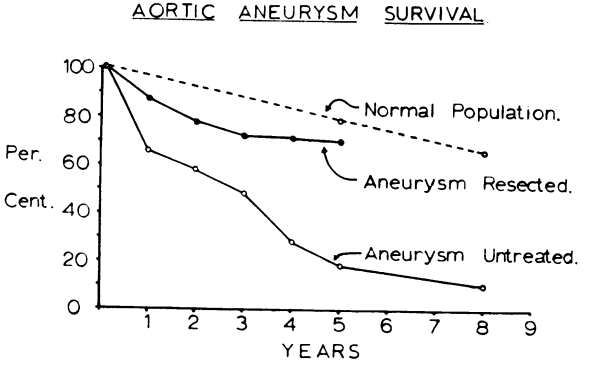

Fig. 8. Five-year follow-up of surviving patients, with aortic reconstruction, compared with survival rates of the normal population and those with abdominal aortic aneurysm. (Adapted from Estes, 1950).

CONCLUSION

In conclusion we should acknowledge the pioneers in this field, many of whom are our contemporaries. Dubost of France has already been mentioned; Rob (1955) in Great Britain and DeBakey (Cooley and DeBakey, 1953) in the U.S.A. were among the first to resect and reconstruct. Carrel and Guthrie in the early 1900s laid the experimental foundations of vascular surgery; in 1952 Hufnagel and Eastcott introduced techniques for storage of homografts which facilitated aortic reconstruction. Most of all we must pay tribute to John Hunter, upon whose precepts of observation and experiment all advances in surgery have been founded.

ACKNOWLEDGMENTS

The author is indebted to Professor C. G. Rob and Professor W. T. Irvine for permission to undertake the operative surgery and management

of many patients in this series; also to Mr. L. L. Bromley, who co-operated in the management of the five thoracic aneurysms described, to David Sutton for the radiology, and to Dr. P. N. Cardew for the photographic reproductions.

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