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Presentation and management of aneurysms

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Summary

The aetiology and pathology of aneurysms, their sites of occurrence, and their general management are outlined. Since the abdominal aortic aneurysm is the type most commonly encountered by the surgeon its presentation, assessment, and operative and postoperative management are discussed in detail.

Introduction

If you want to please a vascular surgeon refer a patient with an aneurysm to him (before it has ruptured or thrombosed!) because, in contrast to much obliterative arterial disease, aneurysmal disease carries an excellent long-term outlook after surgical treatment. In this lecture I will briefly consider those aneurysms dealt with by the peripheral vascular surgeon but not those involving cerebral vessels or the thoracic aorta.

Any artery in the body may be the site of an aneurysm but there are certain characteristic locations and of these the most common is the abdominal aorta. An abdominal aortic aneurysm is a life-threatening lesion and is far too often misdiagnosed and under-treated[1].

Aetiology and pathology

The main pathological types of aneurysm are set out in Table I, and the aetiology has a definite influence on the site and management of the lesion.

TABLE I *Aetiology and pathology of aneurysms*

1)	Atheroma
	Hypertension
	Hyperlipidaemia
	Inflammatory
2)	Trauma
	Direct—missiles and knives
	Indirect—road accidents
	Iatrogenic—catheters
	operations
3)	Poststenotic dilatations
4)	Infective
	Syphilis
	Mycotic
	Secondary
5)	Connective tissue disorders
	Marfan syndrome
	Ehlers-Danlos syndrome
	Multiple aneurysms

Atheroma By far the most common cause of aneurysm in Britain is 'atheromatous degeneration'. Atheroma seems to be the end result of many types of insult to the artery wall; it is not a single disease but should be understood in the same way as the term 'fibrosis'. Hypertension is one well-recognized 'cause' of atheroma and it is not surprising to find that the majority (63%) of patients with abdominal aneurysms are hypertensive[2]. Hypercholesterolaemia rather than hypertriglyceridaemia seems to characterize dilating forms of atheroma in contrast to stenosing forms[3]. An 'inflammatory' type of aneurysm occurs in this group and is typified by a very thick fibrous wall and a lower incidence of rupture. Microscopically, inflammatory cells are seen in the aneurysm wall and the patient often has a high erythrocyte sedimentation rate[2]. Such a patient of mine, who was deemed inoperable 5 years ago because of extensive fibrosis involving the duodenum and left renal vein, making an approach to the neck of the aneurysm impossible, was treated by intraluminal wiring. He lost all his pain and is alive and well today. The localization of atheromatous aneurysms in the infrarenal aorta and popliteal arteries has given rise to the suggestion that absence of muscle support is a factor or that the aneurysm is the result of added stress because of resonance set up in the artery between points fixed by large branches.

Trauma Direct injury to arteries by knives and missiles may result in false aneurysms if

Postgraduate lecture delivered on 18th September 1974

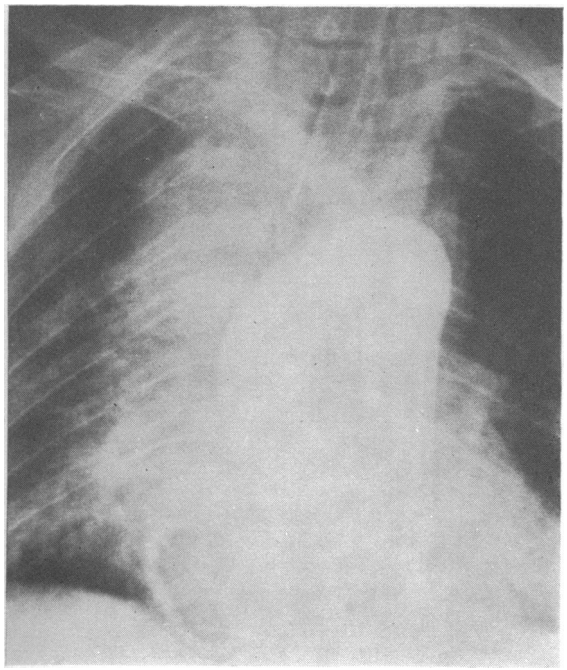

FIG. 1 *Arch aortogram of patient after road accident showing broadened mediastinum associated with false aneurysm arising at origin of right subclavian artery, which was partially avulsed.*

the wall is only partially divided, but these injuries are rarely seen in civilian practice. Indirect injury such as occurs in road accidents with tissue displacement is, in my experience, a commoner cause.

A man aged 40 was involved in a head-on collision while driving. He was noted to have no right radial pulse and a dislocated sternoclavicular joint. A chest X-ray showed broadening of the mediastinum and arch aortography revealed a false aneurysm at the origin of the right subclavian artery (Fig. 1). At operation through a median sternotomy with extension of the incision in the line of the clavicle it was clear that posterior dislocation of the inner end of the clavicle with associated gross displacement had partially torn the subclavian artery from its origin. Repair was accomplished with a good result.

It has to be admitted that the commonest cause of arterial injury is iatrogenic, and the vascular surgeon and investigator of cardiac patients are equally to blame. An aneurysm arising from the common femoral artery is illustrated in Figure 2. This followed the passage of a percutaneous arterial catheter. The aneurysm was excised and a tiny defect in the artery was closed with two Prolene sutures.

Silk sutures must never be used to join Dacron arterial prostheses to arteries. Although silk is non-absorbable by general surgical standards, it is a biological product and does in fact slowly disintegrate in the tissues, losing most of its strength after a few months. Stoney *et al.*[4] found that almost one-quarter of anastomoses completed with silk became the site of anastomotic false aneurysms.

Poststenotic dilatation Subclavian artery aneurysm in association with cervical rib (Fig. 3) is an example of poststenotic dilatation, the second part of the artery being nipped between the abnormal rib and the scalenus anterior muscle. These aneurysms nearly always present because of emboli formed in the sac passing to the brachial artery or its branches. Unilateral Raynaud's phenomenon must make you think of cervical rib and its complications and calls for an arteriographic study.

Infective Syphilitic aneurysms are now uncommon and usually affect the thoracic

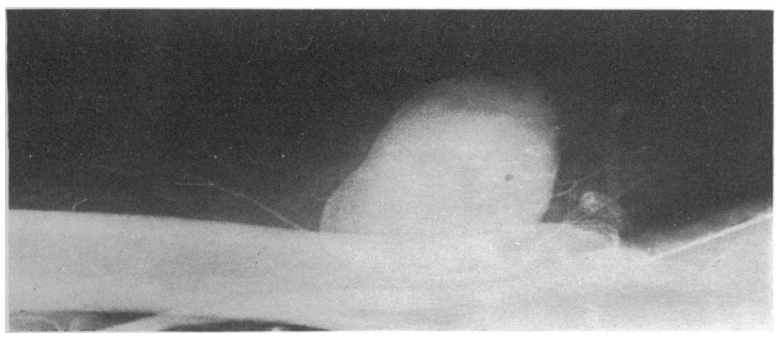

FIG. 2 *Common femoral artery aneurysm following investigation by catheter.*

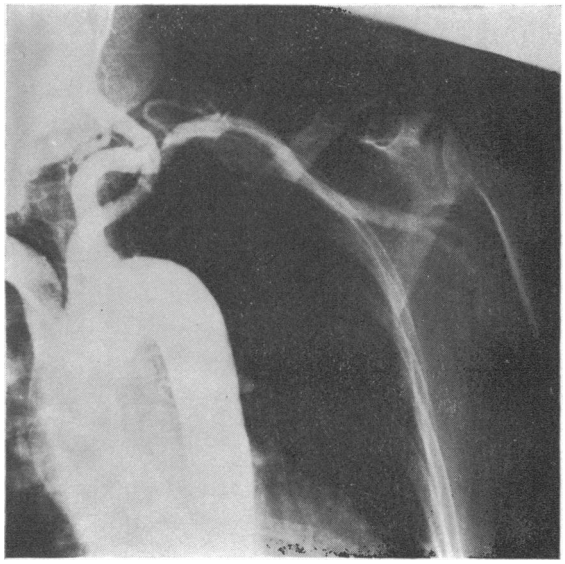

FIG. 3 *Subclavian aneurysm associated with cervical rib. There is much thrombus in the aneurysm and the brachial artery is occluded.*

aorta, while mycotic aneurysms have also become less frequent with the development of antibiotics. An occasional problem now is dealing with apparently atherosclerotic abdominal aortic aneurysms which are found incidentally to contain staphylococci, salmonellae, or other organisms. It seems probable that in most of these cases the bacterial infection is secondary, for an organism gaining access to the blood stream is likely to settle in the thrombus which lines an existing aneurysm. If this is not recognized at the time of surgery and a prosthetic graft is inserted the outcome is likely to be unfortunate. When the thrombus in an aneurysm looks unusual it should certainly be sent for culture and there is a lot to be said for culturing the thrombus from all aneurysms as a routine.

Connective tissue disorders Poor connective tissues result in weak arteries, so that aortic aneurysms are a well-recognized feature of arachnodactyly (Marfan's syndrome) and the Ehlers-Danlos syndrome. Occasionally multiple peripheral aneurysms are found in patients in whom no specific connective tissue disorder can be identified.

Sites

Where do aneurysms occur? They may

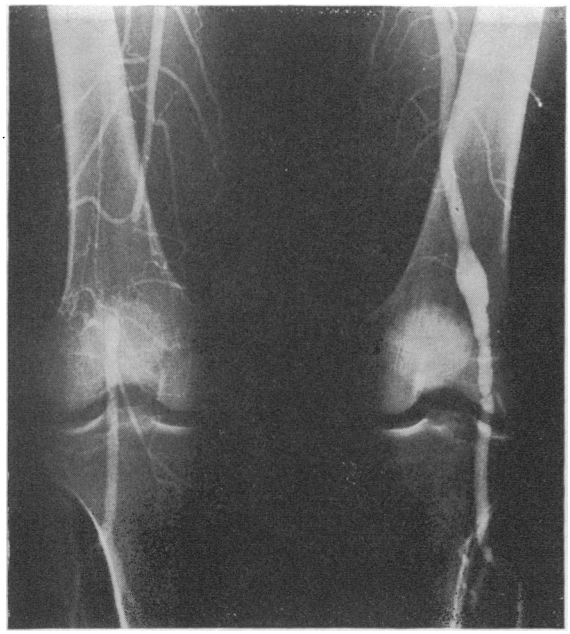

FIG. 4 *Arteriographic study of man who presented with claudication due to thrombosed right popliteal aneurysm. What should be done about the left popliteal aneurysm?*

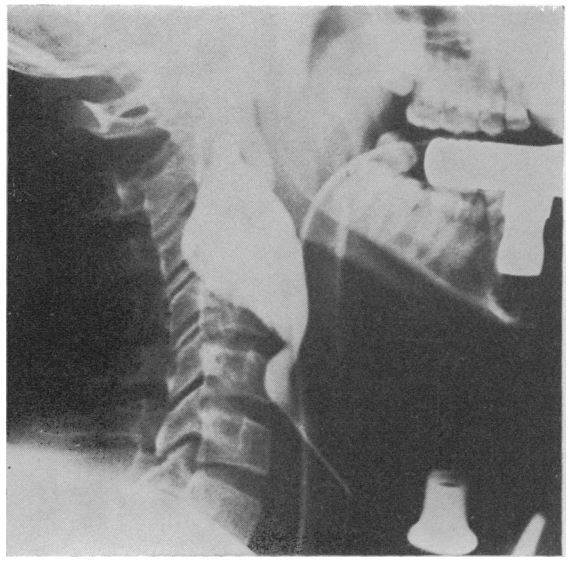

FIG. 5 *Arteriogram of internal carotid aneurysm in a man of 25 which was replaced by a saphenous vein graft. Note loop formed in artery above aneurysm. Sometimes there is sufficient artery for end-to-end anastomosis after resection of the aneurysm.*

occasionally be found on any artery but there are certain characteristic sites in addition to those already mentioned. Atheromatous aneurysms affect the femoral and popliteal arteries and are often eventually bilateral (Fig. 4). The forehead and palmar arteries may be the sites of small aneurysms following trauma. Aneurysms of the carotid arteries, and particularly the internal carotid artery, are well documented, often in quite young patients (Fig. 5). Visceral artery aneurysms are uncommon but are an occasional source of profuse intraperitoneal haemorrhage. Most typically the patient is a pregnant young woman with a ruptured splenic artery aneurysm who can be saved by a splenectomy.

Aneurysmal swellings in unusual sites should make you think of highly vascular tumours, especially secondary deposits from renal carcinoma, or the possibility of an arteriovenous malformation.

General management

Because aneurysms get larger, occupy more and more space, thrombose, embolize, cause pain, and rupture most require surgical treatment, which in modern terms means replacement by a Dacron prosthesis or autogenous vein graft.

Asymptomatic femoral and popliteal aneurysms which often remain small and may be self-curing by thrombosis can be observed and are an exception to the general rule.

It is also justifiable to observe painless small abdominal aortic aneurysms in very elderly or ill patients providing they are not causing symptoms. Pain means impending rupture!

Abdominal aortic aneurysm

This is unquestionably the commonest aneurysm with which the British surgeon is confronted, and although the diagnosis is often obvious in a slightly built patient, it is easily missed in the obese.

Presentation (Table II) The most sinister symptom of these aneurysms is undoubtedly pain. Pain means that the aneurysm is enlarging and stretching the retroperitoneal tissues. I know of two patients who seemed well apart from some abdominal pain and whose aneurysms ruptured while waiting just a few days for urgent hospital admission. Pain from an abdominal aneurysm is a clear and absolute indication for operation. The nature of the pain may vary from mild 'indigestion' to a severe constant complaint requiring opiates for its relief, while back pain is particularly significant. It becomes severe when rupture occurs, when it may be misdiagnosed as due to pancreatitis or renal colic. Occasionally the aneurysm will compress the lumbosacral trunk, giving rise to severe pain in the buttock or sciatic distribution.

TABLE II *Presentation of abdominal aneurysms*

1)	Pain
	Indigestion
	Severe abdominal pain
	Back pain
	Nerve compression
2)	Pulsating mass
3)	Ischaemia
	Associated peripheral vascular disease
	Embolism
	Thrombosis of aneurysm
4)	Urinary symptoms
5)	Venous thrombosis
6)	Rupture

A pulsating mass may be the presenting symptom, as it was in an otherwise fit 76-year-old spinster patient of mine who was distressed because she could not get her skirt on to take her 82-year-old sister for a walk each day. She was back at this task 3 months later.

Carefully examine the abdomen of every patient with claudication or other signs of leg ischaemia. Now and again you will find an abdominal aneurysm which is causing these symptoms by embolism or because of associated peripheral vascular occlusive disease. A third possible cause of claudication is thrombosis of the aneurysm itself or of an associated femoral or popliteal aneurysm.

Pressure on the bladder by a large aneurysm may present as prostatism. In these cases a pulsating mass can often be felt per rectum; if no associated aneurysm is felt in the abdomen you are dealing with an aneurysm of the internal iliac artery. Thus rectal examination is also useful in assessing the extent of aneurysmal disease! Fibrosis around ureters will lead to obstruction, and haematuria follows rupture adjacent to the urinary tract. Encroachment by the aneurysm on the inferior vena cava may lead to caval thrombosis, which is surprisingly uncommon considering the

close relationship of the two vessels.

Rupture of the aneurysm presents in one of three main ways. It may lead to catastrophic intraperitoneal haemorrhage if the tear is situated in the anterior wall, and these patients are unlikely to reach hospital alive. Fortunately, however, only 20% of ruptures occur in this position. Most ruptures (70%) are retroperitoneal, but even so are quite extensive, resulting in severe pain and collapse, often with a palpable pulsating haematoma in one loin or iliac fossa. Increased tissue tension and the fall in blood pressure to some extent slow down the bleeding, but all patients die within 48 h unless resuscitation and surgery are carried out. In a third group (10%) the rupture is small and sealed off by surrounding tissue, the condition of the patient remains good, and the local tenderness and pyrexia from absorbed blood products may lead to a mistaken diagnosis of intraperitoneal sepsis[5].

Assessment of the patient A careful assessment of the patient must be made before embarking on the major procedure of replacing an abdominal aorta. A full cardiovascular history is essential as carotid bruits, myocardial infarcts, hypertension, heart failure, and peripheral vascular disease are frequently associated problems. In addition peptic ulcers[6] and gut cancers[7] frequently coexist in this age group.

Is it an aneurysm and if so how large is it? Place the fingers of each hand on either side of the aorta and assess whether the pulsation is transmitted or truly expansile. An aorta of more than 5 cm diameter is accepted as aneurysmal. Can you get above it? If you can get your fingers over the upper end of the aneurysm below the costal margin the dilatation will be found to start below the renal arteries at operation. Always sit the patient up and look at his back and you will not be taken in by the displaced aorta consequent upon a kyphoscoliosis (Fig. 6). Another possible cause of confusion, grossly elongated and tortuous iliac vessels, may give the impression of an aneurysm (Fig. 7). You must note the presence or absence of femoral, popliteal, and foot pulses because postoperative loss of a pulse is an indication to return your patient to the theatre for embolectomy.

Special investigations will include renal function studies, electrocardiography (ECG), a chest X-ray, and intravenous pyelography with lateral views. These X-rays will demonstrate the shape and size of the aneurysm in many cases because of calcification in the wall of the sac (Fig. 8). Ultrasonography is the latest technique in our armamentarium as a non-invasive means of confirming and observing the size of aneurysms.

Most British surgeons consider that aorto-

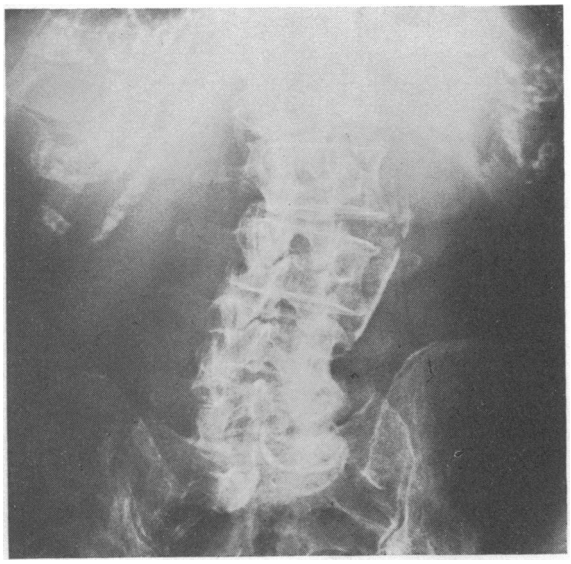

FIG. 6 *Kyphoscoliosis producing displacement of the aorta which may be mistaken for an aneurysm. Aortic calcification illustrates site of 'abnormal' pulsation.*

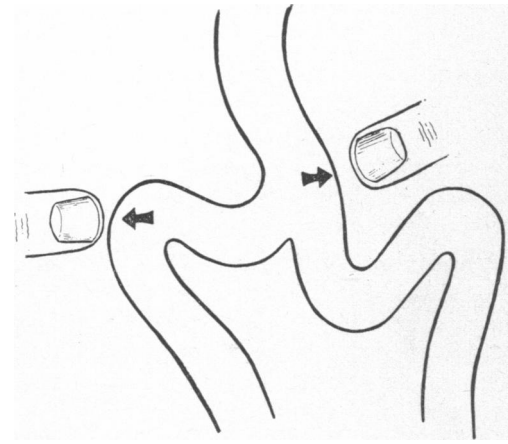

FIG. 7 *Grossly elongated and tortuous iliac vessels may give the impression of an aneurysm.*

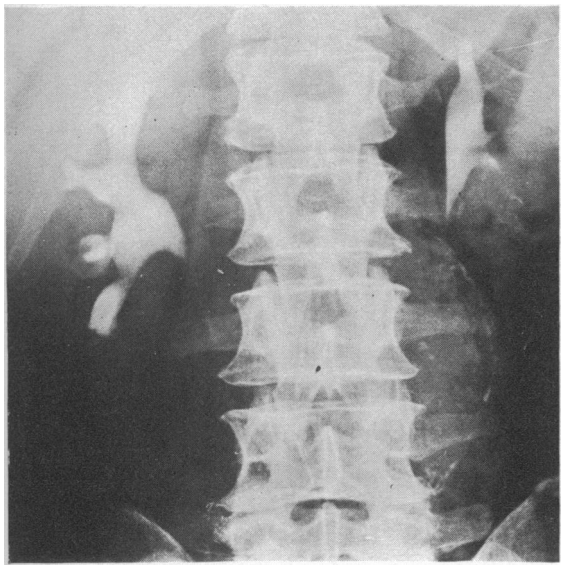

FIG. 8 *Calcification in wall of an aortic aneurysm demonstrated on intravenous pyelogram.*

graphy is hazardous and rarely indicated in the work-up of their cases. Szalagyi, of Detroit, however, has used it routinely and safely in several hundred cases. It should be done in any complicated case, as when there is doubt about the upper limit of the aneurysm, or in the presence of associated peripheral vascular disease, especially if a femoral pulse is absent, to allow planning of the reconstruction. For the same reason complicated aneurysms of the aorta and iliac vessels are best outlined radiologically (Fig. 9). Other indications are associated renal hypertension and the presence of a horseshoe kidney as indicated from the pyelogram, for in these cases the renal arteries must be identified and preserved. Aortography should be avoided if there is clinical evidence of imminent rupture.

Preparation for surgery A planned operation with a small aneurysm can be a very smooth procedure from which the patient recovers as quickly as after a vagotomy and pyloroplasty, but our aim must be to make surgery of this magnitude as safe as possible for every patient. The large, complicated, adherent aneurysm and the ruptured aneurysm tax the most competent anaesthetist and surgeon.

To maintain the patient and monitor all the equipment we find that two experienced anaesthetists are required. To replace blood at an adequate rate two good intravenous infusion lines must be set up in addition to a central venous pressure line. An arterial line is also a great help and we use a radial artery catheter attached to an open-ended tube containing heparinized saline. This is fixed to a long pole reaching almost to the ceiling. Both surgeon and anaesthetist can then see by a glance at the 'skyline' what the arterial pressure is and act accordingly; for the surgeon this means stopping haemorrhage or replacing the aortic clamp while a blood deficit is made good. A urethral catheter is inserted to measure urine output and a nasogastric tube must be passed because dissection around the fourth part of

FIG. 9 *Translumbar aortogram in patient with a palpable abdominal aneurysm and claudication, demonstrating aneurysmal dilatation and stenosis of the iliac systems. Although the aortic lumen is only 3 cm in diameter arteriographically, at operation a large aneurysm was confirmed, the discrepancy being due to layers of laminated thrombus.*

the duodenum will normally result in ileus for a few days. ECG leads are essential for cardiac monitoring.

A heating mattress will make good some of the gross heat loss from prolonged evisceration, relieving the patient of this stress in the post-operative period and encouraging limb blood flow and thus flow down the reconstruction. A weighing machine for swabs and accurate blood loss estimation are essential and 10–12 units of cross-matched blood are held in readiness. The whole abdomen and both thighs must be prepared, for it is not uncommon to have to take the reconstruction down to the common femoral arteries.

When confronted by a patient with a ruptured aneurysm the same preparations are made. A little time spent resuscitating the patient is always well worth while. Sudden induction of anaesthesia in an unresuscitated patient in an effort to 'stop the bleeding' usually results in tragedy and should be attempted only if after a proper trial of resuscitation one is obviously losing ground. Undoubtedly the best place to resuscitate and prepare this type of patient is in the anaesthetic room, where the patient should be taken as soon as possible after arriving at the hospital. The best person to be in charge of resuscitation is an experienced anaesthetist, who will give the surgeon the word to start the operation at the optimal moment. To gain time for resuscitation and to make transportation safer a 'G' suit has recently been recommended[8]. When placed round the abdomen and legs and inflated this increases intra-abdominal pressure, decreasing bleeding and raising the blood pressure and thus allowing more time for preparation of the patient and cross-matching of blood.

Operation Of the three approaches to the abdominal aorta, the full-length midline or paramedian incision is most generally used. There are those who favour a transverse incision, for it is just as long as the pubis-to-xiphisternum incision, but I find this means that the upper end of the aorta is even more deeply placed. It may, however, give better access in some patients with severe kyphosis. The third approach, which has recently gained some favour, is an extension upwards of the well-known extraperitoneal exposure to the lower ureter or iliac artery which, it is claimed, results in less postoperative ileus.

Two large self-retaining retractors are placed in the full-length midline incision and the abdominal viscera are explored to exclude incidental disease. If a concomitant peptic ulcer is found this may be dealt with at the same time by highly selective vagotomy. It is unwise to open the gastrointestinal tract during an aneurysm operation. *Never* remove the appendix, and if the large bowel is opened inadvertently because of adhesions postpone the operation and come back another day. The hazards of sepsis are too great in the presence of a cloth graft to justify combined procedures except those of an undeniably sterile nature. For this reason I am hesitant to adopt gastrostomy in these patients and prefer to stick to nasogastric drainage.

The extent of the aneurysm is now assessed for its complexity and operability. If despite clinical evidence it is found to extend well above the renal arteries the operation must be abandoned and planned for another occasion when bypass facilities are available. Expose the aorta by dividing the peritoneum just to the left of the small-bowel mesentery and third and fourth parts of the duodenum, if necessary mobilizing the whole of the right side of the colon and carrying out a Kocher manoeuvre on the duodenum. The small bowel and right colon are eviscerated over the left costal margin and placed under a moist pack or inside a plastic bag. Dissect the fourth part of the duodenum off the aorta and a little above this will be found the left renal vein crossing the aorta just below the origin of the renal arteries. If access to the neck of the aneurysm is really difficult the upper end of the inferior mesenteric vein may be divided, and it is also occasionally justifiable to divide the left renal vein. This rarely results in renal embarrassment as collateral flow along the adrenal, ureteric, and testicular veins is adequate[9]. Next the aorta just above the aneurysm is isolated by gentle finger dissection and the use of a blunt-ended, curved dissecting forceps. Fortunately, because the expanding aneurysm lifts this part of the aorta forwards (Fig. 10), this is often a fairly simple procedure and a tube or tape can be placed around the neck, giving quick control of any sudden haemorrhage. The vessels at the lower end of

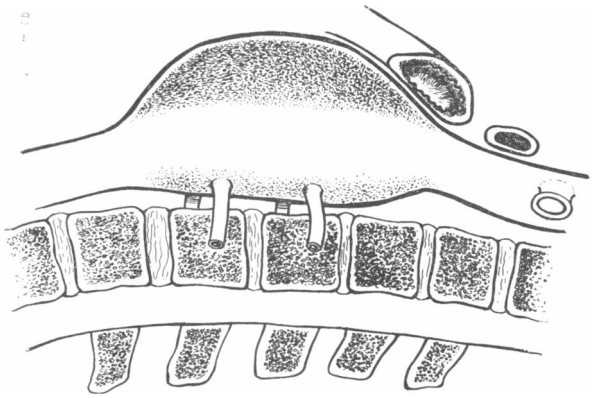

FIG. 10 *Diagram of sagittal section of aortic aneurysm showing its relationship to the renal arteries, left renal vein, duodenum, and lumbar arteries.*

the aneurysm are isolated in the same way at a level depending on the distal extent of the dilatation.

Aortic and iliac clamps are now placed across the vessels and 20–40 ml of heparin in saline (30 mg in 200 ml) is introduced into the iliac vessels below the clamps. A vertical incision through the aneurysm invariably reveals quantities of atheroma and thrombus which are quickly scooped out of the sac to reveal the mouths of a few lumbar arteries bleeding back into the sac. These are transfixed from within the sac to obtain haemostasis. No attempt is made to excise the aneurysm completely as the vena cava and ureters can be damaged; gross redundancy of the sac can be excised and the remainder should be folded back on the posterior abdominal wall and tacked down with a few sutures. A woven Dacron graft is now sutured end to end to the neck of the sac with a Dacron suture. The lower end of the reconstruction will be either to the aorta just above the bifurcation or, with a bifurcated graft, to the iliac arteries or even the common femoral arteries if aneurysmal change is very widespread. One should aim to exclude all grossly aneurysmal vessels from the arterial circulation but to preserve the flow in at least one internal iliac artery to ensure a blood supply to the left colon. If there is any doubt about distal embolism pass a Fogerty catheter down the limb vessels before completing the distal anastomosis.

Closed suction drainage is instituted to the retroperitoneal region and the abdomen is closed with great care. I always give an appropriate broad-spectrum and antistaphylococcal antibiotic intravenously both during surgery and for a few days after. This is not an excuse for sloppy surgery—indeed, as I have already emphasized, this is an operation where great care must be taken with aseptic technique—but because several recent trials have shown that suitable prophylaxis does decrease the rate of wound infections[10]. Infection of these grafts is very difficult to eradicate and often results in massive secondary haemorrhage necessitating removal of the graft, with risk to life and limb.

The technique with a ruptured aneurysm is basically the same, but speed is of the essence if bleeding is rapid. Fortunately the haematoma has usually done most of the dissection and it is often easy to open the posterior peritoneum and feel for the neck of the sac with the fingers. If initial difficulty is found controlling the neck we have found that if a small opening is made in the sac a size-30 Foley catheter can be inserted (Fig. 11) into the lumen of the aorta above the neck and the balloon distended to halt the haemorrhage[11]. Alternatively the aorta can be clamped temporarily above the renal arteries by opening

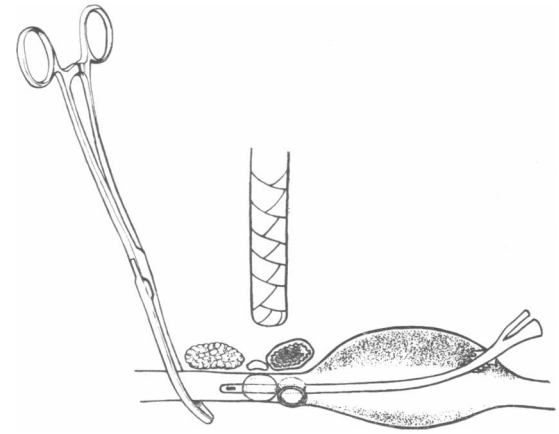

FIG. 11 *Methods of controlling bleeding from difficult aneurysm by balloon tamponade, clamping above the pancreas, or pressure against the spine with a heavy blunt instrument.*

the lesser omentum and finding the vessel lying between the crura of the diaphragm in the posterior wall of the lesser sac. Renal artery perfusion must, of course, be resumed as quickly as possible.

Postoperative care At least 24 h in the intensive therapy unit after the operation is mandatory as there are so many serious complications (Table III) to be avoided. Intensive care cannot be fully reviewed here, but a few points need to be emphasised.

Maintenance of blood volume Continuing loss of blood into the retroperitoneum is usual after this operation. Blood replacement and adequate fluid must be given based on repeated central venous pressure, blood pressure, hourly urine output, and drainage measurements together with an estimate of the adequacy of peripheral perfusion of the tissues. One word of warning—in units dealing with open heart surgery quite high central venous pressure readings (+ 15 cm H_2O (1.5 kPa)) are often advocated. This may be correct for the young postoperative cardiac patient but is much too high for an elderly man with coronary ischaemia recovering from aortic rupture, when + 5 cm H_2O (0.5 kPa) is adequate. Although large amounts of fluid are often necessary for the first 2 or 3 days, on the 4th and 5th days patients start to reabsorb oedema and it is very easy to overload them at this time.

Ventilation Elderly bronchitic patients, often with a history of coronary ischaemia, do not breathe well after a period of shock, a major operation, and a full-length abdominal incision and always require ventilation for a day or two. Blood gas estimations help to make a decision, but if your patient is labouring over his breathing he will exhaust himself and ventilation can only be of benefit.

Renal function It is well recognized that some renal impairment is common after surgery of the infrarenal aorta, although the mechanism is not clear. Add to this arteriosclerosis, hypertension, shock, and perhaps temporary clamping above the renal arteries and the necessity of monitoring renal function becomes obvious. A urinary output of 50 ml/h or more should be maintained and judicious use of fluid and diuretics will help to regulate this.

TABLE III *Complications of aortic aneurysm surgery*

1) Haemorrhage
2) Clotting deficiencies
3) Respiratory embarrassment
   - Previous obstructive airway disease
   - Pain from long incision and exhaustion
   - Shock lung—fibrin microemboli
4) Peripheral arterial embolism
5) Renal failure
6) Myocardial infarction
7) Haemorrhagic gastritis
8) Bowel ischaemia
9) Sepsis
10) Aortoduodenal fistula
11) Further aneurysm in other vessels
12) Paraplegia.

Indications for reoperation Peripheral pulses must be monitored postoperatively and as after any vascular operation excessive haemorrhage, evidence of thrombosis of the graft, or distal embolism are absolute indications to return the patient to the operating theatre. The passage of a Fogerty catheter through a small groin incision is such a simple procedure that it should not be withheld even in a very ill patient. In practice the attention from the anaesthetist often results in improvement in the patient's general condition. It is a shame to save a life but lose a limb for want of a little extra effort.

Ischaemic necrosis of the left colon is occasionally seen, especially after surgery for ruptured aneurysm, even when the internal iliac flow has been ensured. The only hope then is to remove this portion of the bowel.

Myocardial infarction and stress ulceration of the stomach with haematemesis will be familiar to you. The other complications I have listed are fortunately rare.

Finally remember that the patient with a ruptured abdominal aneurysm passes through five crises in the first few hours when he is particularly liable to cardiac arrest if supportive measures are inadequate. The first is before he has been adequately resuscitated; the second is during induction of anaesthesia; the third results from decompression on opening the abdomen; the fourth is at the time of removing the aortic clamp after completing the reconstruction—at first allow just a few beats through at a time and remind your anaesthe-

tist to give some bicarbonate; the last is when you have gone to bed not realizing that bleeding often continues for several hours after the operation.

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