# RUPTURED ABDOMINAL AORTIC ANEURYSMS

I. PENN, M.B., B.CH. (RAND), F.R.C.S. (ENG.), *Senior Medical Officer in Surgery, Baragwanath Hospital and the University of the Witwatersrand, Johannesburg*

Until recent years, rupture of an abdominal aortic aneurysm has been almost invariably fatal. In 1952 Dubost *et al.*[21] reported the first successful resection and homograft replacement of an unruptured aneurysm of the abdominal aorta. Since then this has become the standard treatment of the condition. This procedure has also made it possible to save many patients with ruptured abdominal aortic aneurysms. Up to the present there are not many case reports — less than 150 in the English language literature — of resections of ruptured abdominal aortic aneurysms, and the majority of case reports are from a few centres in America,[16,25] dealing with large numbers of aneurysms. In the literature of this country there have been no detailed case reports of successfully resected ruptured abdominal aortic aneurysms, although Goetz *et al*[20] very briefly mentioned one that they had successfully resected. For this reason a further case is reported (the first time, to my knowledge, that this has been reported in an African patient), and the literature is reviewed.

## CASE REPORT

S.M., an African male, aged 48 years, was admitted to hospital in October 1960, complaining of a sudden pain in the left side of the abdomen, which came on while he was lifting a heavy weight. Before this he had been perfectly well.

*Examination* revealed an obese patient (weight over 200 lb.), who had marked pallor. Pulse rate was 130 per minute, and blood pressure 60/0 mm. Hg. Abdominal examination revealed a pulsatile mass, about 3 inches in diameter, in the middle of the upper abdomen. There was marked tenderness and guarding in the left flank, and an hour later there was a suggestion of a mass in this region. Both femoral pulses were palpable.

*Diagnosis* was ruptured abdominal aortic aneurysm.

*Pre-operative treatment.* Blood transfusion was given through 3 cut-downs, the patient was anaesthetized (Dr. A. J. McKenzie and Dr. H. Ginsberg), and hypothermia was induced by surface cooling.

*Operation*

When the oesophageal temperature was 28° C. operation was commenced (4 hours after admission, and 7 hours after the onset of symptoms), the abdomen being opened through a left paramedian incision, extending from the xiphoid to the

pubis. A massive haematoma was found in the retroperitoneal tissues on the left side, and this had extended into the mesentery of the small bowel. About 1 pint of blood-stained fluid was present in the peritoneal cavity. The aneurysm commenced just below the level of the renal arteries, and extended distally into the proximal portion of the right common iliac artery. It had a ½-inch tear in its anterior wall near its centre.

The aorta immediately above the aneurysm was mobilized, and an arterial clamp was applied across it, just below the level of the renal arteries. The common iliac arteries were then mobilized and clamped, and 20 ml. of heparin in saline were injected into each iliac artery distal to the clamp. The aneurysm was then excised and a woven 'teflon' bifurcation-graft inserted. After completion of the aortic anastomosis, the left common iliac anastomosis was attempted. However, this vessel was grossly atheromatous and friable, and the stitches kept cutting out, so that eventually the left common iliac artery had to be ligated. The graft on this side was now too short for anastomosis with the external iliac artery, the whole graft had to be removed, and a further teflon graft had to be inserted. The right anastomosis was completed first, the graft being anastomosed end-to-end with the right common iliac artery, after which the blood flow to the right leg was restored by removal of the aortic and right common iliac clamps, the left limb of the graft being clamped. On the left side the graft was anastomosed end-to-side to the left external iliac artery. The period of aortic and right common iliac occlusion was 3 hours and 10 minutes, and that of the left common and external iliac arteries was 3 hours and 55 minutes. Owing to the large defect present, it was not possible to close the posterior peritoneum. The abdomen was drained through a separate stab incision in the left flank, and the abdomen was closed with interrupted silk sutures through all layers except skin, which was separately sutured. Total operation time was 6 hours, and the patient was transfused with 22 pints of blood.

*Postoperative Course*

Postoperatively he had intravenous-drip therapy and nasogastric suction, until flatus was passed, when oral feeding was commenced. Antibiotics were administered. Immediately following the operation the blood pressure was 120/70 mm. Hg, and good femoral pulses were detectable. Six hours later the dorsalis pedis pulses were felt, and the patient also passed urine at this stage. Bowel sounds were audible on the third day, and the patient had a bowel action on the fourth day. Urinary output was good at all times.

*Convalescence* was uneventful, apart from superficial wound sepsis, which delayed the patient's discharge from hospital till the 25th day.

When seen 9 months after operation, the patient was well and was working as a porter, again lifting heavy weights. He was able to walk considerable distances without any discomfort, and had good pedal pulses.

*The resected specimen* showed gross atherosclerotic changes.

## DISCUSSION

*Aetiology*

The cause of abdominal aortic aneurysm, in the vast majority of cases, is atherosclerosis.[2,65] Estes[26] found that 95% of a series of 102 cases were caused by atherosclerosis, and de Bakey *et al.*[16] reported a similar incidence in an even larger series of cases. Maniglia and Gregory,[43] in an analysis of 6,000 autopsies, stressed that syphilis as a cause of these aneurysms is diminishing, and that the incidence from atherosclerosis is rapidly increasing.

*Sex.* The condition occurs predominantly in males, the male : female ratio being 4 : 1.[16,55]

*Age.* The condition occurs most commonly in the fifth, sixth, and seventh decades,[16] the average age of women being 73 years, and of men 65 years.[55]

*Race.* Atherosclerosis is far less common in the African than in the White patient. Thus, abdominal aortic aneurysms caused by atherosclerosis are also less common, and Goetz *et al.*,[29] in a series of 28 such cases, found 25 among White patients, 3 in Cape Coloured patients, and none in Africans. However, abdominal aortic aneurysms from atherosclerosis and other causes do occur in these patients, and during the past 9 months, 6 abdominal aortic aneurysms occurring in African patients were resected and grafted at Baragwanath Hospital. Of these, the present patient was the only one who was operated on for rupture of the aneurysm and is, as far as I am aware, unique in being the first successfully treated African patient.

*Association with hypertension* is common, occurring in 60% of patients.[17,55]

*Anatomical Features*

The effect of atherosclerosis on the aorta is one of converting a highly elastic tube into a rigid, tortuous structure, which is unable to withstand the strains of arterial pulsation without some loss of form. Since the degenerative process is diffuse, the resultant general weakening of the wall gives rise to a fusiform aneurysm.[59] Blakemore[7] has pointed out that the abdominal aorta is well supported at its upper and lower ends, with a long middle section lying relatively unattached. It is in this unsupported area that dilatation takes place.

Distally, the aneurysms usually extend to involve the aortic bifurcation and often the iliac arteries, while proximally, in the vast majority of cases, they arise below the origin of the renal arteries.[1,2,16,31] Usually there is a sufficient margin of relatively normal aorta between these vessels and the commencement of the aneurysm to allow the application of a clamp to the aorta without occluding the renal blood flow. This is important from the surgical point of view for 2 reasons:

Firstly, the fact that the aorta is occluded so low down during the resection and graft replacement of the aneurysm, very considerably reduces the danger of ischaemic damage to the kidneys, spinal cord, and other vital organs.

Secondly, there is usually an adequate amount of relatively normal aorta immediately below the level of the renal arteries to permit anastomosis to the graft.

*Natural History of Abdominal Aortic Aneurysm*

The usual fate of a patient with an untreated abdominal aortic aneurysm is for it to rupture, and this applies particularly to patients in the younger age group, between 40 and 50 years.[59] Untreated aneurysms have a dismal prognosis. Numerous reports in the literature illustrate this fact. Colt[9] analysed a series of 121 patients with abdominal aortic aneurysms, and found that the average duration of life was less than 2 years. In a series of 102 cases, Estes[26] found that only 49·2% were alive in 3 years, and only 10% of patients aged 65 years survived 8 years, whereas 65% of normal people of this age would have a life expectancy of such a duration. In 63·3% of the patients death was due to rupture of the aneurysm. Further, the degree of symptoms apparently had no relationship to prognosis, since the patients who were asymptomatic at the time of diagnosis lived no longer than those

who had symptoms. Kampmeier,[35] in a series of 38 patients, found that death from retroperitoneal haemorrhage occurred in 81·6%, while Barratt-Boyes,[2] in a series of 36 patients, found that 73% were dead from rupture within 3 years. Only 2 patients were alive after 5 years. Wright *et al.*,[70] in a series of 68 patients, found that less than 5% lived 5 years, and stated that an aortic aneurysm has a prognosis comparable with many forms of cancer.

In general, these statistics suggest that the average period of survival after diagnosis is between 1 and 2 years, with rupture ultimately occurring in most cases.[16]

*Precipitating cause of rupture.* Rupture may occur while the patient is at rest, but the onset may take place after injury,[61] or while the patient is taking moderate exercise such as digging.[11] In a few cases rupture occurred during defaecation, and in 2 (including the present case) symptoms developed while the patient was lifting a heavy weight.[11]

*Pathology of rupture.* The aneurysm usually contains laminated thrombus, which gradually undergoes liquefaction immediately adjacent to the wall of the aneurysm. De Bakey *et al.*[16] considered this to be an important factor contributing to eventual rupture of the aneurysm.

Another factor affecting rupture of aneurysms is their size. Crane[13] found that the greater the size of the aneurysm the higher the incidence of rupture. Lesions that were at least 7 cm. wide had a far higher incidence of rupture than the smaller ones.

When rupture occurs, it usually results in bleeding in the retroperitoneal tissues, with stripping up of the peritoneum. Less commonly, rupture occurs into the general peritoneal cavity, or an adjacent hollow viscus, usually the third part of the duodenum, giving rise to massive haematemesis and melaena.[68] Very occasionally, rupture may occur into the inferior vena cava, giving rise to a massive arteriovenous fistula.[18,24]

'*Acute aneurysm*' is a term used by Elliot *et al.*[25] to describe an aneurysm which presents clinically with acute abdominal signs and symptoms suggestive of rupture, yet at laparotomy no rupture is found to be present. Rupture is, however, imminent, and resection and graft replacement is advisable. This is borne out by the fact that one of Elliot's patients, treated expectantly after exploratory laparotomy for acute abdominal symptoms, had revealed an intact aneurysm and died 10 days later from frank rupture. Gerbode[29] also reported having operated on at least 3 patients thought to have ruptured aneurysms, but found instead a remarkable inflammatory response around the aneurysm, no doubt from small tears or dissection in the wall and, perhaps, also from the foreign-body reaction occasioned by the clot itself. Savage and Harris[58] also reported a patient with this condition.

### Natural History of Ruptured Aneurysm

There is a widespread misconception that rupture of an abdominal aortic aneurysm is fatal within a matter of minutes. This may be so when there is free rupture into the general peritoneal cavity, or into a hollow viscus;[27] however, with the usual type of retroperitoneal bleeding, death may be delayed for many hours, or even days or weeks. Thus, Blakemore[6] found that an interval of 2 - 6 days almost invariably occurred after retroperitoneal haemorrhage began, before death ensued from sudden rupture of the retroperitoneal haematoma into the peritoneal cavity. Other authors[34,35] have stressed this point. Usually, the interval is not less than 12 hours,[2] and the patient may withstand transport for distances up to 160 miles immediately before operation.[11] Even when rupture occurred into the gastro-intestinal tract, death followed within 6 hours in only 17 of 63 cases, while in 25 cases the interval was from 1 day to 2 weeks.[68] This delay is probably due to the large thrombi, so frequently found in these aneurysms, which temporarily occlude the site of rupture.[29] Increasing pressure within the retroperitoneal haematoma may also help to slow down further blood loss from the tear in the aneurysm.[45]

Thus, in most instances of ruptured abdominal aortic aneurysm there is a sufficient interval between the onset of bleeding and death to permit life-saving measures to be instituted.

## DIAGNOSIS

The diagnosis of an abdominal aortic aneurysm has often been made before rupture occurs, and in these cases diagnosis of rupture is fairly easy. But it is not uncommon for symptoms caused by rupture to call attention to the aneurysm for the first time;[25] then the diagnosis is often missed. Thus, Barratt-Boyes[2] found that in only 7 of 18 cases was the correct clinical diagnosis made. Elliot *et al.*[25] found that valuable time was lost before operation, the average delay being 12 hours. They stressed that, with increasing experience of the condition, the diagnosis can be made with ease in most instances. It is essential that the diagnosis should be made early, so that surgery can be undertaken with the patient in as good a condition as possible.

The diagnosis depends upon a triad of symptoms and signs, consisting of (1) pain, (2) shock, and (3) the presence of an abdominal mass.

### 1. *Pain*[41]

The fact that most abdominal aortic aneurysms are atherosclerotic in origin, has an important bearing on the symptoms. Blakemore[6] has shown that syphilitic aneurysms commonly erode the vertebrae, giving rise to nerve-pressure pain, whereas atherosclerotic aneurysms rarely do so, the aorta in this condition being elongated and tortuous, and angulated forwards, so that the aneurysm is hardly in contact with the vertebrae. Thus, pain from vertebral erosion is uncommon, and *the onset of pain is a warning of impending disaster.* It indicates that the aneurysm is enlarging and that rupture is imminent.

Rupture is heralded by a sudden increase in the severity of the pain. On occasion the onset is dramatic, with a sensation that something has burst or torn internally,[27] or it may be spread over a few minutes, or even half an hour. The pain is excruciating, and may be most severe in the back or over the sacrum, but it may occur anywhere in the abdomen, in the thigh, or in the testicles, depending on the direction in which the haematoma dissects. It may radiate as a result of lumbar-root irritation, and may resemble acute prolapse of an intervertebral disc.[45,57] It may mimic renal colic, or gallstone colic;[30,37] other conditions with which it has been confused are

coronary thrombosis, perforated peptic ulcer, acute pancreatitis, intestinal obstruction, and mesenteric vascular occlusion.[25,40]

After the initial period of pain, which may persist for 6 - 8 hours, the patient's condition improves for as long as 24 or even 48 hours, owing to temporary arrest of the bleeding. Then there is a sudden return of the pain, which is as severe as it was at first, but its distribution is often different. It is uncommon for more than 3 episodes of pain to be experienced before the final fatal bleed.[41]

2. *Shock*

This develops after the onset of the pain. Signs of shock may be absent for a long time, for the temporary arrest of bleeding from the aneurysm results in a period of apparent well-being, which may last for several days or even weeks. Mavor *et al.*[45] stressed the fact that in the initial stages the illness is often not a dramatic one, and Elliot *et al.*[25] found that one of the reasons for the delay in diagnosis was this period of compensated shock. However, once shock develops, it is most severe, and is far more marked than in most of the conditions with which a ruptured retroperitoneal aneurysm is likely to be confused. The severe shock is not entirely accounted for by the amount of blood loss, but it is probably — at least partly — the result of disruption of the great autonomic centres in the retroperitoneal tissues and the splanchnic bed.[41]

It is important that the diagnosis should be made before the onset of severe shock if the patient is to have a real chance of recovery.[45]

3. *Palpable Mass in the Abdomen*[41]

The diagnosis is relatively simple if, in addition, a pulsatile tumour can be felt in the abdomen. This may be well circumscribed, and confined to the region of the aorta. If the haemorrhage has been severe, there may be an extension into the flank, or into one or other iliac fossa. This is more readily felt under anaesthesia. It may or may not pulsate, for it is composed of haematoma, into which the arterial pulse wave spreads only during the actual period of leak from the aorta. The amplitude of pulsation in the haematoma may be considerably reduced by the pronounced hypotension, and may be difficult to detect because of muscle guarding. If the patient or his doctor noticed an abdominal swelling previously, the onset of haemorrhage may coincide with a sudden increase in its size, or with the appearance of a second swelling. On occasion the mass will literally increase beneath one's eyes.

It is not always easy to palpate the aneurysm, particularly where there is marked tenderness, guarding, and distension resulting from blood in the retroperitoneal tissues and, perhaps, in the peritoneum itself. Loewenthal *et al.*[41] stressed that the clinical picture is sufficiently characteristic for the diagnosis to be made even in the absence of a palpable mass.

Difficulties in diagnosis may result from the retroperitoneal haematoma presenting in the inguinal canal, and being mistaken for a strangulated inguinal hernia;[5] the haematoma in the flank has been mistaken for a perinephric abscess, and a haematoma which tracked along the psoas muscle to present in the femoral triangle has been mistaken for a psoas abscess.[40]

4. *Other Clinical Features*[41]

In some cases there is nausea and vomiting, from compression of the third part of the duodenum by the aneurysm and haematoma.[34]

There are 67 case reports in the literature[38] of abdominal aortic aneurysms which ruptured into the gastrointestinal tract, giving rise to haematemesis and melaena as the presenting symptom, but the history and physical signs, particularly the presence of a tender pulsating mass, will distinguish it from other causes of gastrointestinal bleeding.

In some cases irritation of the sigmoid colon by the blood infiltrating through the mesentery gives rise to diarrhoea.[61]

Abdominal examination, apart from the mass, reveals distension from paralytic ileus. Tenderness and muscle guarding may be present, but the marked rigidity associated with perforated abdominal viscera is absent, unless the haematoma has ruptured into the peritoneal cavity.

Bruising of the lower abdominal wall, in one or other flank, or on the anterior surface of the thighs, may appear, owing to direct extension of the extravasated blood. However, this is a late sign, and therefore not of great diagnostic value.

In contrast to dissecting aneurysms of the aorta, in which the extravasated blood separates the coats of the vessel, leading to eventual occlusion of the iliac and femoral arteries, the pulses in the femoral arteries in cases of ruptured atherosclerotic aneurysm usually remain palpable as long as the blood pressure is adequate.[11]

5. *Laboratory Investigations*

These confirm the presence of blood loss, there being a fall in the red-cell count and the haemoglobin level. There may be a marked leucocytosis.[68] This does not indicate secondary infection, but is simply a non-specific response to a large collection of effused blood.[41]

6. *Plain X-ray of the Abdomen*[11,41]

This may be extremely valuable in establishing a definite diagnosis. It may show calcification in the wall of the aneurysm. Surrounding the calcified area there may be a broad soft-tissue shadow from an extensive retroperitoneal haematoma. X-ray may also help in a negative way, by excluding radiopaque renal or biliary calculi, or the presence of gas under the diaphragm.

Very occasionally, an emergency aortogram may be necessary to establish a diagnosis of ruptured aneurysm.[20]

## TREATMENT

Emergency surgical treatment of a ruptured abdominal aneurysm is mandatory, unless there is previous knowledge that the aneurysm is technically unresectable, or unless the patient's condition prohibits the administration of an anaesthetic.

*Pre-operative Measures*

1. *Immediate blood replacement* is necessary, and the blood is best given in the arms, where blood flow will remain uninterrupted during the operation. One, or better 2, cut-downs are used. Surgery must not be delayed in the hope that

transfusion will improve the patient's condition. Indeed, this may cause resumption or extension of the bleeding. The sooner the operative control of aortic blood flow is obtained, the more effective is the treatment of shock. Accordingly, the operation should be started as soon as adequate amounts (4—5 litres) of blood are available, even though shock has not been completely relieved.

2. *A catheter* should be inserted into the bladder to keep it empty during the operation; this will facilitate the exposure of the iliac vessels.

3. *Hypothermia.* Some surgeons feel that this is helpful in treating shock and maintaining postoperative renal function.[25] Others[45] feel that it is necessary only where the aneurysm extends above the renal arteries. They commence hypothermia (by the wet-blanket method) at the same time as the operation, and it is discontinued if suprarenal aortic occlusion is found unnecessary.

*The Operation* [16,25,45,51]

A long midline, or left paramedian incision from xiphisternum to symphysis pubis is necessary. Once the abdomen is open, the first essential is to obtain control of the aorta above the level of the aneurysm.

If free rupture has occurred into the general peritoneal cavity with severe collapse, the bleeding is first staunched by pressure with an abdominal pack, while an assistant compresses the aorta against the vertebral column where it passes through the diaphragm. A padded wooden compressor can be substituted for the fingers.[25] A curved clamp is then thrust around the aorta, above the aneurysm, and a tape can then be rapidly drawn through above it and used temporarily to occlude the aorta, while it is dissected free for a short distance, to enable a right-angled vascular clamp to be applied around it. This temporarily deals with the problem of blood loss, and in the meantime blood is rapidly transfused into the patient.

In cases where the rupture is retroperitoneal, more time can be spent in dissecting out the aorta just distal to the renal arteries, where it is usually clear of aneurysmal dilatation. This dissection is often done blindly, because of the bulk of the aneurysm and extravasated blood. The posterior peritoneum is first incised; then blunt dissection with the index finger will enable the surgeon to encircle the aorta within a few minutes,[64] care being taken that the left renal vein is not damaged in the process. A vascular clamp is then applied.

Savage[56] stated that compression of the aorta against the vertebral column above the level of the renal arteries is difficult to maintain effectively, owing to interposition of soft structures, particularly the pancreas, and said that visceral damage might also result. He, and other authors,[34,47,64] therefore, advocate gaining control of the bleeding by first clamping the thoracic aorta through an anterior thoracotomy — the advantage being that it is a quick method of gaining proximal aortic control in cases where the aorta below the diaphragm is seriously obscured by haematoma. Also, it limits further haemorrhage that might occur following the relief of any tamponade effect of raised intra-abdominal pressure by laparotomy. The proximal occlusion is moved down to the area immediately above the lesion as soon as possible. However, this procedure has certain disadvantages:

1. Opening the chest increases the severity of the operation and enhances the risk of postoperative chest complications.
2. Clamping the aorta above the renal arteries increases the risk of renal failure.

Some authors[25,45] therefore feel that it is unnecessary. When it is necessary to control the aorta above the renal arteries, because of upward extension of the aneurysm, hypothermia should be used.

After the proximal aorta has been clamped, the small bowel is lifted out of the abdomen, by incising the mesentery and stripping it off the posterior abdominal wall. The iliac vessels are then isolated and clamped. To prevent clot forming in the aorta just above the clamp and in the iliac vessels distal to the clamps, 10 ml. of heparin in saline (5,000 units in 500 ml.) are injected into the lumina of the aorta above the clamp and the iliac arteries below the clamps, and this is repeated at intervals during the operation.[44]

The aneurysm is then removed, the lumbar vessels being divided and ligated. The inferior mesenteric artery, which is usually thrombosed,[15] is divided.

In some instances, the aneurysm is intimately adherent to the inferior vena cava and left iliac vein, and attempted removal of the aneurysm in such cases is a time-consuming procedure, and might result in serious injury to these vessels. It is better, in these cases, to open the anterior wall of the aneurysm, to remove all contained thrombus, and to cut away the aneurysm freely with scissors, leaving *in situ* the portion that is adherent to the veins. The ostia of the lumbar arteries, presenting in this remaining posterior wall of the aorta, are oversewn. The aorta and iliac vessels are then trimmed to obtain a satisfactory cuff of relatively normal vessel for anastomosis to the graft. One cm. of cuff beyond the clamp is ideal. In the rare instances where the aneurysm extends above the renal arteries, Savage and Harris[58] stated that the safest course is to divide the widened aorta below them, using the wide cuff for anastomosis to the graft, provided, of course, that the rupture is below this point.

Continuity is then restored by inserting an aortic homograft, or a plastic prosthesis, using continuous sutures of 4-0 black arterial silk. The proximal anastomosis is completed first. The iliac clamps are then temporarily released, to flush out from below any clots that might have developed in these vessels, distal to the clamps. One iliac anastomosis is then completed, after which the aortic clamp is momentarily released, to flush out any contained clot, which escapes through the unattached iliac limb of the graft. This limb is then clamped off, and the aortic clamp and the opposite iliac clamp are released to restore blood flow through the completed side, thus reducing total aortic occlusion time to the minimum. The remaining iliac anastomosis is then completed, taking care again to flush out the iliac artery before completing the anastomosis.

Most cases require anastomosis to the iliac vessels. In a few, a single anastomosis to a relatively normal aortic bifurcation is possible.

The distal anastomosis may be made by end-to-end anastomosis of the graft to the common iliac arteries. However, Mavor *et al.*[45] preferred making the anastomosis end-to-side to the external iliac artery, since this vessel is healthy and easy to mobilize. This is borne out in the present case, where the left common iliac artery was grossly diseased, and unsuitable for anastomosis, but the external iliac artery was in relatively good condition. Further, it has been shown[10,28] that long-term patency occurs more often in end-to-side than in end-to-end anastomosis.

Mavor *et al.*[45] preferred removing only the anterior wall of the aneurysm, so that, when the graft is inserted, it lies inside the aneurysm. This is not very satisfactory if a homograft is used, since it has no support from viable host tissues. Berman[3] favoured removal of the aneurysm, for those left *in situ* have caused degeneration of the graft with subsequent rupture and fatal haemorrhage. To obviate this, Cooley[12] sutured the omentum round the homograft to provide a satisfactory viable support. Another reason for removing the sac is that, if it is left in place, the danger of infection is considerable.[53,70]

Once the graft is *in situ*, the posterior peritoneum is closed with a running catgut suture. Elliot *et al.*[25] stated that it is necessary to bring peritoneum between the duodenum and the proximal anastomosis, since these structures may become adherent to one another, followed by erosion and gastro-intestinal haemorrhage. Cases of this type have been described by these authors and by Clayton *et al.*[8]

Aneurysms rupturing into uncommon situations, such as the gastro-intestinal tract, are also amenable to surgery,[28] the aneurysm being resected, and the gastro-intestinal defect — usually in the duodenum — being repaired.

Similarly, arteriovenous fistulae, following rupture of the aneurysm into the inferior vena cava, the common iliac veins, or the renal veins, can be successfully treated surgically, and de Bakey *et al.* recorded such a case.[18]

Drainage of the abdomen is advised,[25] because of the large

amount of extravasated blood in the retroperitoneal tissues. However, it carries the risk of introducing infection from without along the drainage tube.

Closure of the abdomen is simple, but must be strong. Evisceration of these huge wounds in elderly people is common, the distension from postoperative paralytic ileus being a contributory factor.[53] To prevent this complication, interrupted silk sutures, through all layers except the skin, were used in the present case. Elliot *et al.*[25] recommended through-and-through wire closure for both speed and security.

*Supportive Treatment during Operation*

Before proximal aortic control, blood transfusion should be limited, since any increase in blood pressure will cause further bleeding. Aortic control alone produces prompt improvement in the patient's condition, by diminishing further blood loss and by increasing the peripheral resistance. A rough estimate of the blood loss into the haematoma is made and this amount is rapidly infused. Any further blood loss during the operation is made good as it occurs. When the clamps are released, there is a sudden fall in blood pressure, owing to: (a) sudden diminution in the peripheral resistance, (*b*) reflex hyperaemia in the lower limbs, and (*c*) leakage from the suture lines.[45]

This fall should be treated by blood transfusion. In addition, Elliot *et al.*[25] treated this by intermittent re-application of the clamps until the patient's condition was stabilized, while Kenyon and Cooper[36] combated this fall in blood pressure by the application of pneumatic tourniquets to the lower limbs. These can be inflated and released when necessary. Other recommended measures are lowering the head of the table, and the use of a vasopressor drug immediately before release of the clamp.[32] It is most important that this fall in blood pressure should be prevented or combated at once, otherwise the patient, who probably has abnormal coronary arteries, may die from relative cardiac ischaemia.[53]

In patients with severe shock, or with shock resistant to control of the aorta and transfusion, intravenous hydrocortisone may be necessary during the operation, and in diminished amounts in the postoperative period.[25]

*Postoperative Treatment*

The expected ileus is combated by nasogastric suction and intravenous-fluid therapy. The head of the bed is elevated to enhance the arterial blood supply to the lower limbs. The haemoglobin levels are estimated daily, and any deficiencies made good. The urethral catheter is left *in situ* for several days. Antibiotics are administered. A careful check is kept on the urinary output, since oliguria is an important complication. Retained bronchial secretions are common in aged patients subjected to a major operation, and tracheotomy is sometimes necessary to deal with these.

## POSTOPERATIVE COMPLICATIONS[25,45]

1. *Gastro-intestinal Complications*

(a) *Paralytic ileus* is common, and is due primarily to the massive collection of blood in the retroperitoneal spaces,[29] but prolonged evisceration also plays a part.

(b) *Intestinal obstruction* may result because of adherence of the intestines to the graft,[20] or because of the intestines herniating between the graft and the posterior abdominal wall, if the posterior peritoneum has not been closed.[44]

(c) *Ischaemia of the sigmoid colon.* When removing abdominal aortic aneurysms, the inferior mesenteric artery can be divided close to the aorta with impunity. In fact, in many cases it is already thrombosed.[15] Occasionally, however, the operation is followed by ischaemic necrosis of the colon, involving the mucosa, or the deeper layers of the rectosigmoid region. Thus, Bernatz[4] recorded 4 deaths from this cause in patients operated on for unruptured aneurysm, this complication occurring in about 1% of the Mayo Clinic cases. Other authors[30,45] recorded similar experiences. Blood supply to the sigmoid colon depends on the marginal artery in its anastomoses between the inferior and superior mesenteric arteries, and also on the anastomosis between the sigmoid branches of the inferior mesenteric artery and the middle rectal branches of the internal iliac artery. These anastomoses may be endangered by associated atherosclerosis of these vessels. In cases of ruptured aneurysm, particularly in ruptures occurring on the left side, the additional factor of extravasation may further impair the blood supply and lead to gangrene. To prevent this, every effort should be made to maintain direct arterial flow into the internal iliac arteries.[62] In the early postoperative course, the condition presents with distension, diarrhoea, or melaena, and a diverting colostomy may be necessary.[62] In occasional cases, ischaemia produces less dramatic changes, and several weeks or months after operation the patient presents with a stricture about 9 cm. from the anal margin. This may give rise to symptoms sufficiently severe to warrant resection.[46,48,49]

2. *Renal Shut-down*

This is one of the most important complications. There is a considerable difference of opinion regarding the incidence of this complication. Some[51,67] feel that it is one of the common causes of death after a successful operation, and that oliguria in the first few postoperative days may occur in as many as 30 - 50% of cases,[25,52] while others feel that the incidence of this complication is low.[20] This complication may arise in several ways:

(*a*) A prolonged period of hypotension before, during, and after operation may result in lower-nephron nephrosis, and is to be avoided by earlier diagnosis and adequate blood replacement.[61]

(*b*) Clamping the aorta above the renal arteries may damage the renal tubules. Although the exact safe period of occlusion at this level has not been established, it has been found that periods of up to 30 minutes have all been well tolerated by the clinically normal kidneys.[60] If it is necessary to clamp the aorta above the renal arteries, the clamps should be moved to the infrarenal position within 30 minutes, or hypothermia should be used.[45] Rob[53] found that 1 hour's cross-clamping is safe at a body temperature of 28°C.

(*c*) Renal damage can occur despite the fact that only infrarenal aortic clamping has been used. Experimental studies by Nanson *et al.*[50] suggested that the clamping results in reflex renal arteriolar spasm, leading to tubular damage. There is a good correlation between the duration of aortic cross-clamping and the development of distal tubular necrosis.[52] No renal impairment is seen when the period of cross-clamping is less than 1½ hours, and the longer the period of clamping, the more likely is the syndrome to occur. The spasm can be prevented by infiltrating the renal pedicles with a local anaesthetic agent,[50] or by the use of a ganglion-blocking drug.[52] This viewpoint is disputed by de Bakey,[20] who stated that abnormalities of renal function are better correlated with phenomena other than aortic occlusion.

(*d*) Clamping the aorta may cause fragmentation of atheromatous plaques and considerable turbulence in the

blood flow immediately proximal to the clamp, carrying emboli of atheromatous material into the nearest vessels, the renal arteries.[67]

(*e*) In cases where severe ischaemia of the lower limbs develops as a postoperative complication, anuria may result from absorption of tissue-breakdown products from these limbs.

(*f*) Renal shut-down may be further complicated by the absorption of potassium from the extravasated blood.[23]

3. *Impaired Circulation in the Legs*

This may occur as a result of embolism or thrombosis. The necrotic lining of the aneurysm, or a loosened plaque, may break off during operation and pass down as an embolus. There is probably an increased risk of thrombosis in the lower limb vessels in cases of ruptured aneurysm,[61] since the period of aortic occlusion is longer than in unruptured aneurysm, where it is possible to do a considerable amount of dissection before it is necessary to apply the clamps. Nevertheless, these complications are less frequent than in operations for occlusive vascular disease, since the vessels are large and generous, and anastomoses can be made. Where a limb is threatened, the occluded vessel should be explored, under local anaesthesia if possible, to add as little further stress to the patient as possible. Important preventive measures are the securing of the intima, flushing out the graft, introduction of heparin at the time the vessels are clamped, and rapid restoration of lower-limb circulation.

4. *Other Vascular Complications*

The aneurysm is but one manifestation of generalized atherosclerosis, and complications such as cerebrovascular accidents or coronary thrombosis do occur in the postoperative period, coronary thrombosis being a common cause of death after these operations.[69]

5. *Wound Complications*

(*a*) *Infection*. Superficial infection is fairly common, while the danger of deep infection is particularly great in operations for ruptured aneurysm, where the extensive extravasation of blood and tissue trauma create a fertile soil for bacterial growth,[62] and may lead to secondary haemorrhage from the suture line.

(*b*) *Evisceration* may occur, and sometimes results in death. The wound should be repaired under local anaesthesia, since these gravely ill patients tolerate an additional general anaesthetic badly. This complication can be prevented by closing the abdomen using the methods indicated above.

6. *Pulmonary Complications*

Bronchopneumonia and retention of pulmonary secretions are common in these elderly patients, and tracheotomy may prove necessary.

7. *Graft Complications*

These may result from technical faults, or from defects in the graft itself.

(*a*) *Technical faults* may result in haemorrhage from the suture lines, or early thrombosis of the graft.

(*b*) *The arterial replacement used*. Some homografts develop marked degenerative changes in their wall, leading to complications. In a review of the literature, and a study of their own cases, de Weese *et al.*[22] recorded 38 cases of homograft failure, resulting in aneurysm formation (of which several ruptured), free rupture of the graft, rupture of the homograft into the intestine, thrombosis of the graft, and infection. On the other hand, Smith and Szilagyi[60] reported on the complications following the use of plastic prostheses. Sometimes infection occurs, either superficial or deep, the deep infection often leading to secondary haemorrhage from the suture line, with death in some cases. False aneurysm formation at the anastomotic line also occurs, and may rupture, leading to death. Further, Martin[44] stressed that considerable oozing of blood may occur through the interstices of a synthetic graft, and when operating on a ruptured aneurysm in a desperately ill patient, he prefers using a homograft replacement to reduce the blood loss. He has lost a patient operated on for ruptured aneurysm from this cause. Aortic homografts are generally considered to be inferior to synthetic materials.[14,22,25,42,54,60]

8. *Damage to the Spinal Cord*[20]

This is uncommon during infrarenal surgery, because the cord usually receives no branches from the aorta below that level, and even when it does, interruption does little harm, because the collateral supply from the important low thoracic spinal vessel is constant.

9. *Damage to the Receptaculum Chyli*[44]

This is rare and is recognized by the escape of milky fluid when operating in the region of the right crus of the diaphragm. It is important to recognize this injury, otherwise serious chylous ascites may result. The damaged receptaculum is ligated.

## MORTALITY FIGURES

Adding together all the cases reported in the English language literature, there are between 100 and 150 case reports[2,10,18,25,27,28,30,32,34,41,45,51,53-55,58,61,64,69] of resection and grafting of ruptured abdominal aortic aneurysms. The largest series (44 cases) was reported by de Bakey *et al.*,[18] two-thirds of whose patients survived. The overall mortality figures are probably about 50%, compared with a mortality of 10% in unruptured aneurysms.[51]

At first sight, an operative mortality of between 33 and 50% would appear to be formidable, but these figures should be interpreted in terms of the gravity of the condition without surgical treatment. Thus, we contrast a recovery rate of between 50 and 67% following surgery with an almost zero recovery rate without operation.

In view of these results it is felt that in this condition, which is otherwise hopeless, resection should always be attempted, regardless of the apparent hopelessness of the situation.[11,27]

## CONCLUSION

The expectation of life has increased, so that a greater proportion of the population is living to an age when the degenerative vascular diseases become more common. Thus, aneurysm of the aorta can be expected to increase in frequency, and we shall be seeing more patients with ruptured aneurysms. The problem arises how the prognosis of patients with abdominal aortic aneurysms can be improved.

De Bakey *et al.*[17] have pointed out that the operative mortality of ruptured aneurysms is more than 4 times that of non-ruptured aneurysms. Therefore, the first step in improving the prognosis is to treat the aneurysm before rupture can occur. This applies to asymptomatic as well as to symptomatic aneurysms, since rupture often occurs without any premonitory symptoms,[20,34,35] as in the present case. Thus, Barratt-Boyes[2] found that before the onset of fatal rupture 50% of the patients were completely symptom-free. Therefore — with the possible exception of patients with asymptomatic, very small aneurysms (less than 5 cm. in diameter), which have very little tendency to rupture[13] — our policy should be to operate on all aneurysms, except where there are strong contraindications such as very advanced age, or serious cerebral, cardiac, or renal disturbances. It is surprising how well elderly patients, with a constitution that is far from robust, withstand operative intervention.[59]

This aggressive approach is justified by the results of long-term studies, which show an increase in the 5-year survival rate from about 10% in untreated cases to over 60% in treated cases.[19]

The second step in improving prognosis lies in the early diagnosis and treatment of ruptured aneurysms. We must constantly bear in mind the possibility of ruptured abdominal aortic aneurysm in all patients presenting with acute abdominal symptoms, particularly in patients over the age of 40 years. In this way treatment can be started before irreversible damage has been done.

## SUMMARY

1. A successfully treated case of ruptured abdominal aortic aneurysm in an African patient is presented, and the literature is reviewed.

2. These aneurysms are usually due to atherosclerosis, and occur mainly in men over 50 years of age.

3. Rupture is the main cause of death.

4. Untreated aneurysms have a very bad prognosis, most patients being dead within 5 years.

5. The main clinical features are pain, shock, and the presence of a pulsating mass.

6. Operative treatment consists of resection of the aneurysm and replacement with a graft.

7. The complications are discussed, and the salvage rate of 50 to 67% is commented on.

8. A plea is made for the surgical treatment, where possible, of all unruptured abdominal aortic aneurysms, and for early diagnosis and treatment of ruptured aneurysms.

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