Around two-thirds of abdominal aortic aneurysms (AAA) are incidental discoveries during the investigation of backache, hip pain or urinary tract complaints. They are much more common in men than women (5:1) and account for 2% of all deaths in men aged >60 yr. Open surgical repair of the aneurysm is considered as the standard, traditional method of treatment. Surgery is recommended when the AAA exceeds 55 mm in anteroposterior diameter as measured by ultrasound scan. The risk of spontaneous rupture depends on aneurysm size, ranging from <1% per annum for AAA <55 mm diameter to >17% per annum for aneurysms >60 mm diameter. Ninety per cent of AAAs are located distal to the renal arteries.

Endovascular repair of an aortic aneurysm using an in-situ prosthetic graft was suggested as a technique in 1969 by Dotter, but was only first performed successfully by Parodi and colleagues in 1990. Over the last 10 yr, the availability of endovascular stent grafts has provided an alternative treatment for patients with AAA, especially the elderly with significant co-existing medical conditions. Endovascular repair is much less invasive. However, it is challenging technically and requires a multidisciplinary approach.

During endovascular surgery, an aortic stent graft is passed via the femoral arteries through the aortic lumen to fit tightly above and below the AAA. The aim is to exclude the aneurysm sac from the systemic circulation, thereby decreasing or eliminating the risk of future rupture. The procedure is performed through incisions in one or both groins; no laparotomy is required. However, certain anatomical considerations apply.

**Anatomical and surgical considerations**

About one-third of AAAs have anatomical features that make them suitable for endovascular repair. The neck of the aneurysm must be straight (as opposed to the usual fusiform shape) and longer than 15 mm. Additionally, there must be minimal atherosclerotic plaque inside the neck so that a good seal between the stent graft and the wall of the aorta can be obtained. Distally, there must be disease-free zones in the iliac arteries to ensure good leg perfusion and at least one of the femoral arteries should be >8 mm in internal diameter. This is to enable insertion of the stent through the arteriotomy. (A collapsed stent graft has an external diameter up to 7.5 mm.)

Several types of endovascular stent grafts are available; all have a fine metal skeleton supporting a very thin Dacron membrane. Most in current use are self-expanding whereas the early stents required expansion with a balloon. Some grafts are supported throughout their length by a metal skeleton while some are supported only at the ends. The early stents were tube grafts but current availability of bifurcated grafts or ‘Y’ grafts has made many more patients suitable for endovascular repair.

**Surgical procedure**

Endovascular aneurysm repair (EVAR) is usually carried out by a radiologist and a vascular surgeon working together either in a specialized radiology suite or in an operating theatre that has specialized angiography equipment. The choice of location depends on local facilities and preferences. The patient is positioned supine on a tilting radiolucent table or trolley and prepared as for conventional surgery. The initial part of the operation is usually performed by the surgeon exposing both femoral arteries with longitudinal groin incisions. Alternatively, only one artery is exposed surgically with access to the other being carried out percutaneously by the radiologist.

Angiography is then performed to confirm the anatomy of aneurysm (Fig. 1). Careful positioning of the endoluminal guide wire is essential to permit accurate placement of the graft. This will require the patient’s active cooperation when regional anaesthesia is used as they may be asked to hold their breath temporarily. The large endovascular graft delivery system is provided an alternative treatment for patients with AAA, especially the elderly with significant co-existing medical conditions. Endovascular repair is much less invasive. However, it is challenging technically and requires a multidisciplinary approach.

During endovascular surgery, an aortic stent graft is passed via the femoral arteries through the aortic lumen to fit tightly above and below the AAA. The aim is to exclude the aneurysm sac from the systemic circulation, thereby decreasing or eliminating the risk of future rupture. The procedure is performed through incisions in one or both groins; no laparotomy is required. However, certain anatomical considerations apply.

**Anatomical and surgical considerations**

About one-third of AAAs have anatomical features that make them suitable for endovascular repair. The neck of the aneurysm must be straight (as opposed to the usual fusiform shape) and longer than 15 mm. Additionally, there must be minimal atherosclerotic plaque inside the neck so that a good seal between the stent graft and the wall of the aorta can be obtained. Distally, there must be disease-free zones in the iliac arteries to ensure good leg perfusion and at least one of the femoral arteries should be >8 mm in internal diameter. This is to enable insertion of the stent through the arteriotomy. (A collapsed stent graft has an external diameter up to 7.5 mm.)

Several types of endovascular stent grafts are available; all have a fine metal skeleton supporting a very thin Dacron membrane. Most in current use are self-expanding whereas the early stents required expansion with a balloon. Some grafts are supported throughout their length by a metal skeleton while some are supported only at the ends. The early stents were tube grafts but current availability of bifurcated grafts or ‘Y’ grafts has made many more patients suitable for endovascular repair.

**Surgical procedure**

Endovascular aneurysm repair (EVAR) is usually carried out by a radiologist and a vascular surgeon working together either in a specialized radiology suite or in an operating theatre that has specialized angiography equipment. The choice of location depends on local facilities and preferences. The patient is positioned supine on a tilting radiolucent table or trolley and prepared as for conventional surgery. The initial part of the operation is usually performed by the surgeon exposing both femoral arteries with longitudinal groin incisions. Alternatively, only one artery is exposed surgically with access to the other being carried out percutaneously by the radiologist.

Angiography is then performed to confirm the anatomy of aneurysm (Fig. 1). Careful positioning of the endoluminal guide wire is essential to permit accurate placement of the graft. This will require the patient’s active cooperation when regional anaesthesia is used as they may be asked to hold their breath temporarily. The large endovascular graft delivery system is provided an alternative treatment for patients with AAA, especially the elderly with significant co-existing medical conditions. Endovascular repair is much less invasive. However, it is challenging technically and requires a multidisciplinary approach.

During endovascular surgery, an aortic stent graft is passed via the femoral arteries through the aortic lumen to fit tightly above and below the AAA. The aim is to exclude the aneurysm sac from the systemic circulation, thereby decreasing or eliminating the risk of future rupture. The procedure is performed through incisions in one or both groins; no laparotomy is required. However, certain anatomical considerations apply.
introduced via an arteriotomy of the femoral artery and advanced under fluoroscopic guidance to the diseased aortic segment. The graft is usually inserted on the right side provided the femoral artery meets the minimum diameter requirements. When the final position is reached, the stent graft is deployed within the aorta. Angiography is then performed again to confirm that there is no leakage of blood into the aneurysm sac (Fig. 2). When leakage is observed, the stent position may be adjusted or a second graft inserted to obstruct the leak.

Anaesthetic considerations

Successful outcome of EVAR requires good communication between surgeon, radiologist and anaesthetist plus appropriate patient selection based upon the anatomical features of the aneurysm.

Pre-operative assessment

This should be no different from that of a patient listed for open AAA repair: careful evaluation of associated co-existing medical conditions (cardiac, renal, respiratory and other vascular pathology). Patients should be informed about the choice of anaesthesia (local, regional or general) and the rare possibility of an open repair being required.

Monitoring

Direct arterial pressure monitoring is considered essential in order to detect beat-to-beat variations in blood pressure during deployment of the stent graft. Central venous pressure (CVP) monitoring is rarely necessary unless there is significant comorbidity because there is usually minimal blood loss. Bladder catheterization is indicated to monitor urine output.

Anaesthetic technique

The procedure can be performed using local infiltration anaesthesia (LA), general anaesthesia (GA) or regional anaesthesia (RA). The latter may be performed as a spinal, epidural or combined spinal epidural (CSE). The potential advantages of LA and RA are that there is usually excellent perioperative and postoperative analgesia with a stable cardiovascular system. However, there is no evidence to suggest that outcome is improved with LA or RA compared with GA.

In our hospital, a typical anaesthetic plan includes insertion of a large bore venous cannula and radial arterial line in the right hand followed by a single shot spinal or CSE. The latter has the advantage of rapid onset with the possibility of top ups via the epidural in the event of an unexpectedly prolonged procedure, or simply to provide post-operative analgesia. Continuous spinal anaesthesia has also been used successfully. Local infiltration anaesthesia of the groins is equally successful since it is only this anatomical area in which anaesthesia is required. Deployment of the stent graft within the aorta is usually pain free. The right hand is used for the venous and arterial cannulation as access to the aorta via the left axillary artery may be required on very rare occasions. Such an occasion would be when the radiologist wishes to reduce haemorrhage by placement of a balloon catheter above
the aneurysm when direct femoral cannulation has failed. This requires conversion to GA. Regional anaesthesia is usually supplemented with sedation, either by a continuous low dose infusion of propofol or small intermittent boluses of midazolam. In an extremely restless patient, conversion to GA may be required.

**Intraoperative period**

Usually, the whole procedure is completed within 2 h and i.v. heparin 5000 IU is administered after the femoral arteries have been exposed. Blood loss is not usually significant and ‘group and save’ of serum is usually adequate. The results of a recent multi-centre trial comparing open surgical repair with EVAR showed that the patients who underwent EVAR had a 60% lower blood loss (650 ml) compared with open repair (1600 ml) and only 12% of the EVAR patients required blood transfusion compared with 40% in the open repair group.

Some radiologists will request that i.v. hyoscine 20 mg is administered to reduce intestinal motility during screening, thereby improving the digital subtraction angiography image obtained. Local infiltration of the groin with bupivacaine provides very effective post-operative analgesia and is strongly recommended.

**Post-operative period**

Ideally, the patient should be nursed in an environment where arterial pressure can be monitored continuously for several hours. Because the EVAR procedure involves the liberal use of contrast media to assist placement and deployment of the graft to ensure proper exclusion of the aneurysmal sac, it is worthwhile ensuring that the patients are well hydrated to prevent postoperative renal impairment. There is no current evidence to support routine use of diuretic agents during EVAR.

Several non-randomized or retrospective studies have demonstrated that hospital and ICU/HDU stay are reduced by ~50% when EVAR is compared with open surgical repair.

**Complications**

Surgical complications include primary endoleak, damage to the femoral arteries, dissection, embolization, ischaemia, aneurysm rupture, reaction to contrast media, neurological deficit, bleeding, myocardial ischaemia, renal failure, hypotension, delayed stent displacement and other device-related complications. Endoleak is defined as persistent blood flow outside an endovascular graft, but within the aneurysm sac. This can be immediate or delayed. Studies have shown that the incidence of endoleak can be as high as 18%, but the average incidence is 5–10%. Delayed aortic rupture may occur in a few patients because of increased growth of the stented aneurysm (~1–2 mm per annum). The reasons for this are uncertain; it may be because of the pressure transmitted through the stent or caused by de novo endoleak at the distal end of the stent graft.

Post-implantation syndrome is sometimes observed after EVAR. This is characterized by fever, raised plasma C-reactive protein and white cell count in the absence of infection. It may last 2–10 days and responds to non-steroidal anti-inflammatory drugs. Conversion to open repair is necessary in ~2% (aneurysm rupture, inability to deploy the graft, femoral and iliac vessels more diseased than anticipated). However, a patient with a contained, leaking aneurysm may be eligible for treatment using the EVAR technique.

**Mortality and morbidity**

Most published reports have shown that perioperative mortality after endoluminal aneurysm repair is similar to that reported for open repair. Some of the larger studies showed mortality rates between 4 and 6%, including the UK Small Aneurysm Trial (5.8%), Canadian Aneurysm Study (4.7%), and Michigan Statewide Study (5.6%). European investigators have shown that, in patients with infrarenal aortic aneurysms, endovascular repair is associated with a risk of subsequent rupture of 1% per annum. The rate of conversion to open repair is 2% per annum.

In 1994, the EUROSTAR registry (European collaborators on Stent-graft Techniques for Abdominal aortic aneurysm Repair) was established for the purpose of the collection and analysis of data on patients who undergo EVAR. Data from nearly 3000 procedures performed between 1994 and 2000 showed that the incidence of device-related complications decreased from 21.7 to 7.3%. This has been attributed to better case selection, improved stent devices and delivery systems together with increased operator experience.
A number of retrospective and non-randomized studies have shown that cardiovascular and inflammatory responses and short-term morbidity are reduced after EVAR compared with open surgery, although no prospective randomized data are available. However, the national multicentre randomized EVAR 1 and 2 trials (which are currently recruiting in the UK) are aiming to compare both the complications and outcomes of endovascular and open surgical repair in suitable patients (EVAR 1) and the outcome after EVAR compared with non-intervention in less fit patients (EVAR 2). The results of these trials are anticipated in the near future. Consequently, the long-term durability of the EVAR technique is still not yet known. The advantages and disadvantages of EVAR are summarized in Table 1.

Key references
Laheij RJF, Van Marrewijk C on behalf of the EUROSTAR group. The evolving technique of endovascular stenting of abdominal aortic aneurysm; time of reappraisal. Eur J Vasc Endovasc Surg 2001; 22: 436–42
Moore WS. UCLA School of Medicine, endovascular repair of abdominal aortic aneurysm. Riverside Cardiology Associates, January 2000; 1–5

See multiple choice questions 66–68.