Abdominal Aortic Aneurysms

7

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7.1 Summary

- Abdominal aortic aneurysm rupture should always be suspected in men older than 60 years with acute abdominal pain.
- Patients who present with the triad of circulatory shock, abdominal or back pain, and a positive examination for a pulsating mass in the abdomen should immediately be transferred to the operating room for emergency laparotomy.
- Urgent surgery should not be delayed by unnecessary computed tomography or ultrasound scans.

7.2 Background

7.2.1 Magnitude of the Problem

Abdominal aortic aneurysm (AAA) is common. In men older than 60 years the prevalence is 5–10%, which is four times the prevalence in women (Table 7.1). Not more than 1% of men over 60 years of age, however, have an AAA with a diameter around 5 cm, which is the limit at which the risk of rupture is considered motivation for elective operation. The rupture incidence is reported to be 3–15% per 100,000 individuals per year. This means that every surgeon on call as well as emergency department physicians will most likely manage several patients with a ruptured AAA each year. It is possible that the number of patients with ruptured AAAs will decrease in the future because of screening programs. Presently, however, it is still a very common patient type in many countries.

Table 7.1. Prevalence of asymptomatic abdominal aortic aneurysms (>3 cm) in different populations, as determined by ultrasound

Country	Year	N	Population	Prevalence
United Kingdom	1993		Men, 65–75 years	8.4%
United States	1997	73,451	50–79 years	4.7% (men) 1.3% (women)
Netherlands	1998	2,419	Men, 60–80 years	8.1%
Sweden	2001	505	65–75 years	16.9% (men) 3.5% (women)

7.2.2 Pathogenesis

AAA is a dilatation of the aorta caused by degeneration of the elastic components of the arterial wall. The risk for developing AAA is related to atherosclerosis, hypertension, and a genetic predisposition, but its etiology and the pathologic process leading to AAA are unclear. Aneurysms usually originate below the renal arteries and extend down to the aortic bifurcation. The natural course is a gradually increasing dilatation leading to a progressively thinner wall that might end with rupture. The risk of rupture starts to increase exponentially when the aneurysm diameter exceeds 5 cm, but aneurysms of smaller sizes can also rupture. The mortality from a ruptured AAA left untreated is close to 100%, but the length of the process that leads to exsanguination and death varies from minutes to several days. The longer time period involves circumstances when the bleeding is contained within the retroperitoneal space.

7.3 Clinical Presentation

When patients seek medical attention for abdominal or back pain, it is extremely important to always keep the diagnosis of a ruptured AAA in mind.

NOTE

An early correct diagnosis is crucial because the prognosis for patients who are not yet in shock is much better than for those in whom shock has already developed.

7.3.1 Medical History

The classic case of a ruptured AAA is brought to the emergency department by ambulance. Often the patient is a man who experienced immediate onset of severe pain in the upper abdomen with radiation to the back and flanks a few hours earlier. The patient often describes an episode of unconsciousness, dizziness, or sweating when the pain started. Sometimes the family knows that the patient has been previously diagnosed to have an asymptomatic AAA.

7.3.2 Examination

The patient may be circulatory-stable but with positive signs of impending hypovolemic shock: affected consciousness, tachycardia, sweating, and hypotension. A pulsating tender mass is usually found in the epigastrium above the umbilicus. Because the aorta is a dorsal structure in the abdomen, a mass is easy to miss in obese patients. It is also difficult to palpate a pulsating mass when the blood pressure is low because of shock. Accordingly, a pale patient with an increased heart rate and blood pressure <90 mmHg but negative for a pulsating mass may have a ruptured AAA. A distinct local tenderness over the aneurysm is also a common finding. The pain is caused by the retroperitoneal bleeding surrounding the aneurysm. While almost all incipient and already ruptured AAAs are tender, the specificity of this sign is low.

7.3.3 Differential Diagnosis

Patients with a ruptured AAA who are not in shock present with signs that are similar to a variety of other acute diseases in the abdomen or back. To avoid misdiagnosis with conditions that do not require emergency laparotomy, careful examination of the abdominal aorta is important.

Ruptured AAA, or symptomatic aneurysms with incipient rupture, should be included in the discussion about differential diagnosis in all abdominal emergencies, particular in elderly men. Kidney stones located in the ureter, diverticulitis, constipation, intestinal obstruction, pancreatitis, gastric or intestinal perforation, intestinal ischemia, vertebral body compression, and even acute myocardial infarction are all primary diagnoses that can be mixed up with a ruptured AAA. Of course, there is a potential risk of sending a patient home believing that, for example, a ureteral stone has caused the trouble when AAA rupture is the true diagnosis. A significant risk is also related to performing a major operation because of a suspected ruptured AAA in a patient who actually is suffering from an acute myocardial infarction. The only way to avoid this is to keep the AAA diagnosis in mind and to carefully examine the patient.

Another important differential diagnosis is aortic dissection. It is common that a patient will initially have been treated at a smaller healthcare unit or in the emergency department where an ultrasound was performed and misinterpreted as "dissection in an aortic aneurysm." This misunderstanding is caused by the thrombus within the AAA, which can be interpreted as a doubled aortic lumen. There is, however, a clear distinction between rupture and dissection. Rupture is a true burst of the aortic wall with bleeding out from the vessel. Dissection starts with a tear in the inner layer of the vascular wall through which the blood passes and cause a longitudinal separation of the layers, causing a double lumen. Rupture is common in AAA, but dissection is rare (see the information on aortic dissection in Chapter 8).

7.3.4 Clinical Diagnosis

A summary of different clinical presentations of AAA is presented in Table 7.2. These different scenarios can be used in determining the risk for the presence of a ruptured AAA.

NOTE

The presentation of a patient with a ruptured AAA varies, but in most cases a classic triad is found:

- **Abdominal pain**
- **Circulatory instability**
- **Tender pulsating mass**

This combination of symptoms and clinical findings should always be regarded as a ruptured AAA until the opposite is proven.

The purpose of Table 7.2 is to facilitate patient management, and the remaining part of this chapter is largely based on this table. It should be remembered, however, that patients might present with a clinical picture that lies in between the categories.

7.4 Diagnostics

When an aid in detecting AAA is needed, a computed tomography (CT) scan is the first choice for all categories used in Table 7.2. When the suspicion is strong and the risk for sudden deterioration is considered high, the scan should be performed quickly. The responsible surgeon should supervise the procedure so that it can be stopped if necessary and the patient transferred to the operating room immediately. The CT scan should be performed with contrast. The primary questions the scan should answer are as follows: Is there an AAA? Are there signs of rupture? What size is the AAA, and how far proximally and distally does it extend?

NOTE

In the classic case of a ruptured AAA, no diagnostic tools except the physical examination are needed.

Table 7.2. Clinical findings and management of ruptured aortic aneurysms (*AAA* abdominal aortic aneurysm, *OR* operating room, *CT* computed tomography)

Pain	Hemodynamic instability	Pulsating mass	Clinical diagnosis	Measures
Yes	Yes	Yes	Ruptured AAA (classic triad)	Immediate transfer to OR
Yes	Yes	No	Rupture suspected (lack of mass may be due to obesity or low blood pressure)	If history of AAA or signs peritonitis, transfer to OR; Perform ultrasound scan in the OR or CT scan with the surgeon present
Yes	No	Yes	Rupture possible (may have an incipient rupture or an inflammatory aneurysm)	Perform CT scan and consider urgent surgery if diagnosis of AAA is made
Yes	No	No	Rupture unlikely (may have a contained rupture if the patient obese or difficult to palpate)	Perform CT or ultrasound scan

Fig. 7.1. Typical appearance on computed tomography of a ruptured abdominal aortic aneurysm with contrast in lumen, thrombus, calcifications in the wall, and a large retroperitoneal hematoma

To look for anything other than what is mentioned above is unnecessary in an emergency work-up of a patient with a suspected ruptured AAA. The diagnosis made by CT is easy, and typical findings are demonstrated in Fig. 7.1.

Signs of rupture on the scan include a hematoma and contrast that is visible outside the aortic wall retroperitoneally. An early sign of rupture is the presence of contrast in the thrombus and a very thin aortic wall overlying it. The location of the aneurysm in relation to the renal arteries is important for planning an operation but rarely influences the indication for surgery. It is important to remember that a patient with a diagnosed AAA and pain but with a CT scan showing no signs of rupture needs to be managed as if the patient has impending rupture. Pain may precede rupture, and the scan only answers the question of whether a rupture is already present at the examination. Unfortunately, no signs can predict whether an AAA is going to rupture soon.

There is rarely a place for ultrasound when trying to diagnose a ruptured AAA. Performed in the operating room, it might occasionally be helpful to exclude or verify the presence of an AAA.

When the patient is hemodynamically stable or when the suspicion of rupture is low, the use of additional diagnostic tests to exclude other illnesses is encouraged. Examples of such diseases are pancreatitis and myocardial infarction. These can be verified by electrocardiogram (ECG), a plain abdominal x-ray, a CT scan, ultrasound, or urography as well as by blood tests.

7.5 Management and Treatment

7.5.1 Management Before Treatment

7.5.1.1 Ruptured AAA

If the triad is present the patient needs to be operated without delay caused by preoperative examinations or tests. The time available for making the correct decision regarding patient management is usually limited. The following measures should rapidly be done in the emergency department:

1. Obtain vital signs, medical history, and physical examination.
2. Administer oxygen.
3. Monitor vital signs (heart rate, blood pressure, respiration, SPO_2).
4. Obtain informed consent.
5. Place two large-bore intravenous (IV) lines. Insertion of central lines is time-consuming, and to avoid delays it is better done in the operating room after surgery has started.
6. Start infusion of fluids.
7. Obtain blood for hemoglobin, hematocrit, prothrombin time, partial thromboplastin time, complete blood count, creatinine, blood urea nitrogen, sodium, and potassium, as well as a sample for blood type and cross-match.
8. Catheterize the urinary bladder (this often has to be done in the operating room to gain time) and start recording urine output.
9. Administer analgesics, such as 2–3 mg morphine sulphate IV up to 15 mg, depending on the patient's vital signs, severity of pain, and body weight.
10. Order eight units of packed red blood cells and four of plasma.

The list suggested above may vary among different hospitals. Remember to include pulses, including femoral, popliteal, and pedal, in the physical examination. This is important as a baseline test in case of thromboembolic complications to the legs during surgery. It is also important to be cautious about rehydration and administration of inotropic drugs. The latter should be used only when the patient is in shock and when the low blood pressure threatens to affect cardiac or renal function. The aim should not be to restore the patient's normal blood pressure; a pressure of around 100 mmHg is satisfactory if the patient's vital functions are intact. Hypotension may be an important factor minimizing the bleeding and keeping it contained within the retroperitoneal space. Too intense volume replacement and increased blood pressure may initiate rebleeding.

As soon as possible, the patient should be taken to the operating room and a vascular surgeon contacted. If no surgeon with experience performing AAA procedures is available, consider contacting another hospital and presenting the case to the vascular surgeon there. The patient may then be referred to that hospital or the vascular surgeon could come and perform the procedure if the patient's condition does not allow transport. Even stable patients might start to rebleed at any moment and should therefore not be transported too liberally. If the patient is hemodynamically stable, the start of operation should be delayed until an experienced surgeon is available. However, if there are signs of hemodynamic instability or manifest shock despite treatment, the operation should be initiated. The aim then is to achieve control of the bleeding.

7.5.1.2 Suspected Rupture

The checklist described before is, by and large, also valid when rupture is only suspected.

This category of patients is the most challenging, and generally applicable advice is difficult to give. This category includes patients with a ruptured aneurysm but without a palpable pulsating mass due to obesity and severe hypotension. There are also many other life-threatening conditions that should not be treated with surgery in this group. One such condition is acute myocardial infarction, which also may start with thoracic and abdominal pain and hypotension. Therefore, the surgeon must rapidly decide whether to perform an emergency operation or order diagnostic examinations to verify the diagnosis. In the case of an actual rupture, it is evident that examinations that delay the start of the operation are associated with severe risk. Therefore, every such step should be performed simultaneously with other preoperative measures if possible. For example, ECG is helpful in the diagnosis of myocardial infarction, and ultrasound can verify or exclude the presence of an AAA.

7.5.1.3 Possible Rupture

A tender pulsating mass supports the suspicion of rupture. In a circulatory-stable patient with possible rupture, the following is done in the emergency department:

1. Place an IV line and start a slow infusion of Ringer's acetate.
2. Order an emergency CT scan, with the patient monitored by a nurse.

If the CT scan shows an AAA >5 cm in diameter without signs of rupture and the patient has not displayed hemodynamic instability, the diagnosis impending rupture should be considered. The patient then needs surgery within 24 h. The timing of the operation is based on the patient's condition and the hospital's available resources. While awaiting surgery, patients who need medical treatment to improve cardiac or pulmonary function should receive it. In this category they are also possible candidates for transfer to other hospitals if necessary.

If the patient already has a known aneurysm at admission, the management is also as described above. However, if this known aneurysm has a diameter <4 cm, rupture is unlikely. In such patients the sign of a pulsating mass is also probably lacking. A patient with a known small aneurysm who is in shock should be resuscitated followed by a CT scan. The possibility of cardiogenic shock due to an acute myocardial infarction is a possibility that has to be considered. If cardiac causes have been excluded and the shock is refractory to treatment, laparotomy is advised.

7.5.1.4 Rupture Unlikely

This category of patients should be evaluated with regard to all possible differential diagnoses and managed as any case of "acute abdomen." To rule out or verify AAA a CT scan or ultrasound is performed. The risk for rupture is substantially less for an AAA <5 cm in diameter than for larger aneurysms. The patient should be admitted for observation and worked up considering any other causes of pain, such as kidney stone, pancreatitis, gallstone, perforated duodenal ulcer, perforated intestine, acute myocardial infarction, or vertebral body compression. If the patient does not improve and no other reasonable cause for the pain can be identified, operation of the aneurysm should be considered if it is large.

7.5.2 Operation

7.5.2.1 Starting the Operation

Elevated blood pressure in association with anesthesia induction can accentuate the retroperitoneal bleeding. The patient should therefore be scrubbed and draped and the surgeon ready to start the operation before the patient is anesthetized and intubated. The procedure starts with a long midline incision from the xiphoid process to the pubis. This allows fast and good access to the abdomen. Proximal control of the aorta above the aneurysm is of highest priority. The rest of the operation includes reconstructing the aorta with a straight aortic tube graft or an aortoiliac or aortofemoral bypass graft. The use of autotransfusion of blood, a "cell saver," is recommended. Resuscitation and anesthesia must be monitored closely. The goal is to achieve optimal hemodynamics, with a balance between infused volume and actual, as well as expected, bleeding. The surgeon must realize that it is sometimes necessary to stop the procedure and maintain temporary bleeding control by tamponade or manual compression in order to allow time for the anesthesiologist to compensate for blood and fluid losses. Close contact with the anesthesiologist is important during the entire operation.

7.5.2.2 Exposure and Proximal Control

The conventional technique for exposure and proximal control with a long midline incision and incision of the dorsal peritoneum is recommended. The exposure must sometimes be modified because of bleeding or presence of a hematoma. Infiltration of blood in the tissue surrounding the aneurysm makes it difficult to identify structures such as the mesenteric, renal, and lumbar veins. On the other hand, it often facilitates dissection of the proximal neck by loosening the fibrous tissue adjacent to the aorta.

In a hemodynamically stable patient it is recommended to apply a self-retaining retractor after entering the abdomen. Preferably, a type that is fixed to the table (such as the OmniTrac^{tm}) is used. This facilitates dissection by reducing protruding organs. After incision of the dorsal peritoneum and mobilization of the duodenum to the right, sharp and blunt dissection is used to carefully approach the anterior aspect of the aneurysmal neck (Fig. 7.2).

The correct plane of dissection is reached when the white and smooth surface of the aorta is visualized. An important guide during the dissection through the hematoma is the aortic pulse. Accordingly, a weak pulse due to hypotension makes the dissection more difficult. Exposure of the aneu-

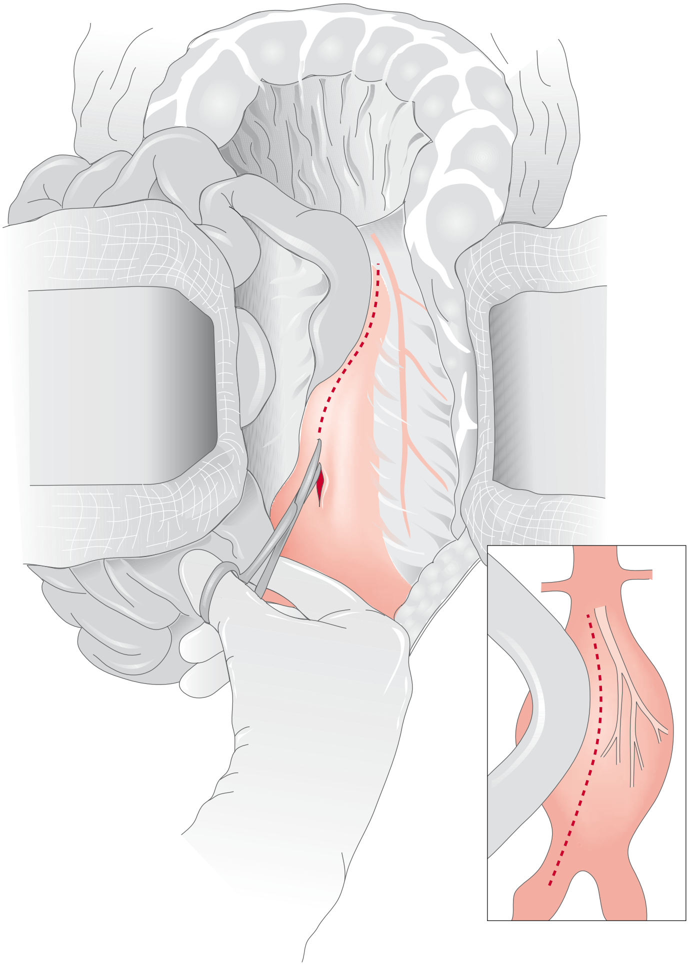

Fig. 7.2. Incision in the posterior peritoneum for exposure of the infrarenal aorta and the neck of an abdominal aortic aneurysm. The incision is placed in the angle between the duodenum and the inferior mesenteric vein, which occasionally has to be divided for good access. A 1–2-cm edge of the peritoneum is left on the duodenum to facilitate restoration of the anatomy at closure

rysmal neck is usually facilitated by the dissection of tissue around the anterior aorta caused by the hematoma. Blunt dissection with a finger behind the aorta in the "friendly triangle" can therefore often be the easiest way to achieve control of the aorta (Fig. 7.3).

When a finger can be pushed behind the aorta, application of the aortic clamp is possible. In this situation an angled Satinsky clamp is suitable. When it is difficult to circumferentially free the aorta, a straight clamp can be applied in an anteroposterior position just inferior to the renal arteries, leaving the aorta adherent dorsally. This often works well, but suturing the anastomosis can be more difficult. The dissection behind the aorta should be performed with great care to avoid damage to the left renal vein, its gonadal branches, and the lumbar veins. Bleeding during this part of the dissection usually emanates from any of these veins and is controlled by ligature, suture, or a local tamponade. Another common source for venous bleeding is the inferior mesenteric vein. It can also be ligated. If profuse bleeding from the ruptured aorta occurs during dissection control can be obtained by several different strategies.

7.5.2.3 Other Options for Proximal Control

There are ways to achieve proximal control of the aorta that fit most situations. The recommendations listed below are ordered according to the probability that they might be needed.

Fig. 7.3. When an abdominal aortic aneurysm is present the anatomy is often changed. The first centimeters of the infrarenal aorta (the neck of the aneurysm) are usually angulated ventrally. The triangular space between the spine, the aneurysm, and its neck is called the "friendly triangle" because its tissue usually allows blunt dissection easily

1. **Manual local compression or "a thumb in the hole"**
   Apply local compression over the rupture with one or several swabs, or try to seal it by putting a finger or thumb into the hole in the aneurysm. This method is convenient when the aneurysm ruptures suddenly during dissection of the neck. It can often be followed by option number two below.
2. **Occlusion with balloon catheter**
   A Foley catheter, size 24-French or larger, is inserted through the hole and the tip is placed proximal to the aneurysmal neck. The balloon is filled with saline until the bleeding diminishes; usually 15–20 ml is sufficient. The remaining bleeding is caused by backbleeding from the distal vascular bed. If it is significant, it has to be controlled before proceeding with dissection of the aneurysmal neck. With this technique the aorta is usually occluded at a suprarenal level and occasionally even higher. When this method is used, the operation should be continued as quickly as possible with exposure of the neck of the aneurysm to allow an aortic clamp to be applied in an infrarenal position. The balloon should then be removed immediately before the clamp is applied. Specially designed balloon catheters for aortic occlusion are also available to facilitate this method of control.
3. **Straight aortic clamp on the neck of the aneurysm – anterior approach**
   If the patient is in severe shock and rapid aortic control is necessary, there is little time for circumferential dissection and exposure. A straight clamp can then be applied as soon as the dorsal peritoneum is divided and the duodenum retracted to the right. It is placed from the ventral portion at the level of the neck. The clamp is positioned by blunt dissection and guided in place by the fingers. The surgeon must be aware of the risk of damaging the vena cava and should also check that the clamp bite includes the entire aortic wall.
4. **Manual compression of the subdiaphragmatic aorta**
   If the rupture is located on the anterior aspect of the aneurysm and there is ongoing significant bleeding within the peritoneal sac, an assistant can achieve temporary proximal control by manual compression of the subdiaphragmatic aorta. This is performed by simply placing the fist against the lesser omentum high up under the xiphoid process and pushing downward and cranially, thereby compressing the aorta against the vertebral column. This gives the surgeon an opportunity to visualize and find the hole, followed by insertion of an occlusive balloon as previously described.

5. **Straight clamp on subdiaphragmatic aorta through the lesser omentum**
   Better control can be achieved by placing an aortic clamp in the subdiaphragmatic position (Fig. 7.4 a–d). The technique is not so easy but is useful when there is a very large hematoma surrounding the neck of the aneurysm, indicating that the rupture is located in that area. In such a case there is considerable risk for uncontrollable bleeding through the rupture when the dorsal peritoneum is opened to expose the aneurysmal neck. To achieve subdiaphragmatic control, the lesser omentum is incised, the aortic hiatus at the diaphragmatic crus is exposed, and the aorta is clamped. The triangular ligament must be divided to allow retraction of the left liver lobe to the right. To avoid damage to the ventricle and esophagus, these organs need to be retracted to the left. Thereafter the muscle fibers in the diaphragmatic crus are divided to allow the straight clamp to be applied in an anteroposterior position. A straight clamp, however, has a tendency to slip off the aorta and cause rebleeding, and repositioning of it is often necessary. This risk is increased if the muscle fibers in the diaphragmatic crus are not cut sufficiently. Great care must be taken to avoid damaging the esophagus and vena cava. As soon as possible, any supraceliac aortic occlusion is replaced by one in an infrarenal position.
6. **Clamping of the thoracic aorta**
   Transthoracic control of the aorta can be used in extreme situations. It is performed through a low left-sided thoracotomy in the 5th–6th intercostal space. The incision starts in the midclavicular line and is extended dorsally as far as possible. After the pleura is incised, the lung is retracted anteriorly and caudally, after which exposure of the thoracic aorta is relatively easy. There are few disturbing surrounding structures. This technique, however, is associated with increased postoperative morbidity and is rarely necessary in the management of ruptured abdominal aortic aneurysms.
7. **Proximal endovascular aortic control**
   In potentially technically challenging and severe cases of ruptured aortic or iliac aneurysms in obese patients or in those with a “hostile” abdomen or traumatic injuries to large intraabdominal, retroperitoneal, or pelvic vessels, it can be advantageous to start the procedure by percutaneously inserting an intraluminal balloon for proximal aortic control (Fig. 7.5). Depending on the location of the injury, this can be done from the groin through the femoral artery or from the arm through the brachial artery. In the former situation, a supporting long introducer left in place is often needed to prevent dislocation by the bloodstream. This procedure requires the surgeon to have experience in endovascular methods or an interventional radiologist to be available for assistance. Briefly the technique is as follows. The brachial artery is punctured with a 12-French introducer. A guide wire is inserted under fluoroscopy with its tip then in the proximal aorta. A 100-cm long catheter with a 46-mm compliant balloon is inserted over the guide wire and connected to a syringe with saline for insufflation. If the patient is in shock the balloon is immediately insufflated by the surgeon for resuscitation. Once positioned such an intraaortic balloon can be temporarily insufflated when needed. This might be a salvaging procedure in many cases of extensive vascular injuries because it controls hemorrhage while allowing dissection of the injured segment. Subsequent application of ordinary vascular clamps can then provide better control. Aortic balloon occlusion can also be valuable in extensive venous injuries in the abdomen or pelvic area because the stopped aortic inflow secondarily leads to diminished venous bleeding.

7.5.2.4 Continuing the Operation

Proximal aortic control usually stabilizes the patient and the operation can proceed as in elective operations for AAA. The iliac arteries are exposed. The aorta and the iliac arteries are clamped, the aneurysm incised, and the thrombus extracted. If there are firm adhesions between the iliac artery and the vein, dissection may be dangerous, potentially causing severe bleeding by injuries to the iliac vein. This can be avoided by using balloon occlusion of the iliac arteries from inside the aneurysm once it has been opened. If there is backbleeding from lumbar arteries, the inferior mesenteric artery, or the median sacral artery, their origins are controlled with 2-0 suture from the inside

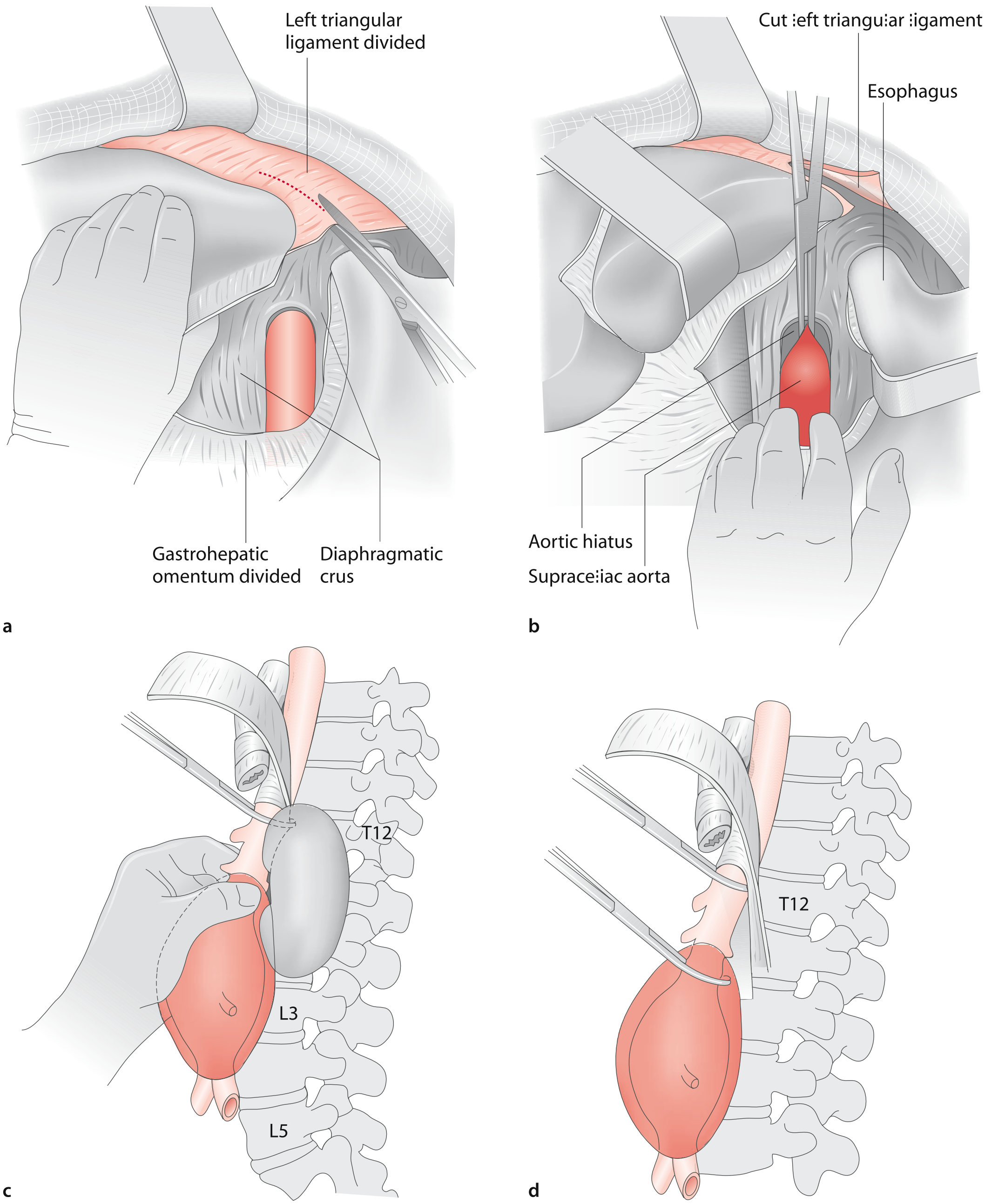

Fig. 7.4. a The left triangular ligament is divided to facilitate exposure of aorta at its diaphragmatic hilus. **b** The gastrohepatic omentum is divided longitudinally, the lesser omental sac entered, and the aorta digitally mobilized at the diaphragmatic crus. **c** After proximal subdiaphragmatic control is achieved by a straight clamp, the posterior peritoneum is divided and the neck of the aneurysm is palpated and digitally dissected, as previously described, through the hematoma. **d** A second clamp is then placed on the neck of the aneurysm and the subdiaphragmatic clamp slowly released

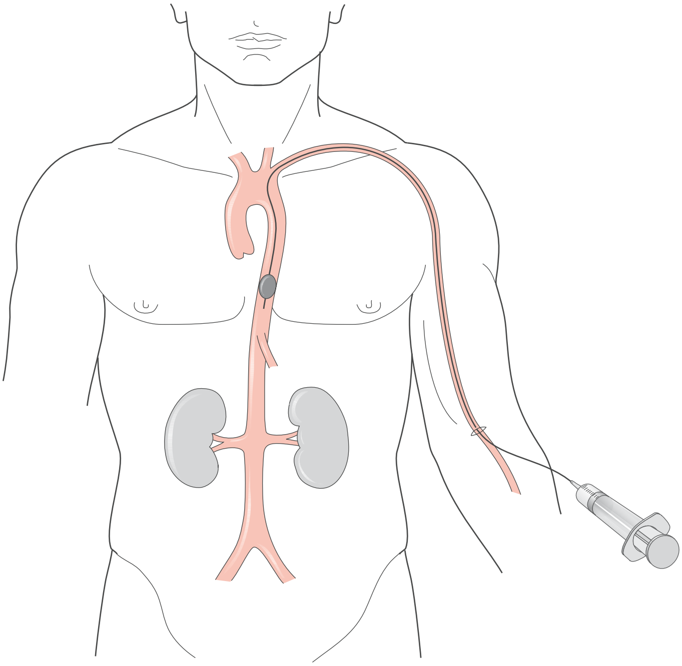

Fig. 7.5. A balloon catheter occluding the aorta at a desired level is inserted through the brachial artery. An alternative is to use a femoral approach with a 16 French 55 cm introducer, supporting the balloon from below

of the aneurysm. Ligature of the inferior mesenteric artery outside the aneurysm should be avoided because this is associated with a certain risk for occlusion of arcade arteries that sometimes are important collaterals in the intestinal circulation. A straight tube graft or an aortobiiliac bypass graft is used for the aortic reconstruction. A collagen-coated woven Dacron graft is recommended; these types of grafts are presealed with albumin and do not need preclotting. A tube graft is used if aorta is soft and not dilated at its bifurcation. If the dilation continues down into any of the common iliac arteries or if there are extensible calcifications in the bifurcation, a tube graft should not be used. If the iliac arteries are calcified or dilated extension of the graft limbs to the common femoral arteries may be necessary. This is combined with ligation of the common iliac arteries. The proximal anastomosis is usually sewn with nonresorbable monofilic 3-0 or 4-0 suture. When the graft is anastomosed to the iliac or femoral arteries a 5-0 suture is used.

After the reconstruction is complete, the anastomoses are checked for leakage and possible obstruction. Finally, the aneurysmal sac is wrapped around the graft and the dorsal peritoneum closed over it. Abdominal drains are never used because even significant postoperative bleeding cannot be drained. More about bleeding complications after aortic surgery can be found in Chapter 12 (page 149). The most common causes for postoperative bleeding are lumbar arteries not being secured during the procedure, anastomotic leakage, or veins that were not ligated but being temporarily contracted during the operation and later dilated.

Because of the increased risk of bleeding, systemic heparin should not be given to all patients with ruptured aneurysms. Those hemodynamically stable and with little operative bleeding should be given heparin IV. A recommendation is to use half the dose used for elective procedures. Local heparinization should be administered by infusing heparinized saline into the iliac arteries. Liberal use of Fogarty catheters to remove clots and emboli dislodged to the leg arteries from the thrombus during dissection is also advocated. If there is no backbleeding from either one of the common iliac arteries, thrombectomy is mandatory.

Antibiotic prophylaxis should be administered according to local protocols for operations involving synthetic vascular grafts. One suggestion is 2 g cloxacillin given at the start of the operation, with the dose repeated after 4 h in prolonged procedures. Besides general perioperative IV fluids, mannitol is recommended to maintain urinary output.

7.5.2.5 What to do While Waiting for Help

For surgeons without experience in AAA surgery it is generally a good idea to wait for a more experienced colleague if the patient is reasonably stable. While the surgeon is waiting for help the patient should be prepared up to the point of anesthesia induction. The surgeon scrubs and the patient is also scrubbed and draped while the anesthesiologist closely monitors the patient's vital functions and hemodynamics. If the patient's blood pressure drops and cannot be maintained at an acceptable level, the patient is anesthetized and laparotomy is initiated without experienced help. The goal is then to achieve control of the bleeding. Besides the previously described techniques to gain proximal control of the aorta, tamponade with lots of swabs and compression with the fist over the bleeding area is usually enough in this situation. These simple measures combined with IV fluids and inotropic drugs is often sufficient to stabilize the patient until help arrives.

7.5.2.6 Endovascular Treatment

In recent years more than 300 patients with ruptured AAA or incipient rupture have been treated with endovascular techniques. The results presented are observational studies and show that endovascular repair of rupture is feasible. A large percentage of the patients in these early series were not in severe shock and the mortality rate averaged around 10%. Furthermore, reduced postoperative morbidity rates compared with conventional open repair have been suggested.

One major benefit of endovascular treatment is the possibility of obtaining rapid proximal control by inserting an inflatable balloon from the groin or through the brachial artery that occludes aorta. This technique makes it possible to delay final treatment until the patient is stabilized. Another potential advantage may be that high-risk patients can also be treated. Particularly favorable is the possibility of using only local anesthesia and sedation for repair.

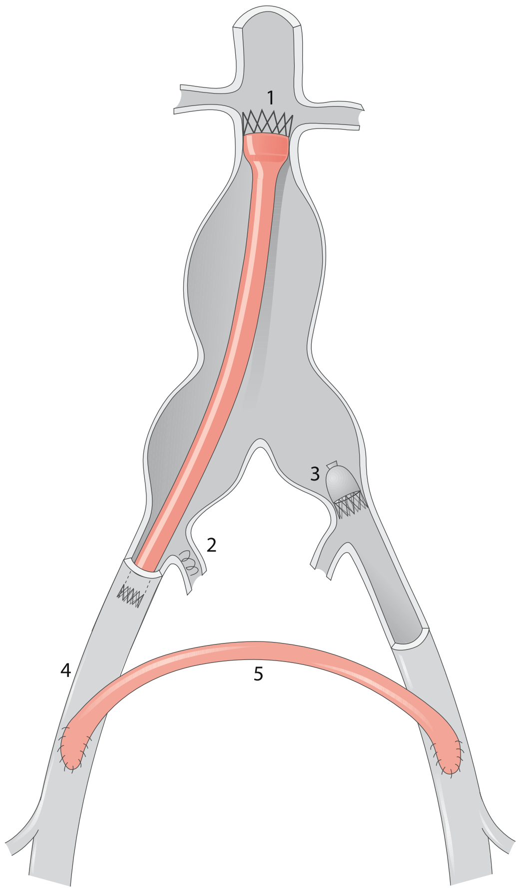

Fig. 7.6. One alternative way to treat a ruptured AAA with endovascular technique. A unilateral aortoiliac endovascular graft decompresses the aortic aneurysm. A coil in the right internal iliac artery and an occluder in the left common iliac artery eliminate pressure caused by backflow, the latter deployed to allow retrograde flow to the internal iliac artery from the groin. A femorofemoral bypass restores perfusion of the left leg

The problems related to endovascular repair include the availability and storage of suitable grafts as well as logistical problems getting the patients worked up rapidly. Pretreatment evaluation with CT angiography or digital subtraction arteriography is necessary to evaluate the possibility for endovascular repair and to plan the procedure. The number of different grafts needed to meet individual requirements is minimized if a unilateral aortoiliac tube graft is used in combination with an occluder of the contralateral iliac system and a femorofemoral crossover, as shown in Fig. 7.6.

The technique involves the following steps: The patient is prepped and draped as for an elective AAA procedure. The common femoral arteries are surgically exposed if a bifurcated graft is inserted or if unilateral aortoiliac tube grafts in combination with a femorofemoral crossover bypass are used. For tube grafts access of only one common femoral artery is enough. One of the femoral arteries is punctured and an introducer is put in place, often a size 7 to 9-French. A guide wire is inserted, an aortogram obtained, and landmarks, either radiolucent (placed preoperatively) or external (such as clamps), are used to assess the length of the AAA. After systemic heparinization, the sheath with the graft is introduced over the guide wire to a level just below the renal arteries. The sheath is then withdrawn somewhat to allow proximal release of the graft. After final adjustment of the proximal fixation level the system is secured by angioplasty. The distal end of the endoluminal graft is deployed in the common, external iliac, or common femoral artery with angioplasty of stents. Depending on the conditions a handsewn anastomosis is another option. An occluder of the common iliac is inserted from the contralateral femoral artery. If a bifurcated endoluminal graft is used, the contralateral graft limb is inserted through the same route. Finally, a completion angiogram is performed after withdrawal of the entire sheath.

A bifurcated aortobiiliac endoluminal prosthesis as a primary alternative in rupture is also growing in popularity. The procedure requires a compliant large-diameter balloon for aortic occlusion, 5 and 12-French introducers, Amplatz guide wires, high-resolution fluoroscopy, and an assortment of endoluminal aortic stent grafts with a body diameters ranging from 22 to 34 mm and limb diameters of 12 to 24 mm.

7.5.3 Management After Treatment

The patient is treated in the intensive care unit until circulatory, respiratory, and renal functions are stable. This usually takes at least a couple of days. The most common early postoperative complications are congestive heart failure, renal failure, and ischemic colitis. The patient, often with concomitant coronary heart disease, is exposed to severe stress during preoperative shock and aortic clamping and declamping. Deterioration of cardiac function with secondary hypotension that requires inotropic treatment is common. Renal function is also often impaired and occasionally the patient requires dialysis. Almost all patients have increased creatinine and blood urea nitrogen elevations after operation for ruptured AAA. These increases are also due to preoperative hypotension and the stress of the operation. If the patient develops renal insufficiency with low urinary output, dialysis should be considered at an early stage.

The greatest risk for developing ischemic colitis is in patients with a ruptured aneurysm and shock. The severity of ischemic colitis varies from only discharge of the mucosa to transmural necrosis. Registration of pH at the wall of the sigmoid with a tonometer can be used to determine the risk for developing ischemic colitis. This condition is further discussed in Chapter 12 on complications in vascular surgery (page 145).

7.6 Results and Outcome

The 30-day mortality after surgery for ruptured AAA averages from 30% to 50%, the variability depending on whether the patient developed shock and whether concomitant diseases were present. For patients without shock, it is 20–25%, which can be compared to 60–70% for those without. The long-term results and prognosis for patients who survive the initial postoperative period is good. Outcome is even better than for patients who have undergone elective aneurysm repair. The reason for this is probably selection – the sickest patients die of rupture, and the survivors who reach the hospital have fewer risk factors.

7.7 Unusual Types of Aortic Aneurysms

7.7.1 Inflammatory Aneurysm

An AAA can be symptomatic and cause pain without actual or imminent rupture. The most common cause for this pain is an inflammatory reaction in and around the wall – an inflammato-

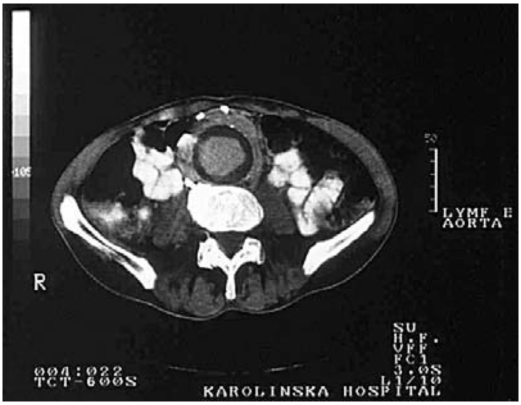

Fig. 7.7. Typical appearance on computed tomography of an inflammatory abdominal aortic aneurysm with its thick wall

ry AAA. CT, which then shows a thickened aneurysm wall, verifies the presence of such a condition (Fig. 7.7). It could be presumed that the thick wall prevents rupture, but rupture of inflammatory AAAs is not uncommon. Because inflammatory AAAs often are painful, separating them from ruptured AAAs is a real diagnostic problem. Elevated erythrocyte sedimentation rate (ESR) or C-reactive protein (CRP) supports the diagnosis, but CT is the only way to exclude it.

7.7.2 Aortocaval Fistula

A special form of AAA rupture occurs when the bloodstream penetrates into the vena cava causing an aortocaval fistula (Fig. 7.8). The patient typically develops sudden cardiac failure and cyanosis of the lower extremities. The cardiac failure is due to the large shunt and the discoloration of the legs occurs because of venous stasis in combination with the heart failure. At physical examination the patient is positive for a bruit and a palpable aneurysm in the abdomen. Treatment for an aortocaval fistula is an emergency operation, but in most cases some time for preoperative preparation is available. The operation follows the strategy for other aneurysms as outlined previously and the fistula is usually closed by suture from inside the aneurysm while vena cava is controlled by manual compression proximally and distally.

7.7.3 Thoracoabdominal Aneurysm

A small number of aortic aneurysms engage the suprarenal or thoracoabdominal parts of the aorta including the orifices of the renal arteries, the superior mesenteric artery, and the celiac trunk. They originate in the thoracic part of the aorta or anywhere below the level of the diaphragm. Management of rupture in such aneurysms is challeng-

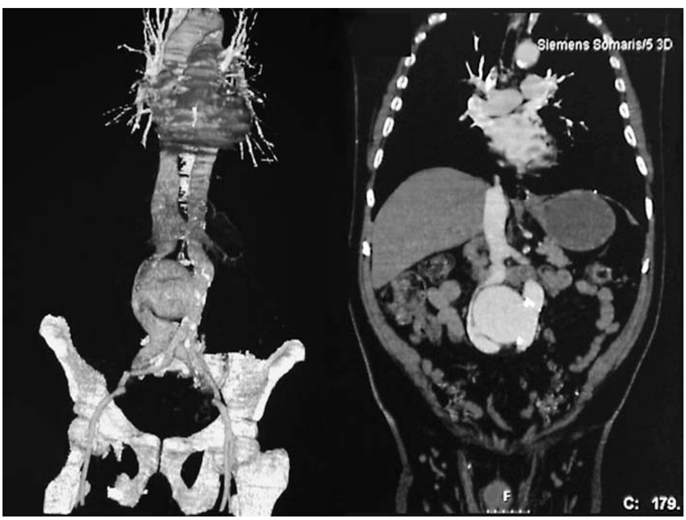

Fig. 7.8. Computed tomography of a patient with an abdominal aortic aneurysm and a fistula into the inferior vena cava

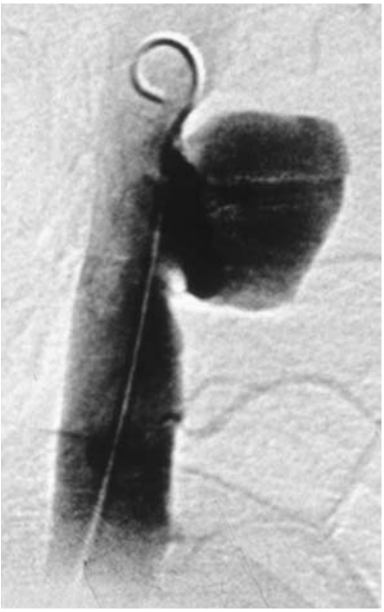

Fig. 7.9. Angiographic appearance of a typical mycotic aneurysm, with its saccular shape caused by local erosion of the aortic wall and subsequent leakage of blood into an aneurysmal sac consisting of a fibrous capsule (not a true vascular wall)

ing, and if its extension is known prior to the operation someone with experience should be contacted before surgery begins. If such an aneurysm is achieved during surgery for rupture, proximal control is sought by one of the techniques described previously. Endovascular repair is also an option that needs to be considered.

7.7.4 Mycotic Aneurysm

Another special type of AAA is caused by a local infection in an atherosclerotic and degenerated aortic wall, known as mycotic or septic aneurysm. Different from ordinary AAAs that are fusiform, mycotic aneurysms are usually saccular (Fig. 7.9). Patients with this type of AAA frequently have a medical history that includes fever and malaise. Elevated ESR, CRP, and other inflammatory parameters are also common. The most common bacteria found in mycotic aneurysms and in the patient's blood are of the Salmonella species. It is the infectious process in the wall that causes erosion and subsequently rupture. Treatment is the same as for other AAAs with the addition of long-term antibiotics.

7.8 Ethical Considerations

Difficult and delicate ethical considerations often arise when managing patients with ruptured AAA. Accordingly, it has to be emphasized that the advice given above often needs to be modified in very old patients, patients with dementia, and patients with other serious medical conditions implying only a short expected survival time. On the other hand, patients who previously were determined not suitable for elective repair because of high risk should sometimes be considered for repair of a ruptured AAA. When rupture has already occurred the risk/benefit situation is completely different. The patient has little to lose by undergoing an emergency operation.

Rupture of an AAA often occurs in elderly patients and a complete medical history and information about their present quality of life is frequently missing when they are admitted. Because nonsurgical management is associated with 100% mortality, a policy of accepting every patient for surgical treatment is advocated in many hospitals. A certain selectivity, however, is often wise. It is obvious that a patient who had cardiac arrest in the ambulance and remains unconscious at admission, is anuric, and has ECG signs of myocardial ischemia is extremely unlikely to survive surgery. If the patient is 80 years old and also is known to have dementia, difficulties ambulating, and need for geriatric care, it is reasonable to avoid surgery and instead give the patient terminal care of high quality. Unfortunately, there are no reliable prognostic factors for treatment outcome for the individual patient, but many studies report relationships between presence of different risk factors and survival.

A common conclusion in the literature, however, is that age should never be considered as a contraindication to surgery. It is always the surgeon, the patient and relatives and their individual judgment that finally decide whether to operate or not. If one is in doubt, a good general rule is to be liberal with repair attempts. It is always possible, but difficult, to change such a strategy later during the course when more information is available. Accordingly, stopping the support of vital functions and taking the patient to the floor for palliation is a viable option. Some factors in the postoperative course – large bleedings and cardiac, renal, respiratory, and infectious complications – are considered to be associated with a worse prognosis and thus might indicate a suitable point at which to make such a decision.

Further Reading

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