Abdominal Aortic Aneurysm

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A 59-year-old man presented with an abdominal aortic aneurysm (AAA) discovered on Duplex-scan examination of the abdomen. The AAA was 56-mm large with a slightly conic infra renal neck and an aneurysmal right common iliac artery. The patient was otherwise asymptomatic, with no abdominal or back pain. His medical history was significant for hypertension controlled by bitherapy, non-insulin-dependent diabetes diagnosed 5 years previously, and a smoking history of 30 packs/year. He had neither history of myocardial infarction (MI), angina pectoris nor claudication. He could still play 18 holes of golf and run once a week wi thout difficulties.

His family history revealed that his father died of an aortic aneurysm rupture. He has a 66 year old brother without apparent health problems. On examination, the patient was slightly overweight, no abdominal mass could be palpated. His past surgical history was only relevant for a groin hernia repair in his mid thirties.

A computed tomography (CT) scan was performed (Figs. 2.1 and 2.2). Routine blood tests were normal as well has is electrocardiogram and chest X-ray.

Question 1

The AAA of this patient was found by a systematic screening. In which group(s) of population is Duplex scan screening for AAA justified?

A. Uncomplicated hypertensive patients.
B. Patients with a family history of aneurysmal disease.
C. Patients with a smoking history.
D. Patients with peripheral vascular disease.
E. Obese patients with vascular risk factors
F. All men, starting at the age of 50 years.

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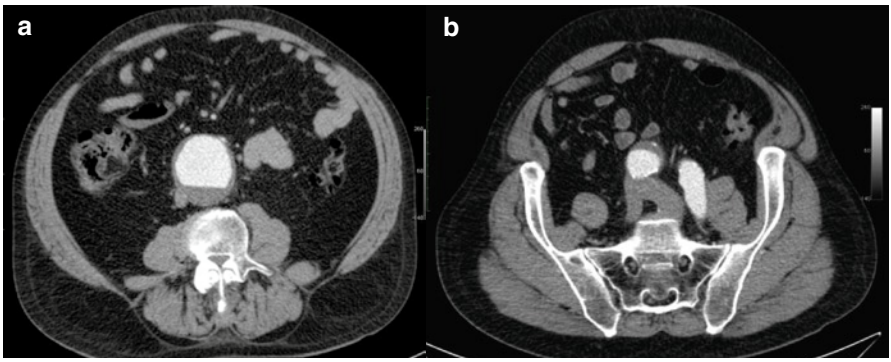

Fig. 2.1 (**a** and **b**): CT scan demonstrating the aortic aneurysm as well as the right common iliac aneurysm

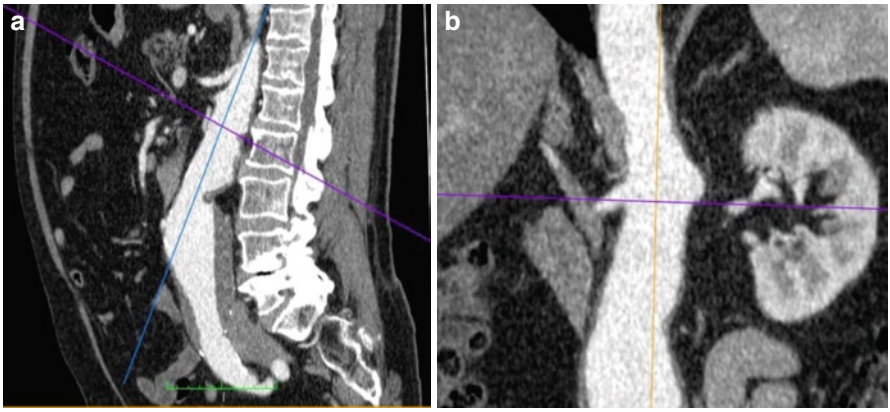

Fig. 2.2 (**a** and **b**): After 3D processing, biplanar reconstruction centered on the renal arteries showing a mild conic shape (**a**) with posterior thrombus (**b**)

Question 2

Without treatment this patient is at risk of rupture. Among the following factors which one(s) have been proved to be associated with an increased risk of rupture?

A. Diameter > 60 mm
B. Association with an hypogastric aneurysm
C. Diabetic patient
D. Lower limb occlusive disease
E. Smoking
F. COPD

Question 3

With the imaging you have been provided with, is (are) there any reason(s) for performing an arteriogram

A. No need, CT-scan is sufficient
B. An angiogram is mandatory to facilitate the planning of the surgical procedure in case of difficult anatomy
C. Angiogram would be needed in case of endovascular treatment
D. Angiography is necessary to rule out any asymptomatic associated visceral arterial stenosis

Question 4

To assess the operative cardiac risk would you need any further test in our patient.

A. None, ECG is sufficient.
B. Cardiac scintigraphy.
C. Cardiac echography.
D. Cardiac echography with Dobutamine test.
E. Coronary angiography.

Question 5

If an operation were being considered, which of the following factors are associated with an increased post-operative mortality?

A. Diameter > 60 mm
B. Association with an hypogastric aneurysm
C. Diabetic patient
D. Renal insufficiency
E. Smoking

Question 6

With the current information you got from the case report, what would you recommend to the patient (a) and which in case of a higher operative risk (b)

A. Duplex scan surveillance every 3 months
B. Aorto bifemoral through a midline incision
C. Aorto bifemoral graft through a left retroperitoneal incision
D. Aorto bi iliac graft through a left retroperitoneal incision
E. Stent-graft

The patient underwent, via a left retroperitoneal approach, an aorto-right and left common iliac bypass with end-to-end anastomosis. The aortic anastomosis was performed just at the level of the renal artery with a supra renal clamping of 10 min. This was justified by the necessity of suturing the prosthesis on the healthiest segment of aorta as possible. Therefore the retroperitoneal route gave a better access to the supra renal aorta. A cell saver was used and no heterogeneous blood had to be transfused.

The patient's postoperative course was uneventful, and he was discharged on the ninth post operative day.

Question 7

During open operation for AAA cell-saver autotransfusion (CSA) can be used. Which of the following is/are correct?

A. It should be used systematically.
B. It should be reserved for when the expected blood loss is significant.
C. It should be substituted in all cases with preoperatively deposited autologous blood transfusion.
D. It presents fewer complications than unwashed cell autotransfusion.
E. It should not be used in case of ruptured aneurysm.

Question 8

Does a genetic predisposition to AAA exist? Describe the pathogenesis of AAA.

Question 9

A duplex scan has been performed to the patient's brother which found a 40 mm abdominal aneurysm.

What recommendation(s) would you give this patient's brother?

A. Serial duplex studies at 3-monthly intervals, and intervention when the diameter reaches 5.5 cm.
B. Serial duplex studies at 6-monthly intervals, and intervention if the diameter reaches or exceeds 5 cm.
C. Serial duplex studies at 12-monthly intervals until the diameter reaches 4.5 cm, then every 6 months until the diameter reaches 5 cm, then every 3 months, and then intervention when the aneurysm reaches 5.5 cm.
D. Schedule the patient for surgery as he is a smoker and therefore his aneurysm will most likely require intervention.

2.1 Commentary

The question of the optimal format for population screening and its cost effectiveness for AAA is still under debate. Many studies have attempted to identify high-risk populations in order to reduce healthcare costs and maximize the yield. Simon et al.[1] have demonstrated a prevalence of AAA of 11% in male patients aged 60–75 years with a systolic blood pressure greater than 175 mmHg. No patient with uncomplicated hypertension had AAA. Claudication was the only cardiovascular complication associated independently with AAA (relative risk 5.8). Baxter et al. found a prevalence of 9% in patients older than 65 years old regardless of cardiovascular risk factors.[2] Furthermore, preliminary results from the Aneurysm Detection and Management (ADAM) study revealed that smoking was the most important risk factor associated with AAA (odds ratio [OR] 5.57), followed by a positive family history (OR 1.95), age, height, coronary artery disease, atherosclerosis, high cholesterol level and hypertension.[3] Similar results were found in the later Multicentre Aneurysm Screening Study (MASS) demonstrating that screening in male patients older than 65 years old would be cost effective.[4] Therefore, most vascular surgeons agree that all men over the age of 65 years and women who did smoke[5] should systematically be offered an abdominal ultrasound, the screening should be done at 55 years if indicated family history.[6] [**Q1: B, C, D**]

Natural history of aneurysms and risk of rupture are better understood with the results of the UK small aneurysms trial[7] and the ADAM trial. As in former cohort studies of patients who refused early operation[8] or who were considered to be inoperable, risk of rupture increased with size, and intervention seems justified over 5.5 cm, in patients with sufficient life expectancy. Growth is recognized as related to tobacco use but diabetes mellitus and female gender are protective. Controversial opinion regarding other risk factors persist as recent data suggests no influence of hypertension, statin use and ACE on aneurysm growth as published in former studies.[9] Rupture is strongly correlated with persistent tobacco use, female gender, aneurysm size, diminution of FEV1, HTA and presence of transplant. [**Q2: A, E, F**]

Pre-operative planning is of outmost importance in order to avoid intra-operative unexpected findings, shortening of the surgery and/or evaluate the possibility of endovascular treatment. Nowadays, the CT scanner with 3D reconstruction, the gold standard, and invasive conventional angiography, is only needed for treatment of subsequent visceral significant and symptomatic stenosis. Albeit relatively frequently in patients requiring AAA surgery, visceral arterial stenosis[10–12] should be treated separately if needed and via endovascular means when possible. One stage surgery with visceral reconstruction increases the operative difficulty and consequently the operative risk.[13] Actual data shows better assessment of vessel morphology with CT reconstruction than angiography for EVAR[14] but is also useful in open surgery to evaluate the vessels morphology and planning of surgery in case of any anatomical anomaly (e.g, horseshoe kidney). [**Q3: A**]

Concerning a pre-operative work-out; routine coronary angiography in vascular patients has shown that 60% of them have severe coronary artery disease.[15] However a large randomized study in patients with stable angina have clearly demonstrated that pre-operative coronary bypass or angioplasty do not improve the post-operative and 5 year survival rate.[16] Beta blockers, statins and antiplatelets have all contributed to the reduction of cardiac events following major vascular surgery. Thus pre-operative investigation can be restricted to patients with poor functional capacity and at least three identified predictive factors of severe coronary artery disease.[17] In the current case diabetes, hypertension and mild renal insufficiency are three of these markers and pre-operative cardiac screening would have been indicated if the patient hadn't shown a good functional capacity.[18] [**Q4: A**] When mandatory cardiac echography with dobutamine probably is the most reliable test.[19] And pre-operative coronary revascularization is only indicated for those patients with acute ST elevation MI, unstable angina, or stable angina with left main coronary artery or three-vessel disease, as well as those patients with two-vessel disease that includes the proximal left anterior descending artery, and either ischemia on non-invasive testing or an ejection fraction of less than 0.50.

Analysis of predictive factor of mortality in patients submitted to open repair of AAA have shown that age, cardiac status, renal insufficiency and pulmonary status were strongly predictive of post operative complications and deaths. Difficult operations are also associated with an increased operative risk mostly related to the increase of blood loss. Unilateral or bilateral hypogastric aneurysm increased the operative risk.[20] [**Q5: B, D**]

In this case surveillance was not recommended due to the aneurysm size and the relatively young age of the patient.

Open surgery via a trans abdominal or retroperitoneal approach is a wise option in case of low operative risk and difficult anatomy as in our case where the infrarenal neck was not suitable for a regular endovascular graft implantation. We choose a retroperitonal approach because of the better exposure of the aorta at the level of the visceral arteries and his obesity. A retroperitoneal approach is an appealing way especially in case of obese patient or the need for preparation of the aorta at the level or upper the renal arteries. Nevertheless the distal right iliac axis remains the Achilles heel's of this approach which would have required a second contra lateral incision for reconstruction of the right external iliac axis if needed. In our case the aneurysm involved only the proximal right common iliac artery and the right iliac anastomosis could be achieved with a slight enlargement of the retroperitoneal route toward the midline.

Femoral anastomosis is not recommended because of the increased infection rate after a groin incision. [**Q6a: D**]

Although a retroperitoneal approach provides a better access to the suprarenal aorta, the former advocated superiority of the retroperitonal route in terms of pain. Bowel and respiratory function was never supported by randomized trials especially in the era of perioperative peridural analgesia. No actual data support the systematic use of trans versus retro peritoneal approach in terms of post operative outcome, therefore the choice should be based on the anatomical features and surgeon preference.

Less invasive with a lower operative mortality (1.5% vs. 4.6% for Open Repair[21]), a shorter in-hospital stay and recovery time, EVAR could have been considered if the

patient had a suitable aortic neck, major comorbidities or hostile abdomen. Although the two major early randomized trials (EVAR 1 and DREAM) failed to show sustained benefit of the post-operative mortality at 2 years, no death in the EVAR group was aneurysm related,[22,23] and a former survey showed an incidence of ongoing aneurysm related mortality after EVAR of 1% per year.[24] A large retrospective case match cohort study including more than 40,000 participants did not show inferiority of the long term results of EVAR compared to Open Repair and the rate of secondary procedure in the EVAR group was largely overwhelmed by the rate of wound hernia after OR. Subsequently secondary procedure frequency seems to decrease after the first year following EVAR.[25]

Therefore EVAR is considered by many teams as the first option in case of adequate anatomy. Usual recommendation for endovascular aneurysm treatment requires a proximal neck length under the renal artery of 15 mm, a limited angulation of the aorta (<;60°) or iliac arteries (90°) and healthy landing zones (no or minor dilatation, parietal thrombus or circumferential calcifications).

As already mentioned the infra renal neck seemed inappropriate for conventional graft placement but could have been amenable for a fenestrated or branched graft as in Fig. 2.3 with good midterm results.[26] Branched iliac grafts can treat aneurysmal distal landing zone avoiding the traditional selective hypogastric coiling before endo-graft deployment down to the external iliac artery which has a subsequent risk of ischemic complication in up to 30% in case of bilateral hypogastric sacrifice.[27] [**Q6b: E**]

Over the past 3 decades, with the appreciation of the risk of transfusion related transmission of infectious diseases, a large body of research and instrumentation has emerged on auto transfusion. The current options are:

- Preoperative deposit of autologous blood.
- Intraoperative salvage and washing of red blood cells (cell saver).
- Intraoperative salvage of whole blood without washing.

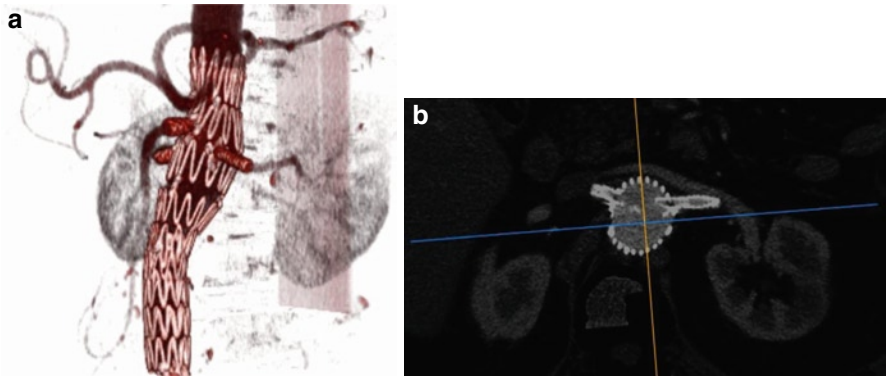

Fig. 2.3 (**a** and **b**): 3D reconstruction of a fenestrated graft with detailed view at the renal arteries level in a patient with a very short infrarenal neck

Although both whole-blood autotransfusion (WBA) and cell saver auto transfusion (CSA) are currently in use, the magnitude of hemostatic and hemolytic disturbances, as well as the clinical side effects, after WBA compared with CSA are still in debate. While Ouriel et al.[28] showed the safety of WBA in 200 patients undergoing AAA repair, others have demonstrated a lower content of hemolytic degradation products and fewer coagulation disturbances after retransfusion of cell-saver blood.[29] Although cell salvage reduce allogenic blood requirement with reduced intensive care and post operative stay no significant impact on the outcome could be demonstrated.[30] Nevertheless its use seems to lower mortality in ruptured aneurysm surgery.[31] Despite its widespread use, several studies have found that CSA is not cost effective and should be limited to patients who have an expected blood loss of at least 1,000 ml, which includes patients with large, complicated aneurysms.[32,33] Finally, transfusion of predonated autologous blood is associated with some of the disadvantages of homologous transfusions, i.e., dilutional hypofibrinoginemia, thrombocytopenia and hypothermia. [**Q7: B, D**]

The causes of AAA are numerous, and may include inflammation, infection with mycotic aneurysm commonly due to Salmonella or Staphyloccous species, nowadays rarely to syphilis infection, aortic dissection, Ehler–Danlos type IV and Marfan syndrome although aneurysm degeneration is rarely seen in Marfan patient without prior dissection. Presence of a common variant of 9p21 is associated with an 31% increased risk for AAA. It is estimated that 15% of patients presenting with an AAA have a first-degree relative with the same condition. Male siblings are at higher risk, but current evidence also supports an autosomal dominant pattern of inheritance.[34]However, more than 90% of all AAAs are associated with atherosclerosis and are classified as either atherosclerotic or degenerative aneurysms. Although aneurysmal and atherosclerotic changes share several common risk factors, atherosclerotic lesions are predominantly intimal with foam cell formation, whereas oxidative stress, immune mediated inflammation leading to matrix degradation and smooth cell apoptosis occurs in the media and adventitial layers in aneurysmal disease.[35]

As ongoing research tends to prove that oxidative stress is the hallmark of aneurysm formation there might be a place in the future for immuno-modulator treatment to cure or prevent arterial aneurysms.[36,37] [**Q8**]

The management and surveillance of small AAAs has been debated for many years. The UK small aneurysm trial has attempted to shade some light on this subject.[38] The participants of this trial concluded that early surgical intervention did not offer any long-term survival advantages for aneurysm under 5.5 cm. Their recommendations, based on the trial methodology, were serial duplex every 6 months for aneurysms of size 4–4.9 cm, and every 3 months for aneurysms of size 5–5.5 cm. In another, larger analysis, the recommendations were yearly duplex for aneurysms measuring 4–4.5 cm on the initial scan.[39] However this study and the later from Thompson et al.[9] did show that only 25% and 50% respectively didn't needed surgery or ruptured during follow up.

Chronic obstructive pulmonary disease (COPD) and continuation of smoking have been associated with aneurysm expansion, but the rate of expansion does not justify intervention on 4-cm aneurysms.[40] Therefore only smoking cessation and careful survey are the only actual recommended treatment for small aneurysms as well as management of frequently associated cardio-vascular co-morbidities. [**Q9: C**]

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