Ruptured abdominal aortic aneurysm repair: introducing a step-by-step protocol

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INTRODUCTION

A controversy still exists around the world on the best strategy to treat ruptured abdominal aortic aneurysms (rAAA). For decades open repair has been considered the treatment of choice, though characterized by high and constant 30-day mortality despite improvements in intensive care unit (ICU) and anesthesiology care.[1] Nowadays EVAR is becoming increasingly popular in rAAA treatment. Both Society of Vascular Surgery (SVS) and European Society of Vascular Surgery guidelines recommend endovascular repair (EVAR) over open repair for a rAAA if anatomically suitable,.[2,3] In the largest meta- analysis so far, Van Beek et al by including 32 studies investigated the short term survival after EVAR or open repair for rAAA.[4] Based on the randomized controlled trials (RCTs) in defined populations 30-day or in-hospital survival were equal between EVAR and open repair, while based on observational studies with probably more selection of patients EVAR performed better than open repair.[4]

Hereby, based on the current literature and personal experience, we try to propose a step-by-step detailed protocol regarding patients with rAAA that arrive at dedicated Hospitals having the ability to perform both treatment modalities. The protocol algorithm is summarized in figure 1 and analyzed below.

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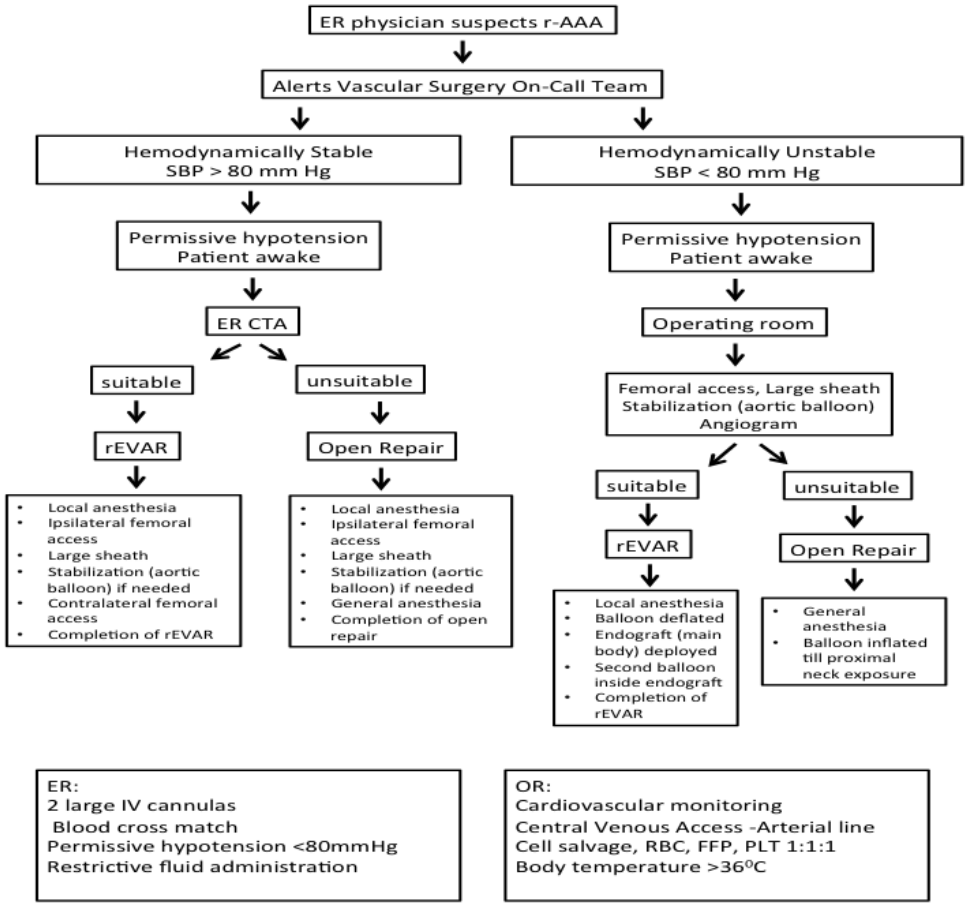

Figure 1. Summary of the protocol algorithm.

PROTOCOL

Emergency room

Information of a rAAA inside or outside the hospital should trigger an immediate alert to the vascular on-call team. This team should include at least two vascular surgeons, an anesthesiologist, OR staff and a radiology technician if available. Patients in the emergency room presenting with a rAAA should be evaluated according to hemodynamic stability (Systolic blood pressure>80 mmHg). The preoperative management of the patient should include securing intravenous (IV) access, two peripheral large bore cannulas, blood cross match and restricted resuscitation (permissive hypotension).[5-9] Central venous access and arterial line are not necessary at this stage and there should be no delay in emergency room (ER) in order to secure them. Intravenous fluids and vasoactive medication should be avoided as long as possible. The concept of permissive hypotension in which low systolic blood pressure (50-70 mm Hg) is accepted, to the extent that oxygen delivery to the brain (conscious patient) and the myocardium is maintained (no arrhythmias or chest pain), until hemorrhage control is achieved should be followed. This concept limits internal bleeding and associated loss of platelets and clotting factors. Systolic pressures of 50-70 mmHg are acceptable for a short period of time.

Stable patients should rapidly undergo a computed tomography angiography (CTA) to assess anatomical suitability for EVAR, while unstable patients should be transferred immediately to the operating room without a CTA. Conventional exclusion criteria for EVAR are used and include: (1) aortic neck diameter greater than 32 mm, neck length shorter than 10 mm, significant calcification (circumferential), thrombus (>40%), or aortic neck angulation greater than 60 degrees; and (2) iliac vessels less than 6 mm in diameter for delivery of the main body graft or with significant tortuosity.[10] Although the planning phase for cases of ruptured aneurysms is often under significant time restrictions, and perhaps with limited imaging quality available, it is important to make the most of the imaging and to spend a few extra minutes reviewing the possible difficulties of each case. A dedicated three dimension (3D) reconstruction software could aid in performing accurate length and diameter measurements and design properly the whole procedure. In any case, the experience of the whole team and the logistics of the hospital should be taken into consideration when the suitability for EVAR is decided. We should also keep in mind that the haemodynamic condition of the patient on presentation may influence CTA image of the proximal neck and, to avoid an intraoperative or late Type Ia endoleak, 30% oversizing maybe preferable when treating a rAAA assessed by CTA performed during permissive hypotension.[3]

To initiate and achieve a proper rEVAR programme it is very important to retain a wide stock of available endografts. It is logical that due to logistic reasons it is not possible to have all types of endografts, however an endograft with suprarenal fixation (28-36 mm diameter of main body) and several limbs can really cover nearly all rAAAs. It is important that the devices used for rAAAs should be the ones that the operator routinely uses for elective EVAR and with which the operating team has significant experience.[2,3]

Operating room

Stable patient with suitable anatomy: Stable patients with a suitable anatomy determined by CTA should undergo EVAR. Permissive hypotension is continued, and the patient is carefully monitored by the anesthesiology team (Monitor Anesthesia Care, MAC). The procedure should be performed under local anesthesia. Use of local anesthesia helps to avoid the hemodynamic changes associated with muscle relaxation and general anesthesia. Emergency EVAR may be performed under local anesthesia alone, but the anesthesiology team should be prepared to emergency conversion to general anesthesia if necessary. The EVAR procedure can be accomplished by the standard way. Systematic heparin administration could be deferred until the rupture is sealed. The uni-iliac configuration offers a fast and reliable solution, especially in inexperienced hands. However, bifurcated stent-grafts, as also stated in the recent ESVS guidelines[3], offer a more physiological solution with a shorter overall operation time in experienced hands, and obviate the need for a femoro-femoral bypass. By appropriately using occlusion balloons (described later), the hemodynamic stability of the patient can mostly be ensured during placement of a bifurcated stent graft without the need to convert to a uni-iliac repair. The main indication for using a uni-iliac system is in the setting of unilateral iliac occlusion or a severely compromised access that cannot be overcome.

Stable patient with unsuitable anatomy: In patients anatomically unsuitable for EVAR as determined by CTA, open repair should be performed. An aortic occlusion balloon could be also used in a similar manner (as described later), as an extra asset to preserve or restore intraoperative instability before exposing the proximal aortic neck. Induction of general anesthesia should be commenced after draping of the patient, in order not to affect patient hemodynamics during preparation. Central venous pressure and arterial line monitoring are suggested for all patients undergoing rAAA open repair. The lines should be secured before induction to general anesthesia, but without causing unnecessary delay.

Unstable patient: Unstable patients should immediately be transferred to the operating room without a CTA. To stabilize patients, which seems necessary in about 10-20% of them, aortic balloon occlusion can be used effectively. This technique was also used in open repair in the earlier years, when clamping proved difficult. The technique of balloon-occlusion in rEVAR involves the use of a large compliant balloon over a stiff guidewire, and inside a long (45cm in length), 12-14F sheath to retain correct position. With proper training, this technique can be applied in every unstable patient at the beginning of the procedure.

After femoral access under local anesthesia is achieved, we recommend placement of a large sheath (12-14 F, 45 cm) in the aorta over a stiff guidewire. The sheath is placed in the suprarenal position (at the level of 12T to L1 vertebra), to provide adequate passage and support for the occlusion balloon. Within this sheath in place, a large balloon for aortic occlusion is inserted and deployed above the renal arteries. After inflation of the aortic occlusion balloon, an angiogram can easi-

ly be performed through the same large sheath to assess for anatomic suitability for EVAR. This should allow to determine the eligibility for EVAR and make a definite choice between rEVAR under local anesthesia or OR under general anesthesia. The patient should be prepared for both types of anesthesia immediately after arriving in the OR.

During intraoperative angiography to determine EVAR-eligibility the vascular surgeon should take into account the angulation, shape and length of the proximal aortic neck. The length can be estimated with the use of a metric catheter. However we must not forget that the angiogram shows only the lumen and certain properties as the proximal aortic neck diameter, the presence of thrombus or a tapered neck cannot precisely be estimated. In every way in these cases the decision on the proper endograft relies on the selection and experience of the vascular surgeon.

In *unstable patients with anatomic suitability* for EVAR the endovascular procedure is continued under local anesthesia. The main body of the endograft is inserted from the contralateral of the balloon side and deployed just below the renal arteries. At this point, a repositioning of the occlusion balloon to a more proximal position may be needed in order to advance the proximal tip of the endograft's delivery system. The 12-14F sheath's position must be maintained well above the renal arteries until the main stent graft has been deployed, in order not only to secure the position of the inflated balloon, but also to facilitate the withdrawal of it after deflation, especially when endografts with suprarenal active fixation are used. When the main endograft has been deployed in the desired position, it's delivery system is withdrawn and a second aortic balloon is advanced inside the endograft and inflated just below the renal arteries and inside the main body of the endograft. The first balloon is then deflated, and removed through the 12-14F sheath, which then should also withdrawn in the aneurysm sac. Alternatively, if a second balloon is not available, the first balloon can be used in the main graft's ipsilateral side after withdrawal. Since an infrarenal occlusion has been achieved inside the main body of the endograft, catheterization of the contralateral gate and completion of the EVAR procedure could be performed, without time strain and additional blood loss.

In *unstable patients anatomically unsuitable for EVAR*, open repair should be attempted. Similar (as described above), the aortic occlusion balloon could act as an initial endo-clamping to preserve intraoperative stability during the induction of anesthesia and laparotomy. Such a maneuver also allows the proper dissection and exposure of the proximal aortic neck to achieve a safe proximal control. Afterwards the balloon could easily withdrawn to the level of the iliac artery (usually at the level of L4 vertebra) and used for an iliac endoclamping.

If the intraoperative hemoglobin level is <10 g/dL and blood loss is ongoing, transfusion of packed blood cells along with fresh frozen plasma and platelets in a ratio of 1:1:1 is recommended. Fibrinogen and prothrombin complex concentrates administration are recommended during massive transfusion, whereas rFVIIa should be reserved until all means have failed. In the operating room the patients' body temperature should be maintained above 36^0C using forced air warming blankets in order to avoid blood clotting dysfunction and metabolic acidosis.[11]

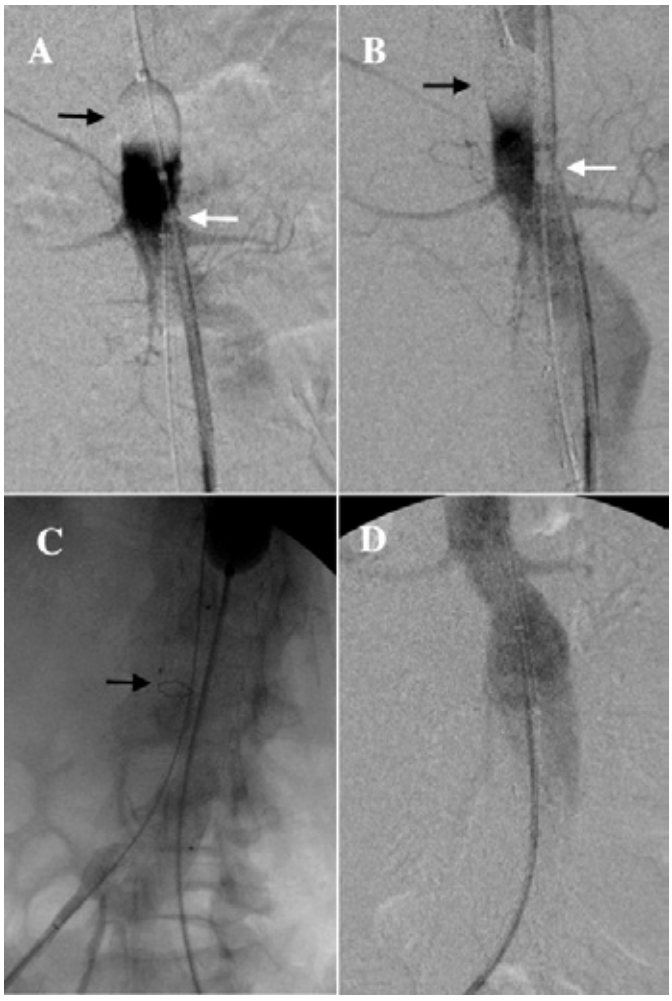

Figure 2. Fluroscopy image showing A. The deployment of the aortic balloon through a 14F sheath coming from the right groin (white arrow) and its inflation (black arrow) well above the renal arteries with the subsequent angiogram through an 8F seath coming fom the left groin.. B. The deployment of the main graft coming from the left just below the renal arteries (white arrow), with the occlusion balloon (black arrow) maintained above them. C. After withdrawal of the delivery system, an aortic balloon is advanced inside the endograft from the left and inflated inside the main body of the endograft, below the renal arteries. Subsequently, the cannulation of the contralateral gate is achieved (black arrow) , D. Final angiogram after the successful deployment of the bifurcated graft.

DISCUSSION

The primary goal of development of a rAAA protocol is to use EVAR as the initial treatment for rAAAs in most cases, which is the current recommendation of several vascular societies.[2,3] Hypotension or hemodynamic instability on presentation should not be considered a contraindication for rEVAR. A secondary aim of the protocol is through introducing a stepwise approach, to standardize the early patient's management from the time of presentation to the initiation of the procedure in the operating room, independently of the final treatment choice.

The establishment of such a protocol is not always easy and requires an on-call multidisciplinary team of various medical specialties and surgical staff, as well as the ability of each Hospital to perform adequately both treatment modalities in terms of personnel capabilities and logistics. Pre-hospital and emergency room personnel should be aware on the use of permissive hypotension, warming and intubation avoidance, factors that may avoid exacerbation of hemodynamic instability. Anesthesiologist should be informed to keep patients awake and apply permissive hypotension until an adequate control of bleeding is achieved. Those performing the procedure should be experienced in EVAR as well as in open repair of AAAs. An always-available inventory of various endografts, wires and catheters is also essential for implementation of a rEVAR programme.

Patient selection seems to play a significant role on outcome after rAAA treatment. In the IMPROVE study, crossover between the two treatment arms was common, showing that factors as hemodynamic instability and anatomic suitability are critical for the therapeutic decision.[12] Selection of patients for achieving favorable results for rEVAR can only be accomplished with the establishment of a standardized protocol. Some studies suggested that an EVAR-driven protocol for treating rAAAs is associated with an improved outcome not only for the EVAR treated patients, but as well as for those treated by OR.[13-14] Moore et al. by assessing 126 patients with rAAA demonstrated that a predefined strategy that includes rEVAR was associated with improved mortality.[15] These results are in accordance with those published by Mehta et al. who showed that emergent EVAR of hemodynamically stable and unstable patients was associated with a reduction in mortality (from 51% to 18%) once a standardized protocol was established.[16] Both studies were conducted in high-volume centers with highly experienced vascular teams.

CONCLUSION

With a standardized team approach, hemodynamically stable and unstable patients with rAAA can be treated by endovascular means. Unstable patients with rAAA may be particularly benefited by EVAR and should not be excluded from repair. Successful implementation of a systematic protocol relies on a devoted experienced team of surgeons, anesthesiologists, nurses, and surgical staff, coordination of pre-hospital and emergency room care, and an adequate stent graft inventory.

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