TECHNICAL NOTE

Techniques in occluding the aorta during endovascular repair of ruptured abdominal aortic aneurysms

Mark Edward O'Donnell, DSEM, MRCS, Stephen A Badger, MB, MRCS, Ragai R Makar, MSC, FRCS, Willie Loan, FRCR, Bernard Lee, FRCS, and **Chee V. Soong, MD, FRCS,** *Belfast, Northern Ireland, United Kingdom*

Among various methods to achieve rapid occlusion of the aorta during endovascular repair for ruptured abdominal aortic aneurysm, particular emphasis is placed on two techniques that have been incorporated into our endovascular repair practice. The sheath-over-balloon technique (the Loan SOB technique) facilitates hemodynamic stability by transfemoral endovascular placement of an aortic occlusion balloon catheter to the infrarenal abdominal aorta. The balloon-ahead-of-graft technique (the Hornsby BAG technique) allows suprarenal hemodynamic control using a stent-graft system with a built-in balloon. The two techniques are simple, quick, and effective in achieving hemodynamic stability. (J Vasc Surg 2006;44:211-5.)

A major apprehension with the use of endovascular repair for an unstable patient with a ruptured abdominal aortic aneurysm (rAAA) is the ability to achieve effective and rapid control of hemorrhage during positioning and deployment of the stent-graft. The placement of an aortic occlusion balloon catheter permits proximal control of the abdominal aorta before endovascular stent deployment. We present two techniques that are simple, quick, and effective in achieving hemodynamic stability during endovascular repair for a rAAA.

ENDOVASCULAR OCCLUSION OF THE AORTA IN RAAAS

Control of hemorrhage in unstable rAAA patients remains one of the most challenging steps of endovascular repair. The use of occlusion balloons has usually been reserved for patients who are precipitously hemodynamically unstable. Proximal aortic occlusion can usually be achieved by inflating a large balloon at the level of the descending aorta, which can be placed using transbrachial or transfemoral approaches. The advantages of aortic occlusion balloon catheter insertion are:

- placement under local anesthetic before induction of general anesthesia,
- Minimal disruption to the visceral arteries if inflated at the infrarenal level,
- Rapid improvement in cerebral and coronary artery circulation after inflation, and
- a reduction in massive hemorrhage when open rAAA repair is performed.[1]

From the regional Vascular and Endovascular Unit, Belfast City Hospital.
Competition of interest: none.
Reprint requests: Mark E. O'Donnell, Specialist Registrar, Regional Vascular and Endovascular Unit, Level 5, Belfast City Hospital, Lisburn Road, Belfast BT9 7AB, Northern Ireland, UK. (e-mail: modonnell904@hotmail.com).
0741-5214/$32.00

doi:10.1016/j.jvs.2006.03.033

ACCESS

Access for aortic occlusion balloon catheter placement can be achieved via the upper limb or femoral arteries.

Upper limb access. Several techniques have been described for insertion of occlusion balloons from the upper limb[2,3] or even carotid[4] artery access. Although there are advantages in terms of balloon stability, and the possibility of insertion without fluoroscopic guidance that may expedite the procedure, major complications of this technique have also been described, including balloon rupture and arterial embolism.[2]

Femoral access. A transfemoral approach is preferred by many centers, as femoral arteries are normally accessed, either percutaneously or surgically, during endovascular repair.[5-7] The descending aorta is then catheterized, and a 14F to 16F sheath is inserted into the suprarenal or pararenal aorta over a stiff guidewire. A compliant occlusion balloon is passed through the sheath and inflated proximal to the rAAA. The sheath is advanced to support the inflated balloon from below and to avoid distal dislocation when the blood pressure rises. The sheath also needs to be fixed firmly outside the patient to prevent it from being pushed out by the balloon due to an increasing pile-driving effect of the rising arterial pressure.

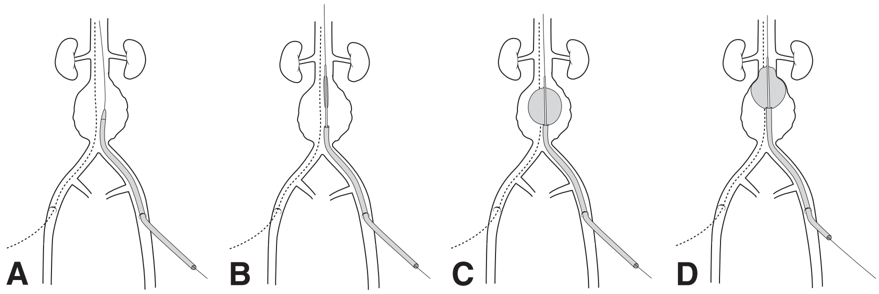

Fig 1. The sheath-over-balloon technique. **A,** A long introducer and 16F sheath is inserted over a guidewire through the contralateral femoral artery into the aneurysm sac either percutaneously or after surgical exposure. An angiocatheter is inserted simultaneously into the ipsilateral femoral artery. **B,** When the top of the sheath is in the aneurysm sac the introducer is removed and a large 30-mL balloon is passed through the sheath until it is beyond the top end of the sheath in the aneurysm sac. **C,** The balloon is inflated and then withdrawn until it lodges against the top end of the sheath. **D,** The sheath is then advanced with the balloon until it abuts against the shoulder of the aneurysm neck from below.

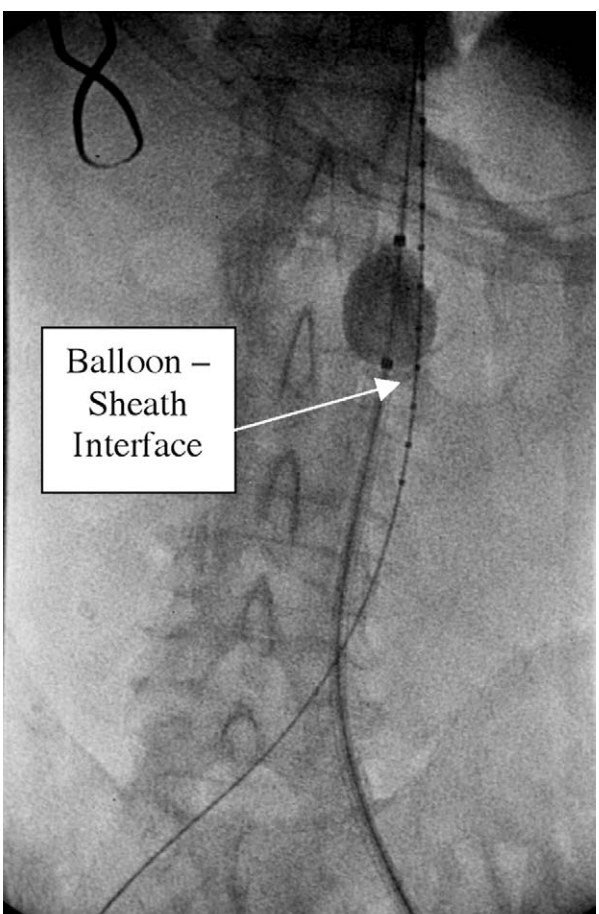

Fig 2. Intraoperative radiograph demonstrates inflated Reliant balloon passed via the contralateral femoral artery lodged against the top of the sheath, abutting the shoulder of the aneurysm neck from below. A calibration catheter is passed via the ipsilateral side. This will be exchanged for a stiff wire to facilitate passage of the stent-graft system.

The aortic stent-graft is inserted through the contralateral groin. At this stage, the aortic occlusion balloon catheter usually needs to be deflated and withdrawn to allow for stent-graft deployment. Deflation can often be followed by catastrophic loss of hemodynamic control. After stent-graft deployment, a second occlusion balloon can be inflated inside the main body of the stent graft.[7]

The advantages of transfemoral access over the upper limb approaches have been previously documented.[3,5] The common femoral artery can usually be accessed percutaneously even in the pulseless, hypotensive patient.[8] The transfemoral approach itself avoids the need for a separate arterial puncture and reduces the risk of cerebral embolization associated with the passage of guidewires and catheters through the aortic arch.

The necessity of fluoroscopic guidance for transfemoral balloon placement may potentially prolong the time taken to achieve hemodynamic stability.[2,9] This could be inappropriate in a very unstable patient, and has led some units to advocate rapid deployment of the stent without delay to obtain balloon occlusion of the proximal abdominal aorta.[10] However, in a dedicated fluoroscopy suite, fluoroscopically guided placement can be achieved rapidly and without the risk to adjacent structures inherent to cross-clamping the aneurysm neck.

TWO TECHNICAL OPTIONS FOR AORTIC OCCLUSION BALLOON CATHETER USE

The two techniques described are modifications of the transfemoral approach.

The sheath-over-balloon technique (the Loan SOB technique). This procedure facilitates hemodynamic stability by endovascular placement of an occlusion balloon catheter to the infrarenal abdominal aorta (Fig 1). Initially a 45-cm 16F (or greater) sheath (William Cook Europe, Inc, Bjaeverskov, Denmark) is inserted into the aneurysm sac via a common femoral artery either percutaneously or after surgical exposure. The sheath is usually inserted on the side opposite to that where the main body of the stent-graft will be passed.

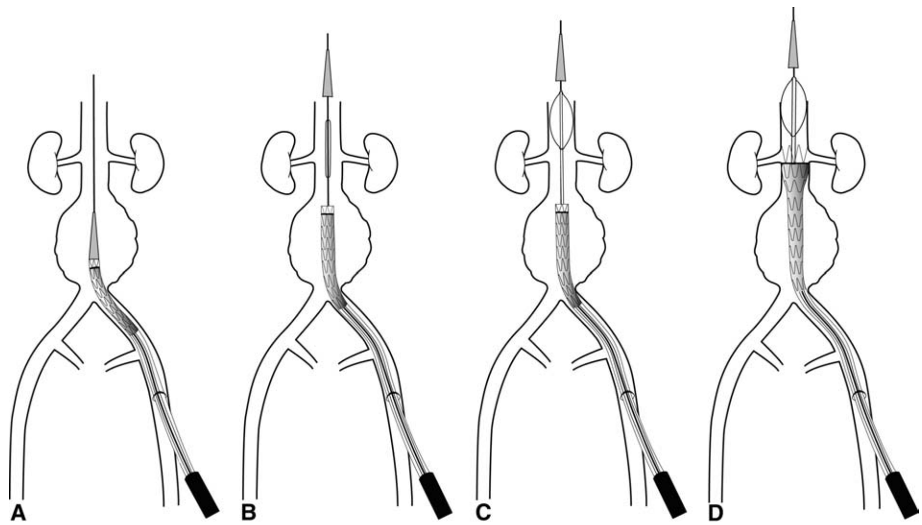

Fig 3. The balloon-ahead-of-graft technique**. A,** The stent-graft system is advanced into the aneurysm sac over a guidewire. **B,** The balloon can be advanced proximally into the descending aorta without moving the stent graft within the sheath, between 5 cm and 10 cm above the top of sheath. **C,** The balloon is then inflated in the suprarenal aorta. The position of the balloon can be maintained by holding the shaft of the delivery system. **D,** The stent is deployed with placement of the first uncovered portion across the renal arteries and then the first covered portion at a level immediately distal to the lower renal artery ostia.

When the top of the sheath is in the aneurysm sac, the introducer is removed and a large 30-mL balloon (Reliant Balloon, Medtronic, Dublin, Ireland) is passed through the sheath until it is beyond the top open end of the sheath in the aneurysm sac, where it is inflated if necessary. Once fully inflated, the balloon is withdrawn until it lodges against the top of the sheath. The sheath is then advanced with the balloon until it abuts against the shoulder of the aneurysm neck from below. This allows the balloon to be held firmly in position (Fig 2). The balloon may remain inflated, because in this instance it is usually soft enough to allow the nose cone of the stent-graft delivery system to be advanced beyond it. Thereafter, the balloon can remain inflated until just immediately before the stent-graft is deployed from its sheath.

An angiocatheter is required for location of the renals and can be passed from either side before balloon inflation if patient stability permits or after balloon inflation, which is usually the priority in the unstable patient. In our experience, it is still possible to pass the angiocatheter or guidewire past the inflated balloon, but it is sometimes necessary to transiently decrease the pressure applied to the balloon to facilitate passage of catheters. Veith et al[11] describe an alternative method in which the balloon can be advanced into the supracoeliac position, and after graft deployment, the balloon can then be removed past the graft through the sheath.

The balloon-ahead-of-graft technique (the Hornsby BAG technique). This procedure facilitates hemodynamic stability by endovascular placement of an occlusion balloon catheter in the suprarenal abdominal aorta and is only feasible with the Talent Coil-trac stent-graft (Medtronic, Watford, UK), which has a built-in balloon (Fig 3). The stent-graft system is advanced into the aneurysm sac as soon as a stiff wire is inserted into the aorta, usually after surgical exposure of the common femoral artery. The top of the first covered stent, which is still within the sheath, should be positioned at the level of the T12 vertebra or just above the level of the renal arteries.

The balloon can be advanced proximally into the descending aorta without moving the stent-graft within the sheath, between 5 cm to 10 cm above the top of sheath, which is easily visible with the built-in radiopaque marker. Once inflated, the position of the balloon may be maintained by holding the external shaft of the delivery system. An angiogram to identify the positions of the renal arteries may concurrently be performed by injecting contrast through the side port of the delivery device (Fig 4). This allows the stent-graft to be positioned at the desired level and accurately deployed while the balloon is still inflated. Moving the stent-graft with the balloon inflated requires care because it is possible to displace the graft from the delivery system.

COMMENT ON TECHNIQUES

Although an aortic occlusion balloon placement may be easily accomplished, placement of the occluding balloon above the renal vessels via a separate wire is associated with a number of problems. The occlusion balloon has a tendency to be forced into the aneurysm sac by the pulsating blood, which acts as a pile-driver, especially when the systolic pressure has been restored. In addition, occluding the aorta above the visceral branches leads to ischemia of the viscera and lower limbs.[10-11] This can

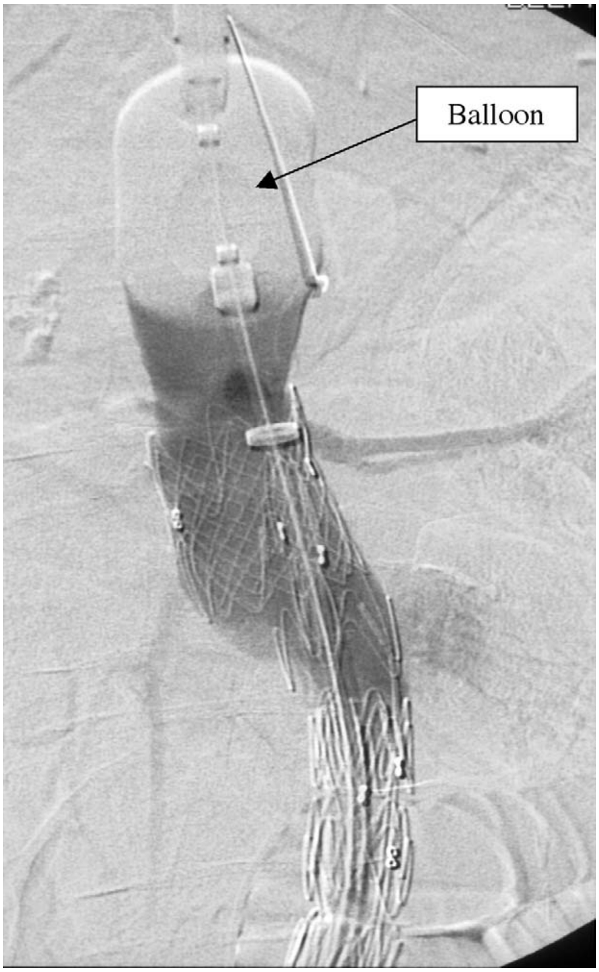

Fig 4. Intraoperative angiogram performed through a side-port of the sheath demonstrates renal arteries after stent deployment with balloon still inflated.

result in overwhelming reperfusion injury when reperfusion occurs, particularly for renal and visceral perfusion,[12] and serves to compound the ischemic insult these organs have already experienced as a result of hypotension. It should also be emphasized that in unstable patients, these supracoeliac balloons require gradual deflation analogous to the slow removal of an aortic cross-clamp.

Ischemia-reperfusion injury of the various organs may be reduced with the infrarenal SOB technique; however, this method of occluding the aorta has a couple of limitations. The balloon may be obstructive to the passage of the stent-graft, although this has not yet posed any difficulty in our experience. The nose cone of the delivery systems will usually slip easily past the balloon. The main potential disadvantage of this technique is the need to deflate the balloon during deployment of the stent-graft.

In contrast, the BAG technique allows the balloon to remain inflated even while the stent-graft is being positioned and deployed. The major advantage of this technique is that occlusion of the aorta may be achieved in the same maneuver as passage of the stent-graft, and only one access point is necessary. Nevertheless, it does have the disadvantage of a suprarenal position of the balloon and temporary obstruction of the origins of the major visceral arteries. The ischemic insult to the various organs may be limited by repositioning the balloon more distally within the deployed stent-graft immediately below the renal arteries if the patient remains unstable. This BAG technique can, of course, only be used with those devices that have built-in balloons.

The sequential use of the SOB technique then the BAG technique has proven useful in a small number of patients and has demonstrated that both techniques are not mutually exclusive. The SOB technique can be used first to allow hemodynamic stabilization during graft insertion followed by the BAG technique, which can then be used briefly to cover stent deployment. The combination of these techniques can facilitate a continuous hemodynamic control whilst reducing the actual overall patient ischemic time.

CONCLUSION

We have described various options of achieving aortic occlusion to arrest hemorrhage in rAAA. As with most procedures, there are many possible modifications to each technique, with individual endovascular practitioners favoring the procedures they are accustomed to and which have been proven safe in their hands. We have found two useful techniques that now form fundamental steps in our endovascular management of rAAA. However, although they may aid in achieving quicker technical success, the question of clinical outcome in this unstable group of patients remains undetermined.

We thank Adrian Knipe, Department of Medical Illustration, Belfast City Hospital, for his assistance in the production of the technical figures.

REFERENCES

1. Smith FG. Emergency control of ruptured abdominal aortic aneurysm by transaxillary balloon catheter. Vasc Surg 1972;6:79-84.
2. Matsuda H, Tanaka Y, Hino Y, Matsukawa R, Ozaki N, Okada K, et al. Transbrachial arterial insertion of aortic occlusion balloon catheter in patients with shock from ruptured abdominal aortic aneurysm. J Vasc Surg 2003;38:1293-6.
3. Greenberg RK, Srivastava SD, Ouriel K, Waldman D, Ivancev K, Illig KA, et al. An endoluminal method of hemorrhage control and repair of ruptured abdominal aortic aneurysms. J Endovasc Ther 2000;7:1-7.
4. Soen M, Nishihara I, Fukuda M, Fujiwara S, Akimoto H, Fukumoto H. Evaluation of 38 cases of employing aortic occlusion balloon catheter. Masui 2005;54:265-9.
5. Veith FJ, Ohki T. Endovascular approaches to ruptured infrarenal aortoiliac aneurysms. J Cardiovasc Surg (Torino) 2002;43:369-78.
6. Parodi JC, Palmaz JC, Barone HD. Transfemoral intraluminal graft implantation for abdominal aortic aneurysms. Ann Vasc Surg 1991;5: 491-9.
7. Zarins CK, Rodney AW, Schwarten D, Kineey E, Diethrich EB, et al. AneuRx stent graft versus open surgical repair of abdominal aortic aneurysms: multicentre prospective clinical trial. J Vasc Surg 1999;29: 292-308.

8. Malina M, Veith F, Ivancev K, Sonesson B. Balloon occlusion of the aorta during endovascular repair of ruptured abdominal aortic aneurysm. J Endovasc Therapy 2005;12:556-9.
9. Rubenstein RB, Wolvek S. Percutaneous aortic balloon occlusion. Surg Gynecol Obstet 1987;164:561-63.
10. Hinchliffe RJ, Braithwaite BD, Hopkinson BR. The endovascular management of ruptured abdominal aortic aneurysms. Eur J Endovasc Surg 2003;25:191-201.
11. Veith FJ, Gargiulo NJ, Ohki T. Endovascular treatment of ruptured infrarenal aortic and iliac aneurysms. Acta Chir Belg 2003;103:555-62.
12. Elmarasy NM, Soong CV, Walker SR, Macierewicz JA, Yusuf SW, Wenham PW, et al. Sigmoid ischemia and the inflammatory response following endovascular abdominal aortic aneurysm repair. J Endovasc Ther 2000;7:21-30.

Submitted Jan 16, 2006; accepted Mar 22, 2006.