What challenging scenarios do you encounter when cannulating and subsequently stenting the renal arteries during fenestrated EVAR, and how do you overcome them?

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With US Food and Drug Administration approval of the Zenith fenestrated device (Cook Medical, Bloomington, IN) for more than a year, we have been treating an increasing number of patients with pararenal and juxtarenal aneurysms using endografts. One of the most challenging aspects of performing fenestrated cases is successfully cannulating and then stenting the renal arteries. With favorable anatomy, this is often rather straightforward. Standard techniques include releasing the endograft with the fenestration slightly higher than the renal orifice, ensuring rotational torque of the endograft and cannulating the renal artery on the side of the aorta that the endograft favors first.

However, with more complex anatomy, this can become much more difficult. Our standard technique in all cases is to preselect the renal arteries and leave catheters in place, which significantly helps to identify the location of the renal orifices while minimizing the need for contrast administration. In cases where there is a preexistent renal artery stenosis, angioplasty at this time will often make it easier to subsequently cannulate through the fenestration. In some cases (tortuous anatomy, small orifice/artery, misaligned fenestration-orifice), it can be difficult to cannulate, track a catheter, or introduce a sheath. Techniques that can aid in these situations include: (1) using a 0.014-inch wire to cannulate and then gradually upsizing to a stiffer 0.035-inch wire; (2) deflecting the wire/catheter/sheath off the top cap to increase "pushability" and then pulling down to straighten the system; or (3) inflating a balloon at the fenestration/orifice and then intussuscepting the sheath over the balloon during deflation. In rare circumstances, coming down from the arm through the scallop may allow for the best angle to cannulate the renal arteries. Finally, it is important to recognize that tortuosity at the distal aspect of the renal stent should be "bridged" with a nitinol stent to prevent kinking and subsequent renal artery thrombosis.

Clearly, the above-described techniques are being used with the Zenith fenestrated device. Newer endograft designs, such as Ventana (Endologix, Inc., Irvine, CA), p-Branch (Cook Medical), Endurant Branch AAA device (Medtronic, Inc., Minneapolis, MN), and others have and will simplify the procedure via precannulation, increased flexibility, mobile fenestrations/branches, and other technological innovations. This will serve to not only increase the applicability of these devices but also improve the already excellent results of fenestrated techniques.

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As the complexity of aneurysm morphology increases, a greater number of fenestrations can be customized into a fenestrated graft, but this brings a corresponding increase in the technical challenges of deployment. However, there are a number of tips and tricks to assist with target vessel catheterization.

Most cases are performed under general anesthesia to control respiration, aiding accurate fluoroscopic control. High-quality imaging is essential, preferably using a hybrid operating suite that combines operating room sterility and an environment with fixed angiography. The graft device should be screened before insertion to gain familiarity with the markers. It is often preferable to advance the fenestrated device from the left side to allow easier catheterization of the target vessels from the right. Care should also be taken to minimize rotation during insertion.

The graft is partially deployed, making sure to align the graft markings with the target vessels on angiography. This may be aided using CT overlay technology and/or selective target vessel catheterization before deployment. We routinely catheterize one renal ostium during this early phase to guide deployment. During the first phase of deployment, the covered stent is only partially released due to diameter-reducing restraining wires. Further rotation and stent movement is therefore still possible at this stage.

The ease of catheterization is greatly aided by accurate positioning of the device. If difficulty is encountered, angiography should be performed to ensure the device has not slipped or rotated. Catheterization may be further hindered if the stent is positioned directly against the aortic wall, especially in angulated necks. Even a tiny inaccuracy in terms of positioning the fenestrations can make cannulation challenging. Instrumentation must be performed with caution to prevent microembolization, dissection, and/or renal capsule perforation.

On occasion, rather than direct catheterization of the target vessel through the fenestration, it can be advantageous to advance a wire through the fenestration into the proximal aorta. A downward-shaped catheter can then be advanced and used to cannulate the target vessel from above. This is particularly advantageous for downward-pointing renal arteries. The image intensifier should also be rotated for each target vessel to gain the best marker alignment relative to each ostium.

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Cannulation of target vessels through their respective fenestrations during endovascular repair of complex aneurysms is a new challenge for the interventional therapist. It requires a specific learning curve because this technique is fundamentally different from visceral and renal artery stenting techniques in the setting of occlusive disease.

Before inserting the endograft, we precannulate the target vessels that are deemed challenging to access (small diameter, ostial stenosis, downward direction). It is mandatory to perform this precannulation in angulated aortic anatomies because the position of the target vessels will not always be in front of their fenestrations once the delivery system has been inserted over a stiff wire. For the same reason, we always check our fusion mask after insertion of the delivery system with the injection of a small volume of contrast (7 mL at 30 mL/s). It is frequently necessary to adjust the fusion mask at this stage. Performing procedures with advanced imaging applications such as fusion is, in our experience, mandatory to reduce the radiation dose and contrast media volume. The endograft is deployed generally with the C-arm in an anteroposterior (AP) position focusing on the position of a renal fenestration located at 3 or 9 o'clock. It is recommended to implant the endograft slightly "too high" because moving the endograft downward will always be easy, but pushing the endograft up might be impossible. Rotation of the device (anterior and fenestrations markers) is checked after releasing each stent and corrected accordingly.

Once the endograft has been deployed (partially at this stage before releasing the diameter-reducing ties), we access its lumen from a contralateral 20-F sheath. This large sheath will serve as an endoconduit to straighten the iliac anatomy and help cannulation maneuvers. Once access to the endograft lumen is obtained, we advance a 7-F 55-cm sheath (Ansel, Cook Medical; or Pinnacle Destination, Terumo Interventional Systems, Somerset, NJ) in the endograft before cannulating the fenestrations. Cannulation is performed with 5-F catheters with various shapes (C2, RIM, VS). It is important to position the tip of the catheter through the fenestration before advancing the Glidewire (Terumo Interventional Systems). The C-arm must be positioned perpendicular to the targeted fenestration to visualize the tip of the catheter protruding through the fenestration. This position is achieved when both lateral markers of the fenestration are superimposed. When the tip of the catheter is in a stable position through the fenestration, the Glidewire should advance directly into the target vessel. If this is not the case, then the fenestration is not correctly positioned (either too high or too anterior or posterior). Contrast media injection through the catheter is an easy way to check the height of the fenestration. An AP fluoroscopic view of all the markers, and especially the anterior tick marker that should be positioned in the center of the anterior endograft wall (often on top of the inner cannula), is useful to check the orientation of the fenestrations.

After having positioned the Glidewire into the target vessel, it can be challenging to advance the catheter over it. Various options are available to overcome this issue. One option is to replace the catheter with a catheter with a reduced profile (4 F), that is hydrophilic, and has a different shape (straight or vertebral). Another option is to replace the wire with a stiffer one (Radifocus Guidewire M Stiff type, Terumo Interventional Systems, or Roadrunner, Cook Medical). This will straighten and give more support to the catheter that can then be slowly advanced into the target vessel. Finally, if the catheter still does not track into the target vessel, we use the top of the endograft that is not deployed at this stage as a roof to obtain support from above. The 7-F, 55-cm sheath is advanced near the "roof" of the endograft, and then a Glide catheter (Terumo Interventional Systems) or CXI catheter (Cook Medical) is advanced over the Glidewire. When the fenestration is far from the top of the endograft, a compliant balloon (Coda, Cook Medical) can be inflated just overhead the fenestration to provide support from above.

After the catheter is positioned as far as possible in the target vessel main trunk, the Glidewire is replaced by a stiffer support wire. We usually recommend a Rosen 0.035-inch wire (Cook Medical), which has an atraumatic tip, but in the setting of a downward target vessel, we recommend the short tip (1 cm) Amplatz wire (Boston Scientific Corporation, Natick, MA). This wire will provide extra support, but it is mandatory to always check the position of its tip because it can perforate arteries if advanced unintentionally.

The next challenge is to advance the 7-F, 55-cm sheath over the stiff wire, through the fenestration, and into the target vessel. We advise to reposition the dilator of the sheath before advancing it and to straighten the stiff wire for a lesser curvature route through the fenestration. When the sheath does not advance easily, it is worthwhile to inflate a 6- X 20-mm balloon (or smaller if the target vessel is < 6 mm) through the fenestration to perfectly align the fenestration with its target vessel and to provide extra support for the sheath. The sheath is advanced on the shaft and positioned against the inflated balloon; the balloon is then rapidly deflated, and the sheath "jumps" into the target vessel. The 7-F sheath can be replaced by a 6-F sheath, but this will only accommodate 5- X 22-mm and 6- X 22-mm Atrium covered stents.

In challenging aortic or renal anatomies, preloaded catheters can provide stability and extra support to the renal sheaths. Another option is to manufacture a delivery system with a preloaded catheter positioned through the fenestration. It enters the endograft lumen through the fenestration and usually exits through a scallop at the top of the endograft. A 300-cm wire advanced through this preloaded catheter can be snared from a brachial sheath positioned in the descending thoracic aorta. This sheath is then advanced into the endograft through the scallop and positioned at the level of the fenestration. The through-and-through brachial/preloaded catheter wire is maintained with a slight tension. A parallel wire is then advanced in the brachial sheath, and the renal vessel is catheterized from above. The through-and-through wire is retrieved once a stiff wire has been positioned in the renal artery to advance the sheath. This technique requires longer sheaths, catheters, and balloon shafts.

These are the challenging steps encountered when cannulating the renal arteries during fenestrated EVAR, and we hope that we have clarified how to overcome them.

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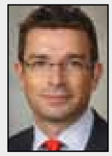

Renal artery catheterization and stenting during fenestrated endovascular repair can be challenged by misalignment of fenestrations, presence of occlusive renal artery disease, downgoing angulation of the renal arteries, or angulated aorta causing malposition between the fenestration and the intended target renal artery. Misalignment of fenestrations and the intended target renal artery is more likely to occur if there is angulation of the aortic neck around the renal arteries; it can also result from inaccurate deployment or problems of stent graft design. One of the first maneuvers is to gain access into the fenestration, advancing the sheath through the fenestration, and to place an 0.018-inch guidewire to keep the sheath at the fenestration without having to secure access multiple times. Small-volume angiography may locate the renal artery; the vessel is then accessed using a "buddy" catheter or microcatheter. Slight rotation of the device may be sufficient to align the fenestration. Lastly, in cases of severe misalignment, a balloon may need to be inflated between the aortic stent graft and the aortic wall to create more space. This is fortunately rarely needed with a well-planned procedure and precise deployment.

Occlusive disease at the renal arteries makes the procedure more challenging. One frequent question is whether the renal artery should be stented ahead of time. My preference is to avoid stenting the renal arteries before placement of fenestrated endografts; this may in fact render the patient not a candidate for fenestrated EVAR if the renal stent is protruding into the aortic lumen. It may change the clock orientation of the renal artery. Instead, my preference in these cases is to plan the procedure with precatheterization of the renal artery, leaving an 0.018-inch angioplasty balloon in position and ready to be inflated in the event it is difficult to gain access because of excessive stenosis. The balloon also serves the purpose of locating the renal artery. Once access is established, sheath advancement can also be difficult. One option is to use a balloon as dilator and to advance the sheath over the balloon into the renal artery. If a renal stent is used for any reason, it is ideal to place the stent inside the renal artery with no stent portion extending into the aorta. Using a covered stent will help avoid issues related to catheterization of the cell of the stent during placement of the fenestrated endograft.

Finally, downgoing renal arteries can be more difficult to catheterize, as well as to advance the sheath. The top cap of the device can be used to allow the catheter to bounce up and down into the top cap. After a stiff wire is positioned, sheath advancement may require use of a balloon instead of a dilator. Almost always, access can be achieved via the femoral approach, but brachial access may be needed.

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I believe that the most important step in avoiding difficult renal artery catheterization takes place in the planning phase of the procedure. It is very important that the physician doing the actual operation is also the one doing the planning. This allows him or her to have an in-depth understanding of the issues that can affect the positioning of the device, such as iliac and sealing zone tortuosity, as well as particular renal artery issues, such as stenosis or orientation. The prerequisite for good planning is high-quality preoperative imaging, and one should never rely on poor CT scans when planning complex EVAR. The cost of performing an additional preoperative CTA is most often much less compared to the contrast and radiation used intraoperatively to compensate for bad preoperative planning.

During implantation of the device, the initial positioning is of course crucial to achieving a smooth procedure. In complex anatomy, precannulation of the renal arteries and/or superior mesenteric artery can be very efficient in guiding device placement. The use of fusion imaging, when available, can also be of great use. I find that this is the phase of the operation during which contrast is of best use. Performing multiple small runs (5–10 mL of contrast) during the deployment of the fenestrated component to achieve precise positioning often reduces the overall contrast dose used during the procedure. And remember, for fenestrated procedures, a low contrast concentration (eg, 140 mg iodine/mL) is almost always sufficient, as the stent graft markers will guide your way.

Incorrect positioning of the fenestrations relative to the target vessels is most often seen when there is significant angulation in the aortic sealing zone. The stiffness of the stent graft and delivery system before complete deployment can prevent the graft from aligning with the aortic anatomy. In these situations, cannulation problems can occur. Catheterizing the fenestration and target vessels in two steps instead of one can often overcome problems. After catheterizing the fenestration itself, a reversed-curve catheter can be used outside of the graft to catheterize the target vessel in a separate step. Another trick is to stabilize the sheath close to the fenestration with a 0.018-inch wire running alongside the outside of the graft. The sheath valve can then be double-punctured and a second wire used to catheterize the renal artery. This prevents the sheath from bouncing away from the fenestration during target vessel cannulation. In the setting of renal artery stenosis, using a 0.014-inch wire can often simplify initial catheterization. After gaining access to the target renal artery, the 0.014-inch wire can then be exchanged for a more stable 0.018-inch wire using a microcatheter.

Sometimes, problems can be encountered when attempting to pass a sheath over the wire into the renal artery, either due to orientation issues or target vessel stenosis. Replacing the sheath dilator for a small balloon (4–5 X 20 mm) and having this halfway into the sheath and halfway into the target vessel and advancing the sheath over the balloon during deflation is often very useful. After gaining stable positioning of the sheath into the target vessel, stent placement is rarely an issue. ■