Understanding renal artery anatomy and its variants in the context of renal sympathetic denervation.

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**Authors:** B. P. Tan, U. Pua; Singapore/SG  
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Learning Objectives

1. To review normal and variant renal arterial anatomy.
2. Discussion on the relevance of renal artery variants in pre-procedural planning and performance of renal sympathetic denervation.

Background

Renal sympathetic denervation (RDN) is a novel endovascular treatment currently showing promise in its use for resistant hypertension.

Patients are assessed on both clinical and anatomical suitability prior to RDN. These criteria are currently largely based on the Symplicity HTN-1 and HTN-2 trials.

Imaging plays a crucial role in detecting and assessing the severity of existing renal artery disease. By providing morphological details of the renal arteries, technical feasibility of RDN may be determined and subsequent pre-procedural planning performed accurately.

Imaging Findings OR Procedure Details

Normal renal artery anatomy:

- In most individuals, each kidney is supplied by a single artery arising from abdominal aorta at level of L1 or L2.
- Right renal artery arises from ventrolateral aspect of aorta and has a slight downward course.
- Left renal artery arises from dorsolateral aspect of aorta and is more horizontally oriented.
- Renal arteries typically branch into anterior and posterior segmental branches before entering the renal hilum.

Renal artery variants

- Accessory renal arteries are the most important and common variant seen in patients. Multiple renal arteries can occur anywhere along the aorta and
iliac arteries from T11 to L4 levels. Rarely, they do arise from the lower thoracic aorta, mesenteric and lumbar arteries.

- They are present in 30% in an anatomic series, occurring unilaterally in 30% and bilaterally in 10% of cases.
- Multiple renal arteries can be detected angiographically in 20-27% of cases.
- Accessory arteries typically originate close to the main renal artery.
- 3-10% of accessory renal arteries are not detected angiographically due to their small sizes.
- Accessory renal arteries commonly enter via the hilum and may supply the upper or lower poles. These hilar accessory arteries are usually of equal calibre to the main renal artery.
- The more direct extra-hilar polar arteries tend to be smaller in calibre and penetrate the capsule directly to supply the renal poles.
- The pre-hilar or early branching variant is also common and is clinically relevant in transplant surgery as well as RDN.

Anatomic Criteria for Renal Sympathetic Denervation (RDN)

Renovascular imaging in the form of Doppler ultrasound, computed tomography angiography or magnetic resonance angiography is routinely performed on patients considered for the RDN procedure.

The anatomic selection criteria for RDN generally assesses patients based on the ability to safely achieve adequate catheter-based circumferential radiofrequency ablation of sympathetic nerves around the renal artery.

Anatomic criteria derived from the Symplicity HTN trials tailor primarily to study objectives. These criteria are more focused at this nascent stage and do not for example, include patients with multiple renal arteries for enrolment into the trial. We have found that patients with accessory arteries are fairly commonly encountered in clinical practice and could be considered for RDN if these vessels were of sufficient calibre (>4 mm in diameter).

The following are anatomic criteria modified from the Symplicity HTN trials and used at our institution when selecting patients for RDN:

Exclusion from renal sympathetic denervation:

1. Significant renal artery stenosis (>60% in diameter). This would be the main contraindication due to limited catheter access, presence of atherosclerotic plaques and increased risk of dissection. Such patients
would benefit from renal artery stenting instead. Fig. 1 on page 4 Fig. 2 on page 5

2. Atrophied or solitary kidney
3. Renal artery length <20 mm (ostium to most distal first order branch)
4. Renal artery diameter <4 mm

Additional useful morphological details for treatment planning:

1. Presence and position of accessory renal arteries. This is an important consideration in achieving thorough renal sympathetic denervation. If feasible, we would prefer to ablate along these accessory arteries as they may contribute significant sympathetic innervation.
2. Size of accessory renal arteries. These arteries will be ablated if >4 mm in diameter. Fig. 3 on page 6
3. Position of plaques. Ablation over intimal plaque is avoided due to risks of distal embolisation and also suboptimal delivery of ablative energy.
4. Orientation of renal arteries influences the choice of guiding catheters used.
5. Presence of early branching pattern. The location of pre-hilar branches are important as ablation directly over their ostia can result in severe spasm. Additional ablation proximal to the branch origin should be considered in order to achieve complete denervation. Fig. 4 on page 7
6. Ectopic kidneys. Ectopic kidneys are a rare occurrence and there is considerable variation in the number and types of renal arteries. There are thus far no reported cases of RDN in an ectopic kidney.

Images for this section:
Fig. 1: Angiogram of a patient with significant bilateral renal artery stenoses who subsequently underwent bilateral renal artery stenting instead of renal sympathetic denervation. The luminal diameters of the renal arteries were successfully restored following bilateral renal artery stenting.
**Fig. 2:** Renal angiogram shows mild stenosis at the proximal right main renal artery (arrow). The patient underwent successful RDN with subsequent improvement in control of blood pressure (see 24 hour blood pressure measurements). This was associated with reduction from an initial 5 to 2 anti-hypertensive medications.
Fig. 3: This patient presents with bilateral accessory renal arteries. All 4 renal arteries received ablative therapy as they were assessed to be of adequate calibre (>4 mm)
**Fig. 4:** An early branching pattern is seen on the left (red arrow). The renal artery is prone to severe spasm if ablated over the branch ostium. Additional ablation proximal to the takeoff of this branch should be undertaken.
Conclusion

An understanding of renal artery anatomy and its variants is crucial in not only facilitating the selection of eligible patients who are likely to benefit from this treatment, but also in enabling vital pre-treatment planning to take place. This ensures that adequate and effective ablation is achieved whilst enhancing patient safety by reducing time taken for the procedure and minimising procedure-related complications.

Personal Information

References