Pulsed Doppler Ultrasonography of the Human Fetal Renal Artery

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The renal arteries arise directly from the aorta just below the projection of the 12th rib and below the superior mesenteric artery. The left renal artery is usually a little higher and longer than that on the right (Fig. 15.1). Close to the renal hilum the renal arteries divide into multiple branches with large anterior and posterior branches. These branches in turn divide into large segment arteries, which eventually terminate in arcuate arteries. The best way to assess the renal arteries is to find the abdominal aorta and the renal hilum using a coronal axis view. The renal arteries are usually seen arising from the lateral aspect of the abdominal aorta. The superior artery is often difficult to visualize in the fetus compared to that in the adult, but the renal artery can be seen using a multipurpose midfrequency scanhead (3–5 MHz). Respiratory or total body movement make it difficult to obtain an adequate duplex signal. With patience, experience, and perseverance, a Doppler examination of the renal artery can be performed successfully in about 90% of patients.

The abdominal aorta and fetal kidney should be localized first using a two-dimensional examination (Fig. 15.2). The Doppler cursor is placed in the area where the ultrasonographer suspects the renal artery to be, with the Doppler sample volume and Doppler angle adjusted prior to turning on the Doppler instrument (Fig. 15.3) so Doppler ultrasound exposure is minimized. The power output should be decreased to about 50%–75% of its spatial peak temporal average (SPTA) specification. Even at this lower power output the Doppler signal is adequate to obtain echoes from the fetal renal artery. Color mapping is used last to confirm the two-dimensional impression that the Doppler signal is indeed coming from the renal artery and not from the fetal aorta (Fig. 15.4). The renal artery Doppler waveform has a characteristically high peak forward velocity and low but continuous forward flow during diastole that is easily differentiated from the adjacent fetal abdominal aorta.

Like any other Doppler examination, the renal velocity waveforms should be obtained during a period of fetal quiescence. The velocity waveforms should be recorded at a fast speed, with the lowest pass filter. Using these guidelines, most ultrasonographers are able to obtain adequate Doppler waveforms from these small renal vessels. It is of the utmost importance to minimize Doppler and color exposure, as the safety of such techniques on human fetuses has not been fully evaluated [1].

![Fig. 15.1. Fetal renal arteries. Note that the left renal artery is behind the renal vein and is longer than the right renal artery](image1)

![Fig. 15.2. Two-dimensional examination of a fetus at 30 weeks' gestation. The fetal abdominal aorta is easily seen at the level of the left kidney. On careful inspection, the fetal renal artery is seen at its bifurcation with the aorta](image2)
Doppler Principles and Hints

Flow is determined by a pressure difference between two points and by the resistance to flow within that structure. This relation is known as Poiseuille’s law and has been mathematically described:

\[ Q = \frac{\Delta P}{R} \]

where \( \Delta P \) is the flow difference, and \( R \) is the flow resistance. The heart (pump) is the driving force behind generating the pressure difference, which in turn is the force behind fluid flow. The flow resistance is mostly determined by the length and radius of the vessel of interest, in this case the renal artery. Increasing the length of the vessel increases the resistance, whereas doubling the radius of the vessel decreases resistance to blood flow by one-sixteenth of the original value [1]. Other than vessel size and pressure differences, the pulsatile nature of blood flow in the fetus results in expansion and contraction of the vessel, which in turn affects the Doppler waveform profile. Thus pulsatile flow in compliant vessels affects forward flow during systole and flow reversal during diastole.

When assessing Doppler flow of the fetal renal artery, attention must be given to whether flow is best described as plug flow or laminar flow [1]. At the immediate bifurcation of the renal artery with the abdominal aorta (i.e., at the entrance of the renal vessel), the flow of the blood is essentially constant across the vessel. Closer to the renal parenchyma, flow becomes more laminar and assumes a parabolic profile (i.e., maximum flow velocity is at the center of the vessel, whereas flow is almost zero at or close to the walls of the vessel). Hence depending on the position of the Doppler sample, the Doppler velocity pattern is affected.

The acute angle between the bifurcation of the abdominal aorta and the renal artery can significantly affect the renal blood flow profile. Theoretically, flow is turbulent at such sites and can result in a random, chaotic flow pattern of red blood cells [1]. Because these aberrant flow patterns can affect the final Doppler waveform profile, the fetal renal artery is sampled close to the renal parenchyma, keeping the Doppler sample within the lumen of the vessel (Fig. 15.3). A Doppler sample size of 1.5 mm is used and is adequate for most studies done on fetuses beyond 20–24 weeks.

Doppler measurement is angle-dependent. Thus it is important to keep the angle at or less than 30° when obtaining Doppler signals from the fetal renal artery. Doppler angles of more than 30° could significantly affect the Doppler shift and thus the Doppler wave-