Doppler ultrasound in renal transplantation

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Introduction

Colour Doppler ultrasound facilitates not only a global assessment of the intrarenal vasculature but can also be targeted to specifically examine the main renal artery and vein in renal transplant recipients. The technique can be used in the early transplant period to monitor patients with delayed graft function and is also useful in confirming the diagnosis of renal vein thrombosis. It is also a valuable non-invasive test in the diagnosis of arteriovenous fistulae and in the diagnosis and post therapeutic monitoring of transplant artery stenosis.

Normal appearances

The waveform of the graft intrarenal vessels (commonly the interlobar vessels) is similar to that of the native kidney and has been described as having a 'ski slope' appearance (Figure 1) with end diastolic flow being approximately one-third or greater of the amplitude of the peak systolic velocity. Examination of the main transplant artery may be technically difficult due to vessel tortuosity however the intrarenal branches and the main renal vein itself are normally easily visualized.

Acute rejection

A single Doppler ultrasound examination is unreliable as a method of diagnosing acute rejection however serial observations may be more useful in the monitoring of graft dysfunction. Although acute rejection cannot be differentiated from acute tubular necrosis, serial changes in the Doppler indices, in combination with clinical parameters, can aid the decision about when to biopsy the patient with delayed graft function (Figure 2). Commonly used Doppler indices are the resistive and pulsatility index (RI, PI). Both are equally as useful although the RI is probably more commonly used. An RI <0.7 is normal, >0.9 abnormal, and between there is a large grey area. A PI <1.5 is normal, and >1.8 abnormal. The higher the RI or PI the more likely is a diagnosis of acute rejection.

Renal vein thrombosis

Renal vein thrombosis is an important cause of early graft failure. It typically occurs in patients with delayed graft function in the first week following transplantation. The diagnosis can be confirmed by Doppler examination and although nephrectomy is usually required early detection and intervention may occasionally salvage the graft. The ultrasonic features include a dilated renal vein containing thrombus, absent venous flow throughout the kidney, and reverse diastolic flow within the main artery and intrarenal vasculature (Figure 3). A low amplitude rounded intra-arterial waveform has also been observed in a few patients with incomplete renal vein thrombosis.

Renal artery stenosis

Doppler ultrasound is a reliable method of diagnosis of transplant artery stenosis although the technique is operator dependant. A significant stenosis results in an increased peak systolic velocity at the site of narrowing and a dampening of the waveforms downstream in the intrarenal vessels (Figure 4). Turbulence, areas of reverse flow, and spectral broadening may also occur close to the area of stenosis. and give a clue as to its presence. Quantification using spectral Doppler is required. We have found a peak systolic velocity in the transplant artery of >2.5ms⁻¹ to be accurate and reproducible for the diagnosis of transplant artery stenosis with a sensitivity of 100% and a specificity of 95% when compared with angiography.

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Fig. 1. Spectral Doppler waveform from an intrarenal artery, probably interlobar, in a normally functioning transplant kidney. The peak systolic velocity is approximately three times the end diastolic value and there is a gentle reduction in velocity from the beginning to end diastole that has been described as a ‘ski slope’.

Fig. 2. Serial monitoring with colour Doppler ultrasound is useful in patients with graft dysfunction in the early transplant period as it can demonstrate whether the blood flow within the kidney is stable, improving or deteriorating. An example of this is shown: (a) normal spectral Doppler waveform from a patient with primary graft dysfunction soon after operation. (b) Spectral Doppler waveform 2 days later showing marked reduction in diastolic flow with a subsequent increase in PI from 0.85 to 2.36. (c) The transplant kidney was biopsied and acute rejection diagnosed. Therapy was instituted with resultant improvement in diastolic flow. (d) Further improvement was noted some days later, the Doppler waveform essentially returning to normal with a PI of 1.19.

Fig. 3. Reverse diastolic flow within the main renal artery in a patient presenting with sudden onset anuria and graft pain 4 days post operative. This waveform was detected in the intrarenal arteries also. Absent flow was noted in the main renal vein and intrarenal branches. A diagnosis of renal vein thrombosis was made and despite early surgery a nephrectomy was required.

Fig. 4. (a) Markedly increased peak systolic velocity of 3.25 ms$^{-1}$ in the transplant renal artery close to its origin. The appearances are those of a transplant artery stenosis. (b) Spectral Doppler waveform from a downstream intrarenal artery showing a dampened systolic part of the waveform. This type of waveform is known as the ‘parvus-tardus’ effect and occurs downstream from a significant stenosis. The acceleration time is significantly prolonged at 0.15 seconds (normal <0.07 s).
References


