Evaluation of renal first pass blood flow with a functional image technique in hypertensive patients

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Abstract. The renal circulation of patients with essential hypertension and renovascular hypertension was evaluated using $^{99m}$Tc-DTPA. The first renal peak count (the first $C_{\text{max}}$: $FC_{\text{max}}$), time phase distribution (the first $T_{\text{max}}$: $FT_{\text{max}}$), and blood velocity (the $FC_{\text{max}}/FT_{\text{max}}$) were calculated by digital imaging. This yields a visual image of the renal circulation. We consider that the increase in the renal first pass blood flow in patients with essential hypertension is best observed pixel by pixel. The $FC_{\text{max}}$ and $FC_{\text{max}}/FT_{\text{max}}$ images before and after treatment by percutaneous transluminal renal angioplasty in patients with renovascular hypertension clearly show its therapeutic effect. The FI technique, therefore, has the advantage that it can be performed at the same time as the conventional routine examinations of renal function. This makes it very useful clinically.

Key words: Essential hypertension – Renovascular hypertension – $^{99m}$Tc-DTPA – Functional image – First pass method

The renal vessels are functional rather than feeding vessels. Renal blood flow changes in various renal diseases by a self regulatory process.

It has been reported that in hypertension, renal blood flow is greater than normal in subjects with essential hypertension, but is less than normal in subjects with renovascular hypertension. The renal function of hypertensive patients has been evaluated with nuclear medicine techniques (Keim et al. 1979; Lamki et al. 1986), but this has not yet included a dynamic evaluation of renal first pass blood flow. Therefore, we evaluated renal first pass blood flow in hypertensive patients using functional images (i.e.: digital images).

Materials and methods
Nineteen studies were performed on 14 patients of whom 5 were normal, 4 patients had renovascular hypertension and 5 suffered from essential hypertension. They ranged in age from 18 to 58 years with a mean of 38.2 years.

The subjects urinated 30 min before the examination and drank water (300 ml). $^{99m}$Tc-(Sn)DTPA was administered to adults at a dose of 15 mCi (555 MBq). Radioactivity was determined using a gamma camera (GCA401-5, Toshiba), a low energy general use collimator, and a data processor (GMS-80A, Toshiba).

Data collection. Each patient was placed in the supine position, and the gamma camera was positioned over the back. The right upper arm was lifted to 90° in a slightly valgus position, and $^{99m}$Tc-DTPA (15 mCi) was rapidly injected intravenously as a bolus at a flow rate of about 3 ml/s. Scintigrams were obtained using a total of 147 frames over a 30 min period from immediately after the injection at a rate of 1 frame/s for the 1st min and 1 frame/20 s for the remaining 29 min. The data were acquired in a 64 x 64 matrix and stored on a magnetic tape. The region of interest (ROI) was set as the entire kidney, and the level of cut at 0%.

A time activity curve was drawn for each pixel (Fig. 1), and images of the first $T_{\text{max}}$ ($FT_{\text{max}}$), first $C_{\text{max}}$ ($FC_{\text{max}}$), and $FC_{\text{max}}/FT_{\text{max}}$ for the first minute after the injection (Fig. 2) were produced on the CRT.

Results

Normal subjects
Figure 3 shows a normal FI of a 36-year-old male. The $FC_{\text{max}}$ image showed an even distribution of counts in both kidneys. The $FT_{\text{max}}$ image showed a partial delay, but an even distribution of the time phase. The $FC_{\text{max}}/FT_{\text{max}}$ image revealed an even central distribution in both kidneys, but the velocity decreased slightly in the periphery.

Renovascular hypertension
Figure 4 shows a case of renovascular hypertension, the FI of an 18-year-old female, with images obtained before
Counts

Fig. 2. Time activity curve of renal first pass blood flow

Fig. 3. Functional image of a normal case

Fig. 4. First functional images before and after treatment of percutaneous transluminal renal angioplasty in a patient with renovascular hypertension

Fig. 5. First functional images before and after the administration of captopril in a case of essential hypertension

Essential hypertension

The case of Fig. 5 shows an essential hypertension before and after captopril in a 55-year-old male. The FTmax image and FCmax/FTmax image did not suggest a marked change after the medication.

Discussion

Renal circulation is clinically very important, because it can produce complicated changes with regard to the body's fluid and electrolyte status via the renin angiotensin system, prostaglandin system, kallikrein kinin system, the sympathetic nerves, and autoregulation. If renal circulation changes, so too do glomerular filtration pressure and glomerular filtration ratio. This then influences the body's fluid balance. The functional images which we studied represent, as one digital image, a good way to measure renal first pass blood flow pixel by pixel. Calculation of the renal blood flow with a washout technique using 133Xe has been reported, but it was disadvantageous and invasive and it was not possible to repeat the study. It is possible to administer large doses of 99mTc-DTPA compared to 133Xe (Nally et al. 1985), and this method is considered to be superior since it can decrease the noise of extraneous signals in the first renal circulation.

The functional images in patients with renovascular hypertension clearly represent a collateral flow from the renal artery with the FTmax image and the FCmax/FTmax image. For these reasons, it is considered to represent a digital image of the velocity and distribution of the renal circulation. These images may also suggest the resistance of the renal cortical vessels.

The renal circulation in patients with renovascular hypertension was observed pixel by pixel to be a stricture in the main renal artery or one of its branches. These details can be of great use in diagnosis and in making therapeutic decisions, and are therefore considered to be extremely useful clinically.

In the first FI of the patients with essential hypertension before and after the administration of captopril, the image clearly shows an increase in the renal first pass blood flow.