RENAL BLOOD FLOW AND MEAN CIRCULATION TIME FOR RED CELLS AND PLASMA IN ACUTE RENAL FAILURE


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In 1963 Kemp et al. (1963a, b) introduced a new method for measurement of the renal blood flow. It is based on injection of the inert radioactive gas Xenon-133 into the renal artery and external counting of the disappearance rate of the isotope from the kidney. The mean blood flow can be obtained from the initial slope of the disappearance or 'wash-out' curve.

**XENON$^{133}$ CLEARANCE CURVE FROM A NORMAL KIDNEY**

![Graph showing Xenon-133 clearance curve](image)

$T_1/2 = 0.133$ MIN
\[ K = 5.2 \text{ MIN}^{-1} \]
\[ RBF = 2.5 \text{ ML/GR MIN} \]

*Fig. 1. Xenon-133 wash-out curve from a normal kidney. The initial slope used for the calculation of the kidney blood flow is shown.*

Figure 1 shows a Xenon wash-out curve. The initial slope for the determination of the mean blood flow is drawn. In animal experiments we have found the blood flow measured in this way to be well correlated with results from simultaneous measurements with an electromagnetic flowmeter (Ladefoged et al., 1965).

Material

We here submit the results from measurements of the renal blood flow by the Xenon wash-out technique in 14 patients with acute renal failure. The patients were examined from one to forty-three days after the onset of the acute renal failure. In six patients more than one examination took place.

Results

Figure 2 shows the renal blood flow correlated to the time after onset of the acute renal failure. Results from measurements in 10 patients with normal PAH-clearances and a slight hypertension are used as control values. The average kidney blood flow in the control group
was 3.2 ml/g.min. (range 2.4–5.4 ml/g.min). Initially most of the patients with acute renal failure had a reduction of the renal blood flow to about one third of the normal value, but a blood flow down to a sixth of the normal was found in a few cases. Gradually the blood flow increased, but 43 days after onset of the disease the flow was still far from normal.

**Renal blood flow in acute renal failure**

![Graph showing renal blood flow over time](image)

*Fig. 2.* The relationship between renal blood flow and time after onset of acute renal failure. Results from repeated measurements in the same patient are connected.

Figure 3 shows the results from the correlation between blood flow and 24-hours endogenous creatinine clearance. The flow shows a tendency to rise with improved clearance

**RENAL BLOOD FLOW IN ACUTE RENAL FAILURE.**

![Graph showing renal blood flow vs. creatinine clearance](image)

*Fig. 3.* The relationship between renal blood flow and 24-hours endogenous creatinine clearance. Results from repeated measurements in the same patient are connected.
values. In one patient six measurements took place during the haemodialysis. The blood flow trebled during this procedure.

In 10 examinations simultaneous measurements of the total renal blood flow by the technique of Shaldon and collaborators (1962) took place, using infusion of indocyanine green into the renal artery, and collection of blood samples from the renal vein.

Fig. 4. The correlation between results from measurements of the renal blood flow with the Xenon-133 wash-out technique and with a dye dilution technique (indocyanine green).

Figure 4 shows the results from these measurements. A significant positive correlation \((r = 0.88)\) between the results from the two methods was found. By the Xenon-133 wash-out technique the blood flow is measured in ml per gram per minute, whereas by the dye dilution technique it is measured in ml per kidney. From these two figures the weight of the kidney can be estimated. The weight varied from 76 g (in a case with renal cortical necrosis) to 322 g, and was on average 220 g in these pathologic cases. In two patients the weight tended to decrease with time.

**Mean circulation times for red cells and plasma**

In connection with determination of the renal blood flow measurements of the cortical mean circulation time for red cells and plasma took place, using a new technique described by Pedersen and Bärenholdt. \(^{51}\)Cr-red cells and \(^{131}\)I-albumin were injected into the renal artery, and from externally monitored disappearance curves the mean circulation times were calculated as shown in Figure 5. After graphical analysis of the curve the mean circulation time was calculated by division of the area ABCD by the height AB (Pedersen and Bärenholdt, in press). By the graphical analysis a part of the curves is excluded. The corresponding part of the tracer is supposed to follow the blood through compartments of the kidney with a slower flow. The mean circulation time thus determined, probably is valid only for blood passing through cortex (Pedersen et al., 1965).

Results from measurements of the cortical mean circulation time for red cells and plasma in patients with arterial hypertension and in patients with acute renal failure are shown in Figure 6. The patients with acute renal failure had significantly longer mean circulation times than the patients with hypertension, and significantly longer than a control group of patients with hypertension and with normal PAH-clearances. The mean values are shown in the figure. The mean circulation times for red cells were not significantly shorter than for those of plasma in the patients with acute renal failure. No evidence of red cell shunts (Shaldon et al., 1963) resulting in very small circulation times was found in any of the groups in the present material.
Fig. 5. Disappearance rate of $^{131}$I-albumin from the kidney after injection into the renal artery. The curve was obtained by external counting. The area ABCD used for the calculations was made by the graphical analysis.

Fig. 6. Mean circulation time for red cells (RC) and plasma (PL) through the renal cortex in three groups of patients. The patients with acute renal failure are further divided into two groups by means of the 24-hour endogenous creatinine clearance ($C_{cr}$).
The mean circulation time for whole blood through the kidney can be calculated from the mean circulation time for plasma and red cells. The cortical vascular volume was calculated from the equation: \( V = F \cdot t_{WB} \), where \( V \) = vascular volume, \( F \) = the renal cortical blood flow and \( t_{WB} \) = mean circulation time for whole blood passing through the renal cortex. In nine cases all three parameters were obtained and the cortical volume varied between 18 and 52 ml per 100 g kidney with a mean value of 26 ml per 100 g kidney.

Summary and conclusion

The renal blood flow was measured in 14 patients with acute renal failure by the Xenon-133 'wash-out' technique. The blood flow varied from \( 1/2 \) to \( 1/3 \) of the normal and gradually normalised during the clinical improvement. In six of the patients, 10 determinations, the renal blood flow was simultaneously measured by a dye dilution technique (Shaldon et al., 1962). The results from the two methods were highly correlated (\( r = 0.88, n = 10 \)). The renal weight was estimated from the figures. It varied from 72–322 g (average 220 g). Furthermore the cortical mean circulation times for red cells and plasma were measured by an external counting technique. The average of the mean circulation times for red cells was 8.1 seconds (range: 4.9–17.0 sec.) and for plasma 8.1 seconds (range: 3.4–13.8 sec.). This is significantly longer than in patients with normal PAH-clearances and arterial hypertension. No evidence of a red cell shunt was found. The cortical vascular volume was determined by use of the mean circulation time for red cells and plasma and the cortical blood flow found by analysis of the Xenon wash-out curve. The volume varied between 18 and 52 ml per 100 g kidney with a mean value of 26 ml per 100 g kidney.

REFERENCES