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Ultrasonographic renal volume measurements in early autosomal dominant polycystic disease: Comparison with CT-scan renal volume calculations

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Abstract
Purpose: To investigate the correlation and concordance between the ellipsoid volume calculated by ultrasonography measurements (Vol3DUS) and the reference kidney volume measured by CT (VolTDM) in early autosomal dominant polycystic kidney disease (ADPKD).
Materials and methods: Prospective study of the correlation and concordance of renal volumes in 24 patients with early ADPKD (48 kidneys analysed separately), with calculation of Vol3DUS using the formula for an ellipsoid in three different manners and VolTDM measurement by manual contouring. Calculations of correlation coefficients (r) and coefficients of intra-class correlation (ICC) with confidence intervals at 95%.
Results: The US volume was strongly correlated with the CT volume by using the maximum width in a transverse section ($r = 0.83$) with a mean Vol3DUS = 692 ± 348 ml [180; 2069]. The most reproducible ultrasonography measurement was the height. When the kidney volume exceeded 800 ml, US underestimated the volume. However, the median error was −57.5 ml [−1090; 183] and 85% of the Vol3DUS calculated differed by more than 5% from the reference measurement.

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Conclusion: The correlation between the US calculated volumes and the CT volumes was strong. However, the median error with ellipsoid US volume was too high to detect a small renal variation in early ADPKD.

Autosomal dominant polycystic kidney disease (ADPKD) is the most common genetic kidney disease with an incidence of 1/1000. Detected in the young adult, it is characterised by the presence of multiple kidney cysts associated with liver cysts and more rarely with cardiovascular anomalies [1]. Terminal kidney failure is the most serious complication and affects about 80% of the patients before the age of 70 [2]. In fact, the progressive growth of the cysts increases the total volume of the kidney and is accompanied by an alteration in the renal parenchyma. There seems to be a relationship between the renal volume and the le glomerular filtration rate (GFR), the main biological marker for the progression of the disease [3]. In fact, the GFR remains stable until about the age of 50, thanks to the compensating ability of the healthy remaining renal parenchyma. However, as of a certain renal volume threshold, the GFR begins to decrease [3]. The new treatments [4,5] try to reduce the growth of cysts and are currently being assessed. They should present an increase in efficacy during the early stage in the evolution of the disease, before the onset of kidney failure (and therefore before the renal volume reaches this critical threshold) [6,7]. Therefore, the monitoring of the renal volume seems to be pertinent in the early assessment of the efficacy of these recent therapies [7—11]. To measure it, the most recent studies have used MRI [10,12]. This expensive examination is of limited access and is not always possible (claustrophobia, pacemaker, high abdominal perimeter...). The CT-scan is also an exact technique [13] although it exposes the patient to the risks of iterative irradiation and possibly the injection of an iodine contrast product. The 2D ultrasound examination, more accessible and without any counter-indications, raises the problem of inter-observer and intra-observer variation [14,15] on the one hand and the approximation of the calculated volume on the other hand. The purpose of this prospective study is to compare the renal volumes calculated by ultrasonography with the reference renal volume measured by CT-scan, in order to determine the value of this technique in assessing the growth of renal volume in early ADKPD patients when their renal function is normal.

Materials and methods

This is a prospective single centre study on patients selected to participate in a therapeutic trial. The criteria for inclusion are:

- adult patients;
- with early autosomal dominant polycystic disease;
- with a normal renal function (defined by a glomerular filtration rate ≥ 60 ml/min), which corresponds to the beginning stage of the disease;
- having signed the French ethics commitee-approved informed consent form.

Twenty-four patients were prospectively included over a period of 7 months. The patients were 25 to 58 years old with a mean of 42.2 ± 8 years [25; 58], comprising 16 women and eight men. Each patient underwent a 2D ultrasound examination and an abdominal CT-scan without injection at an interval of two months.

2D ultrasound measurements

The 2D ultrasound was carried out with an iU22 ultrasound machine (Philips US, Bothell, WA, USA) in composite harmonic mode with a wide band convex sound (C5—1; 1 to 5 MHz), using the ''widescreen'' mode that increases the sector studied. The different readings were taken by a single operator, three consecutive times, for each plane and each kidney (Fig. 1):

- H: maximum height of the kidney, measured in the coronal bivalve plane in widescreen mode;
- Dt_1: maximum transverse width, measured in the coronal bivalve plane at the height of the kidney sinus;
- E: maximum thickness measured in the transverse plane;
- Dt_2: Maximum transverse width, measured in the transverse plane;
- the kidney surface was measured in the coronal bivalve plane (CBP) and in the transverse plane (TP) by the ellipse technique by defining the four cardinal points.

The volume was calculated using the mean of each of the measurements obtained according to the ellipsoid formula: height $\times$ transverse width $\times$ thickness $\times \pi/6$. Thereby, three different volumes were obtained according to the method to measure the transverse width:

$Vol3DUS_1$: $H \times E \times Dt_1 \times \pi/6$
$Vol3DUS_2$: $H \times E \times Dt_2 \times \pi/6$
$Vol3DUS_3$: $H \times E \times (Dt_1 + Dt_2)/2 \times \pi/6$ (transverse width = mean of two measurements)

The time to calculate the volume for a kidney was about 3 to 5 minutes.

CT measurements

The examinations were carried out without the injection of contrast product with a GE VCT LightSpeed scanner (Milwaukee, USA) by optimising the acquisition parameters to obtain a section thickness of 1.2 mm. The volume was calculated in double blind of the ultrasonography by an independent operator on an Advantage Windows 4.1 workstation (GE Advantage Windows, Milwaukee, USA). The volume of the kidneys was obtained in two different ways:

- from the calculation of the three widths of the kidney measured in the three planes obtained by