Abdominopelvic Ultrasound: A Cost-Effective Way to Diagnose Solitary Kidney

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Purpose: Solitary kidneys are detected on approximately 1 of 1,500 prenatal ultrasounds and during evaluation for other urological complaints. Although renal scintigraphy is currently the gold standard for confirming the diagnosis and ruling out renal ectopia, scintigraphy is associated with radiation exposure, placement of an intravenous line and sedation. We hypothesize that ultrasonography alone is sufficient to detect solitary kidneys and that confirmatory renal scintigraphy is unnecessary.

Materials and Methods: We reviewed the records of children with a solitary kidney who underwent ultrasound and nuclear scintigraphy at our institution from 2001 to 2010. Radiological findings were compared to assess the accuracy of ultrasound in diagnosing solitary kidneys. Costs were calculated based on 2011 Medicare global reimbursement.

Results: A total of 25 children met the inclusion criteria of undergoing ultrasound and renal scintigraphy (dimercapto-succinic acid or mercaptoacetyltriglycine scan). The majority of cases were male (16, 64%) and left sided (17, 68%). Median age was 9 days (range 1 day to 11.6 years) at first ultrasound and 4.4 months (3 weeks to 12 years) at first renal scintigraphy. In 24 patients ultrasound correctly diagnosed a solitary kidney as confirmed by nuclear scan. In 1 patient ultrasound suggested a pelvic kidney but repeat ultrasound was negative, as was dimercapto-succinic acid scan. The diagnostic accuracy of ultrasound was 96%. Medicare reimbursement for dimercapto-succinic acid scan (CPT 78700) is $460 to $720 ($222 plus $240 for radiotracer plus $260 for anesthesia, if used).

Conclusions: Our findings suggest that ultrasonography alone is sufficient to make the diagnosis of solitary kidney. Omitting routine renal scintigraphy saves approximately $460 to $720 per case, and avoids radiation and discomfort without sacrificing diagnostic accuracy.

Key Words: child, congenital abnormalities, kidney, kidney diseases, ultrasonography

Abbreviations and Acronyms

DMSA = dimercapto-succinic acid

MAG3 = mercaptoacetyltriglycine

VUR = vesicoureteral reflux

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Study received institutional review board approval.

Urological anomalies are the most common abnormality detected on prenatal ultrasound screening, representing approximately 30% of all defects.[1] The more common renal anomalies include hydronephrosis, cystic disease and solitary kidneys. Elder reported the rate of solitary kidneys found on prenatal ultrasound as 1 in 1,500.[2] This figure is similar to postnatal data from a large-scale ultrasound screening of more than 130,000 Taiwanese schoolchildren, where the prevalence of a congenital solitary kidney was 1 in 1,290 live births,[3] and from autopsy series describing an incidence of 1 in 1,000 live births.[4]

Given its sensitivity, renal scintigraphy has been widely regarded as the gold standard for definitively di-

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Comparison of study renal lengths to normal values

Age	No. Pts	Mean Study Renal Length (cm)	Mean ± SD Normal Renal Length (cm)*	95th Percentile Normal Renal Length (cm)*
0–1 Mo	15	5.1 (range 3.2–5.8)	4.4 ± 0.58	5.39
1–1.9 Mos	3	5.6 (range 5.4–5.7)	4.82 ± 0.46	4.82
3–3.9 Mos	1	5.39	5.11 ± 0.52	6.04
1–1.9 Yrs	2	8 (range 6.8–9.2)	6.34 ± 0.59	7.33
2–2.9 Yrs	1	7.4	6.8 ± 0.71	8.12
10–10.9 Yrs	2	11.05 (range 10–12.1)	8.7 ± 0.85	10.12
11–11.9 Yrs	1	10.8	9.28 ± 0.81	10.34

* Data from Akhavan et al.[9]

agnosing renal agenesis and ruling out renal ectopia.[5–7] However, nuclear scintigraphy is costly and time consuming, exposes the child to ionizing radiation, causes discomfort (intravenous injection) and sometimes requires sedation in younger patients who cannot yet follow commands. In contrast, renal ultrasound is a rapid, safe, less expensive and noninvasive screening method for urinary anomalies and has been used to great effect in prior studies.[3] However, ultrasonography is user dependent and, therefore, may carry less accuracy in identifying an ectopic kidney that is small or obscured by bowel, which may also mimic the sonographic appearance of a kidney.[8]

To our knowledge there are no published studies directly comparing ultrasound to nuclear scintigraphy in making the diagnosis of solitary kidney. There is no universally accepted standard of care at our institution, and practices vary considerably between providers. Some advocate DMSA scan in all cases to rule out renal ectopia and some only when insufficient renal compensatory hypertrophy is observed, while others forgo DMSA altogether in favor of ultrasonography alone. We hypothesize that ultrasonography alone is cost-effective and carries sufficient accuracy in most cases to diagnose a solitary kidney, potentially eliminating the expense and redundancy of routine confirmatory renal scintigraphy.

METHODS

After obtaining institutional review board approval we identified all children diagnosed with a solitary kidney at our institution from 2001 to 2010. Inclusion criteria consisted of prior abdominopelvic ultrasound and confirmatory nuclear scintigraphy using either ^{99m}technetium DMSA or MAG3 scan. The results of the studies were compared by calculating the accuracy of ultrasound vs nuclear scintigraphy in the diagnosis of solitary kidney. Cost analysis was performed based on 2011 Medicare global reimbursement rates for the procedure (CPT 78700), DMSA radiotracer and anesthesia costs.

Ultrasound was performed with the child in the supine position. Images were taken in the sagittal and transverse planes from the midline laterally (sagittal) and from the subcostal area to the pubis (transverse). An empty renal fossa and no evidence of renal tissue within the retroperitoneum or pelvis constituted a suspected solitary kidney.

DMSA scintigraphy was performed 4 hours after intravenous administration of ^{99m}technetium DMSA radiotracer (10 mCi × weight [kg]/100). Pinhole images were recorded in the posterior right and left oblique planes, and the anterior right and left oblique planes. MAG3 scan was temporarily used during a period when the DMSA radiotracer was unavailable nationally. MAG3 studies were performed after urethral catheterization and intravenous hydration at 10 cc/kg per hour. Intravenous sedation was provided by a pediatric anesthesiologist on an individualized basis. The absence of functional renal tissue on scintigraphy was defined as a true solitary kidney.

RESULTS

Of the 135 patients identified with a unilateral solitary kidney there were 25 children (18.5%) who met the inclusion criteria of having undergone abdominopelvic ultrasound and nuclear scintigraphy with either DMSA (18 patients) or MAG3 (7). The children were predominantly male (16 vs 9) and renal agenesis occurred more commonly on the left side (17 vs 8). Median age was 9 days (range 1 day to 11.6 years) at first ultrasound and 4.4 months (3 weeks to 12 years) at first renal scintigraphy. Clinical data were available for 23 of the 25 patients. A total of 14 solitary kidneys were found via prenatal ultrasound, 3 were discovered during evaluation for febrile urinary tract infection and 1 was observed during screening ultrasound before beginning topiramate. Reasons for renal scintigraphy included confirmation of the initial sonogram only in 19 patients, confirmation and to rule out renal scarring in 2, and confirmation of the sonogram and to rule out obstruction in 2. In 2 cases no reason for renal scintigraphy was recorded.

Although the primary focus of our study was to determine the efficacy of ultrasound in diagnosing solitary kidneys, we also recorded associated urological anomalies. The majority of our study patients exhibited supranormal renal growth, with most falling near the 95th percentile of normal values recently published by Akhavan et al (see table).[9] Eight