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Understanding Abnormal Renal Imaging

Sheena Sharma, MD

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**I have no financial or
personal conflicts of
interest to disclose.**

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Today's Agenda

- Overview of Terminology
- Types of Imaging Studies and Their Indications
- Cystic Kidney Disease
- An Overview of Hydronephrosis

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Overview of Terminology

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Case 1

You are precepting a medical student in your busy clinic today. You are quickly reviewing the chart of your next patient who is following-up after recent inpatient admission for pyelonephritis requiring IV antibiotics. The medical student reads the kidney ultrasound report which showed “increased echogenicity bilaterally” and asks you what that means. What do you tell her?

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Case 2

You have a 4th year medical student rotating with you in outpatient Genetics clinic this week. Your next patient was referred for multiple anomalies including sensorineural hearing loss, preauricular pits, and facial asymmetry. You review the renal ultrasound ordered by her pediatrician who referenced this wonderful article!

Syndromic Ear Anomalies and Renal Ultrasounds 🛒

Raymond Y. Wang, MD; Dawn L. Earl, RN; Robert O. Ruder, MD; John M. Graham, Jr, MD

Reprint requests to (J.M.G.) 444 S San Vicente Blvd, Ste 1001, Mark Goodson Building, Cedars-Sinai Medical Center, Los Angeles, CA 90048.

Pediatrics (2001) 108 (2): e32.

The ultrasound report described the kidneys as hypodysplastic. How do you explain this finding to the medical student?

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First, What is Considered “Normal”?

- Kidney length increases progressively from birth to 18 years of age in relation to body surface area
- The best predictor of renal length in children is height regardless of sex
- Limits of normal kidney length (millimeters) in children can be calculated using the following formulas:
 - 2.5th percentile: $0.4 \times \text{height [cm]} + 20.4$
 - 50th percentile: $0.5 \times \text{height [cm]} + 28.2$
 - 97.5th percentile: $0.5 \times \text{height [cm]} + 34.8$

*Note: the left kidney is usually slightly longer than the right

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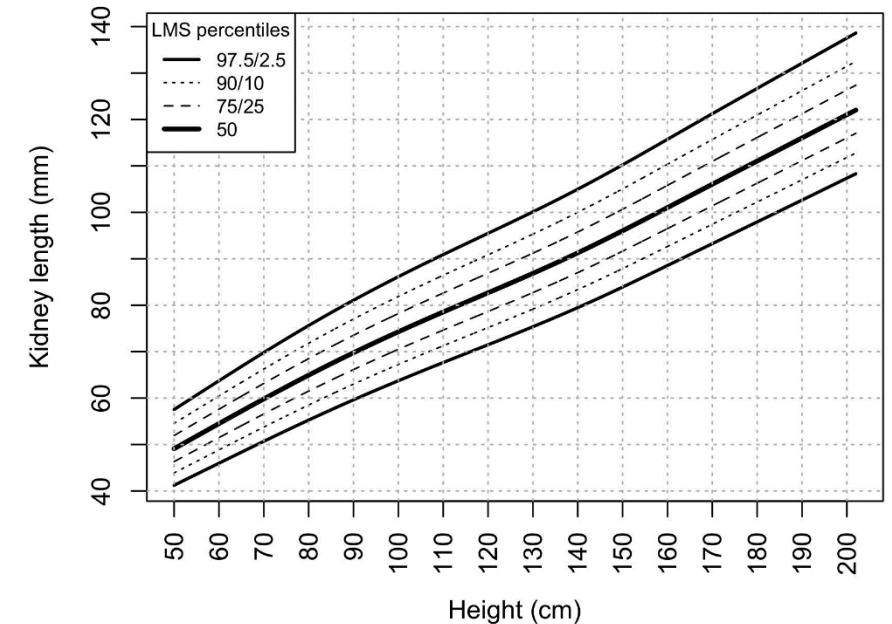
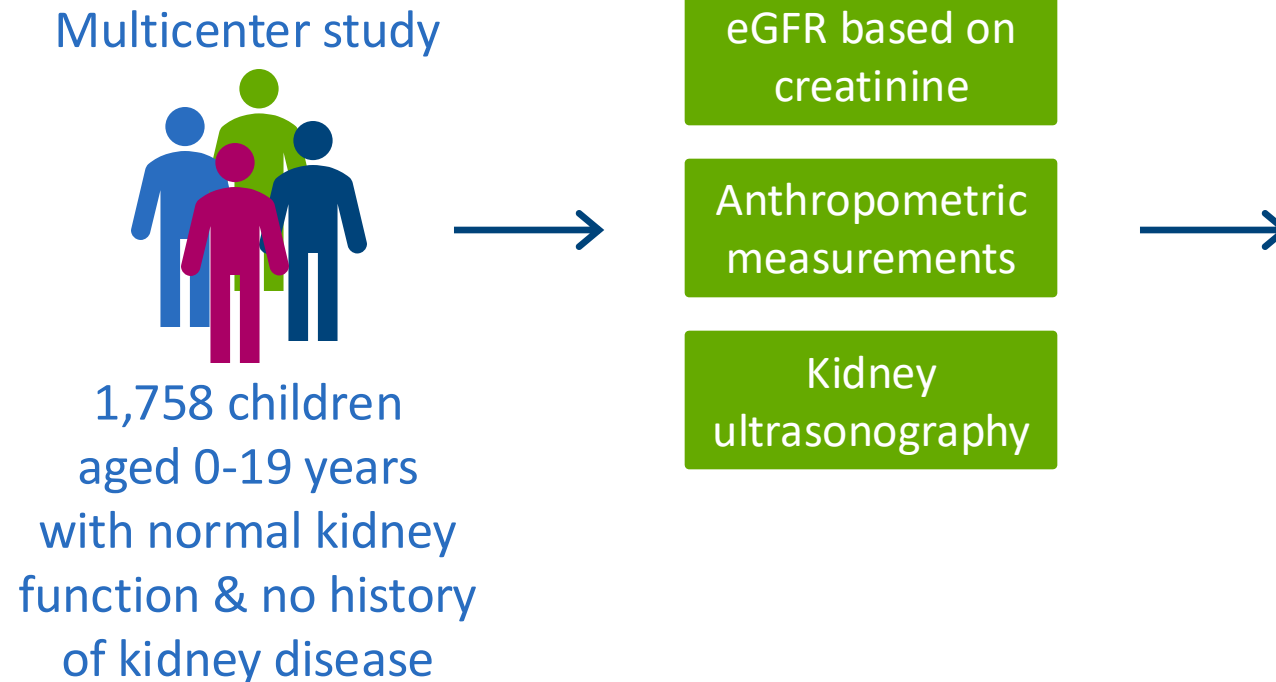
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KIDNEY LENGTH NORMATIVE VALUES IN CHILDREN AGED 0–19 YEARS – A MULTICENTER STUDY

HYPOTHESIS: The aim was to develop sonographic kidney length normative values in children with normal kidney function.

DESIGN & OUTCOMES:

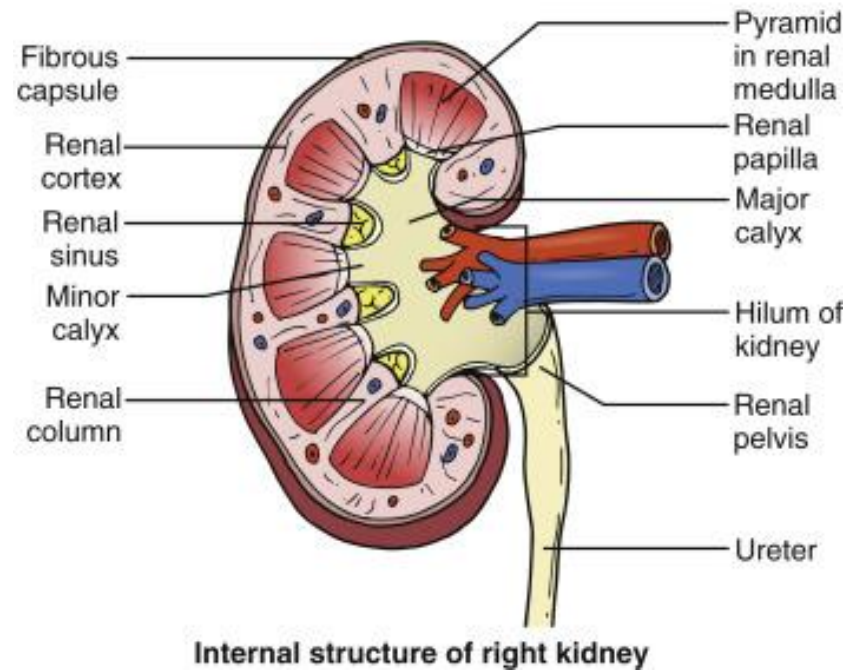
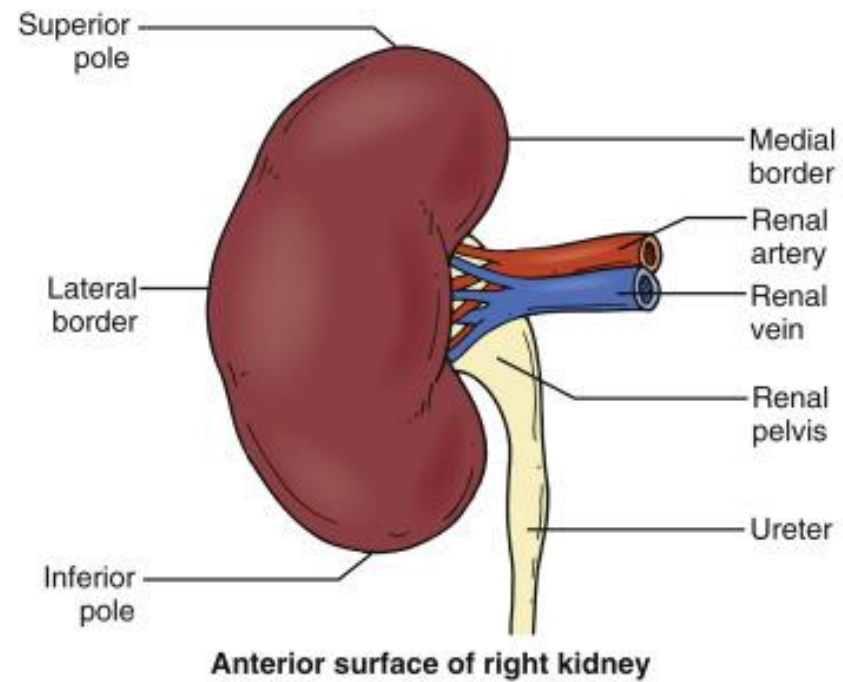


Kidney length percentiles by body length/height

CONCLUSION: The best predictor for kidney length is height. The study provides LMS-percentile charts and tables of normal kidney length in children.

Obrycki et al. 2021

Renal Anatomy



<https://www.vrogue.co/post/external-anatomy-of-the-kidney>

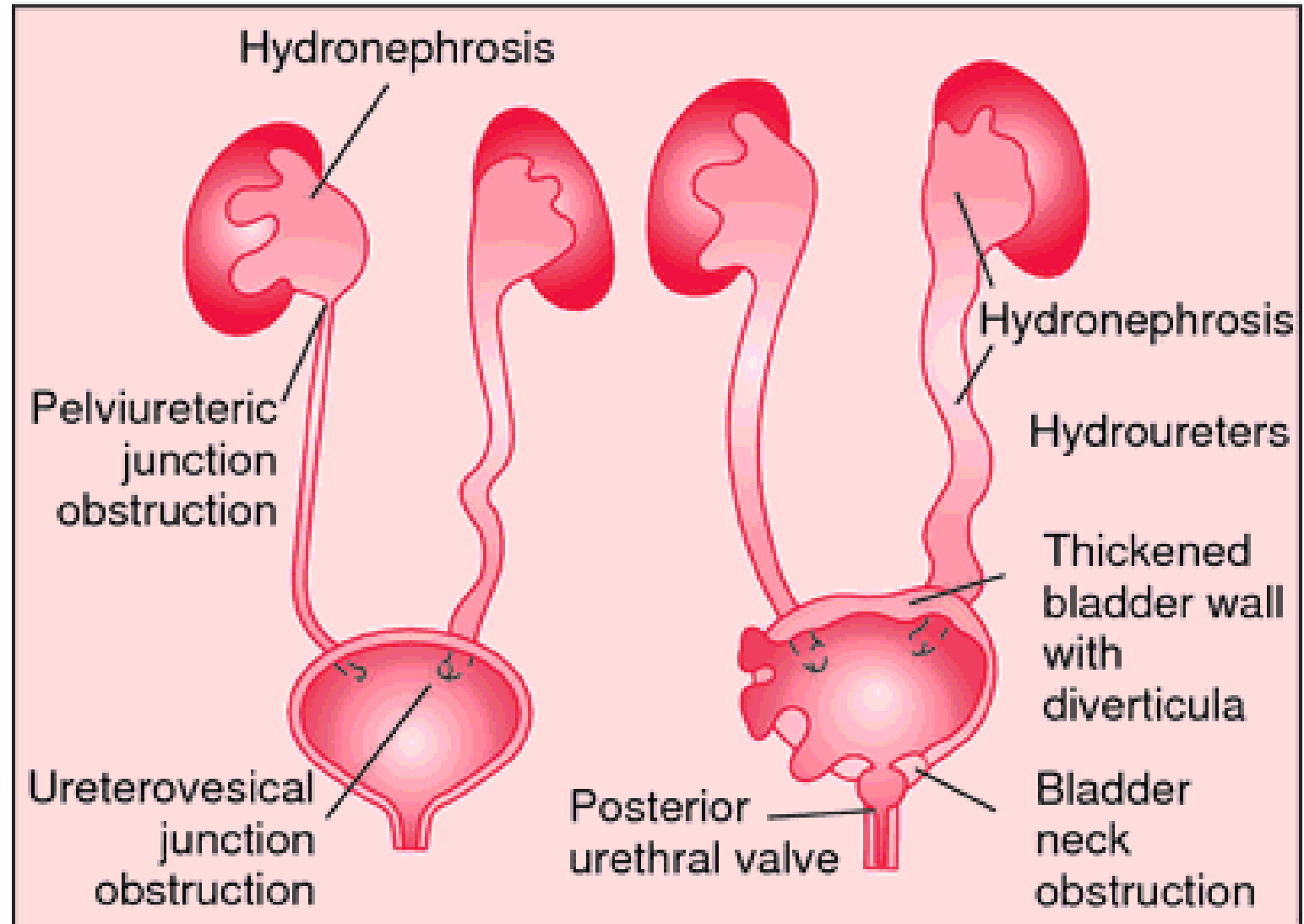
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Types of Obstruction



<https://kr.pinterest.com/pin/131871095312552032/>

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Terminology: Renal Parenchyma

- Renal hypoplasia:
 - Congenitally small kidneys with normal architecture but reduced number of nephrons
 - May be unilateral with contralateral compensatory hypertrophy
 - When bilateral it often results in eventual end-stage renal disease
 - A hypoplastic kidney is smaller than 2 standard deviations of the mean kidney size by age

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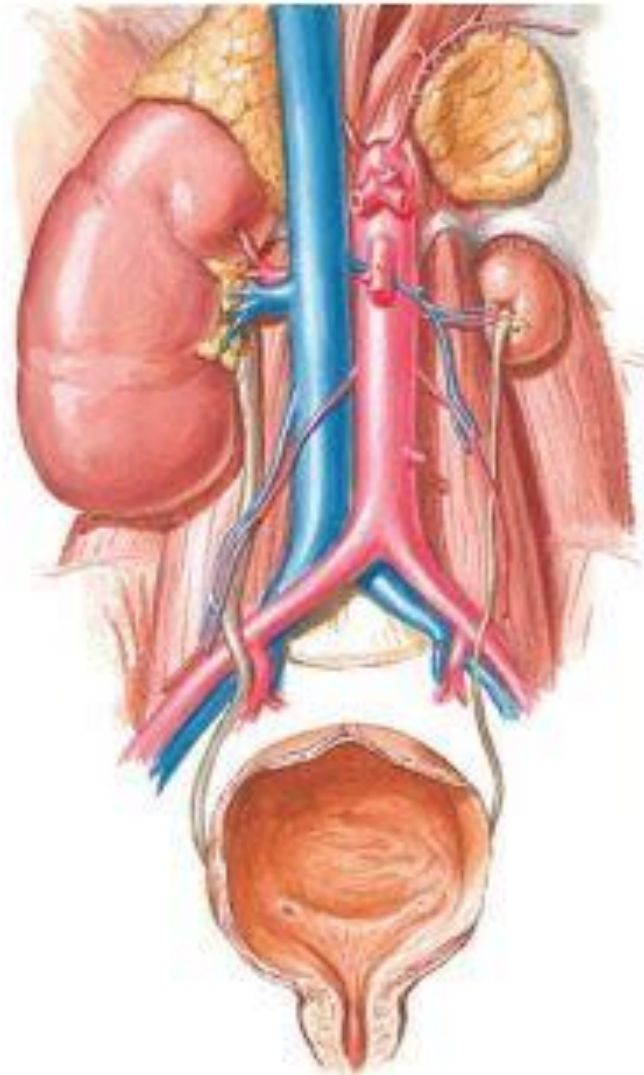
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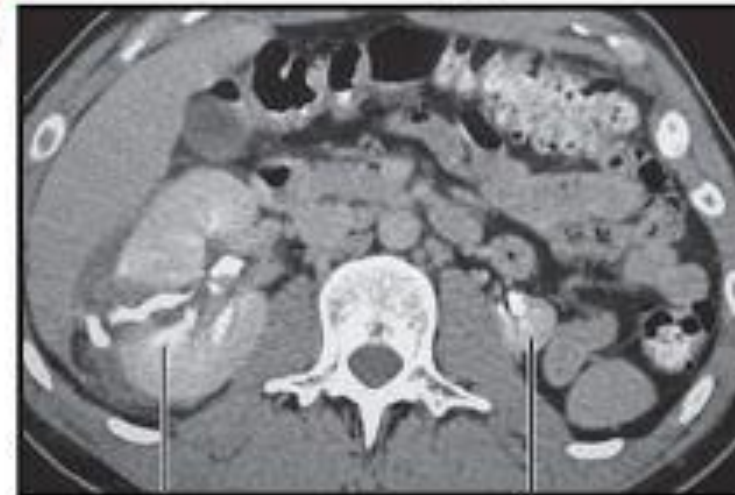


Renal Hypoplasia



Gross appearance of shrunken left kidney secondary to hypoplasia or hypodysplasia. Note normally positioned left adrenal gland and normal-appearing right kidney.

Computed tomography (contrast enhanced) performed for blunt abdominal trauma reveals right-sided renal laceration and incidental finding of left-sided renal hypoplasia.



Right kidney

Left kidney

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[bd7af0b7a72c59771c4a53d83833bbbe.jpg \(466x640\)](#)

Terminology: Renal Parenchyma

- Renal dysplasia:
 - Occurs when the kidneys did not develop as expected in utero
 - The affected kidney often has cysts and tissue that is non-functional, which can affect the entire kidney or segments
 - A dysplastic kidney can be a different size or shape
 - Can be unilateral or bilateral, but if bilateral it usually results in end-stage renal disease



<https://radiologykey.com/renal-imaging-congenital-anomalies-of-the-kidney-and-urinary-tract/>

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Increased Echogenicity?

- Non-specific finding that leads to tissue appearing brighter than normal on ultrasound
- Indicates possible renal parenchymal disease and concern that further testing may be needed

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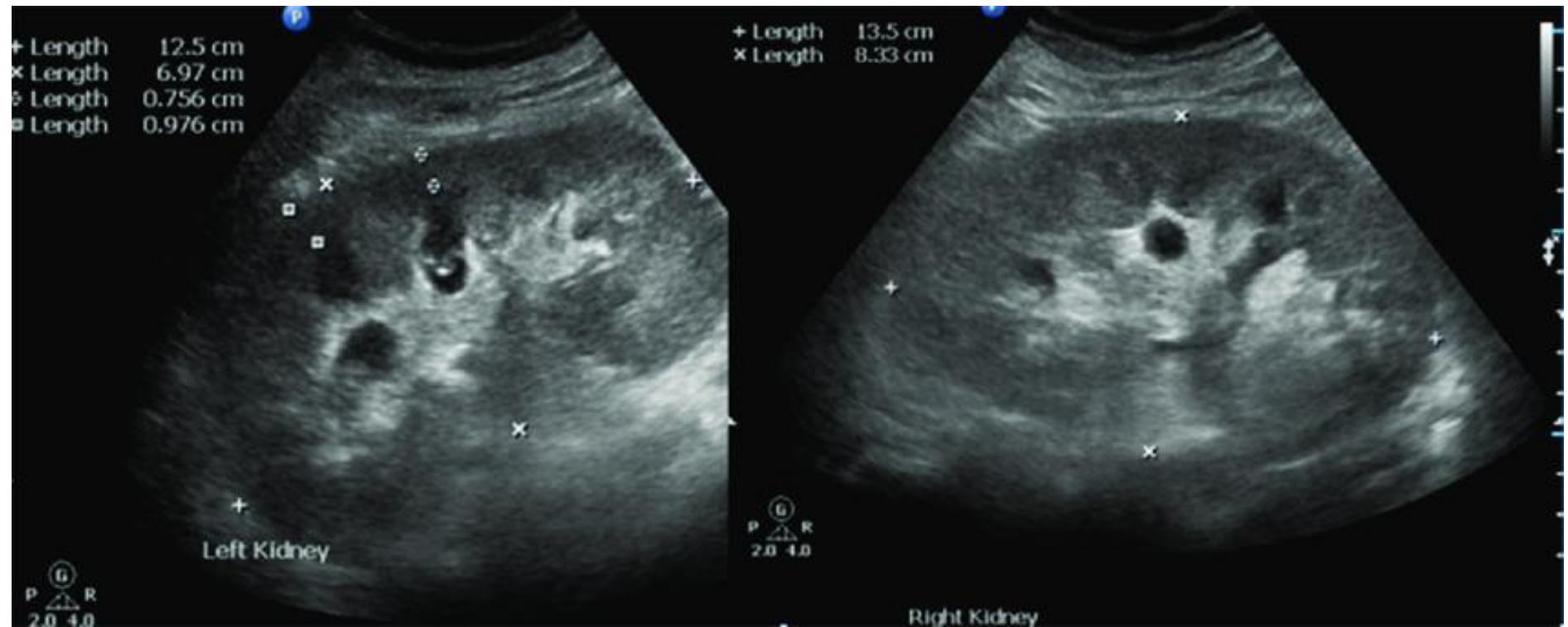
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Increased Echogenicity



https://www.researchgate.net/figure/Kidney-ultrasonography-Kidney-ultrasonography-showing-increased-cortical-echogenicity_fig2_340787148

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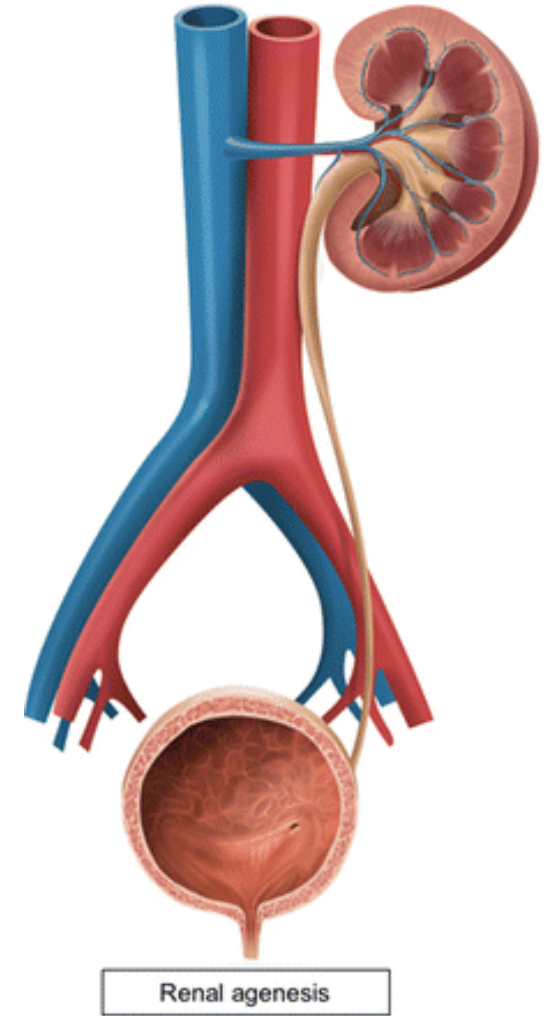
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Terminology: Renal Parenchyma

- Renal agenesis:
 - Congenital absence of renal parenchymal tissue
 - Occurs in approximately 1/3,000-5,000 live births
 - Typically, asymptomatic and found incidentally either in antenatal imaging or imaging performed for another indication
 - Remaining kidney usually undergoes compensatory hypertrophy and can have other abnormalities including vesicoureteral reflux (VUR), utereropelvic junction obstruction (UPJO), or ureterovesical junction obstruction (UVJO)



[rg.2021200078.fig17.gif \(500x448\)](#)

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Terminology: Renal Parenchyma

- Ectopic kidney:
 - Kidney is not in the location expected
- Crossed Renal Ectopia:
 - Occurs in 1/1,000-2,000 live births
 - Associated with fusion to the other kidney 90-95% of the time

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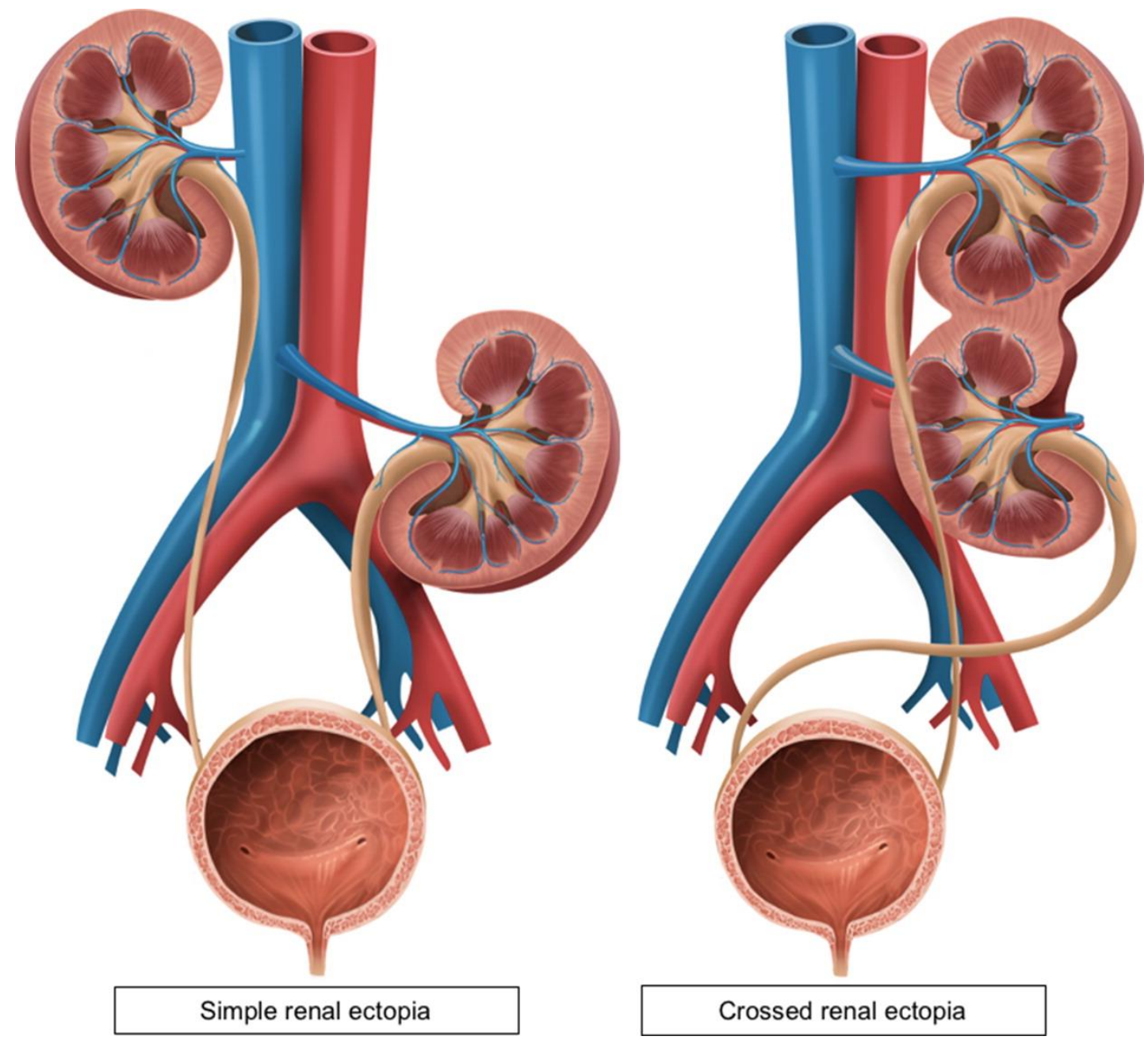
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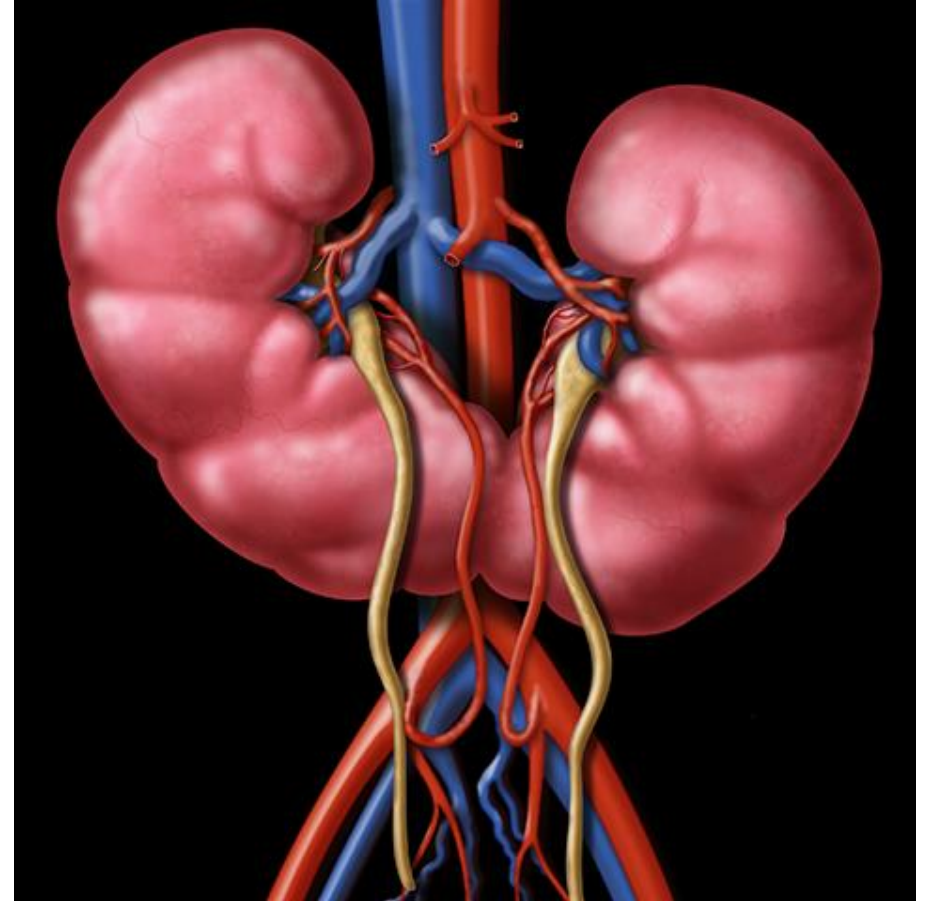
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Terminology: Renal Parenchyma

- Horseshoe kidney:
 - Most common renal fusion abnormality occurring in 1/600
 - Occurs when the lower poles of the two kidneys fuse prior to ascent
 - Often asymptomatic but is associated with an increased risk of VUR, hydronephrosis, UPJO, kidney stones, and urinary tract infections (UTIs)

<https://web.stanford.edu/dept/radiology/radiologysite/site392.html>



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Types of Imaging Studies and Their Indications

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Case 3

You are evaluating a patient with Tuberous Sclerosis (TS) referred to your Nephrology clinic from Neurology for evaluation of possible renal involvement. You are aware that patients with TS can have multiple renal anomalies including angiomyolipomas, renal cysts, or even renal cell carcinoma. What is the best imaging technique to evaluate the kidneys and why?

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Case 4

You are in the middle of your busy shift in the ER when you evaluate a 10-year-old female with right-sided flank pain. She is uncomfortable, diaphoretic, and hunched over on the gurney. What questions would you like to ask? What is your differential diagnosis? What imaging studies would you order to confirm your diagnosis?

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Ultrasound

- Non-invasive and painless test that uses sound waves to create images
- Can be used to detect cysts, stones, tumors, obstruction, injuries, kidney size and shape, or infection (abscess or pyelonephritis)
- Ultrasound with doppler indicates blood flow and can be used to detect renal artery stenosis, renal vein thrombosis, or suspected vascular pathology (e.g. aneurysm, pseudoaneurysm, or arteriovenous fistula)

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MRI

- Has the advantage of superior soft-tissue contrast
- Potentially has the need for sedation or anesthesia
- Used in the assessment of malignant renal lesions, assessment of benign renal lesions, evaluation of stones when CT is contraindicated, cyst delineation, and cancer staging

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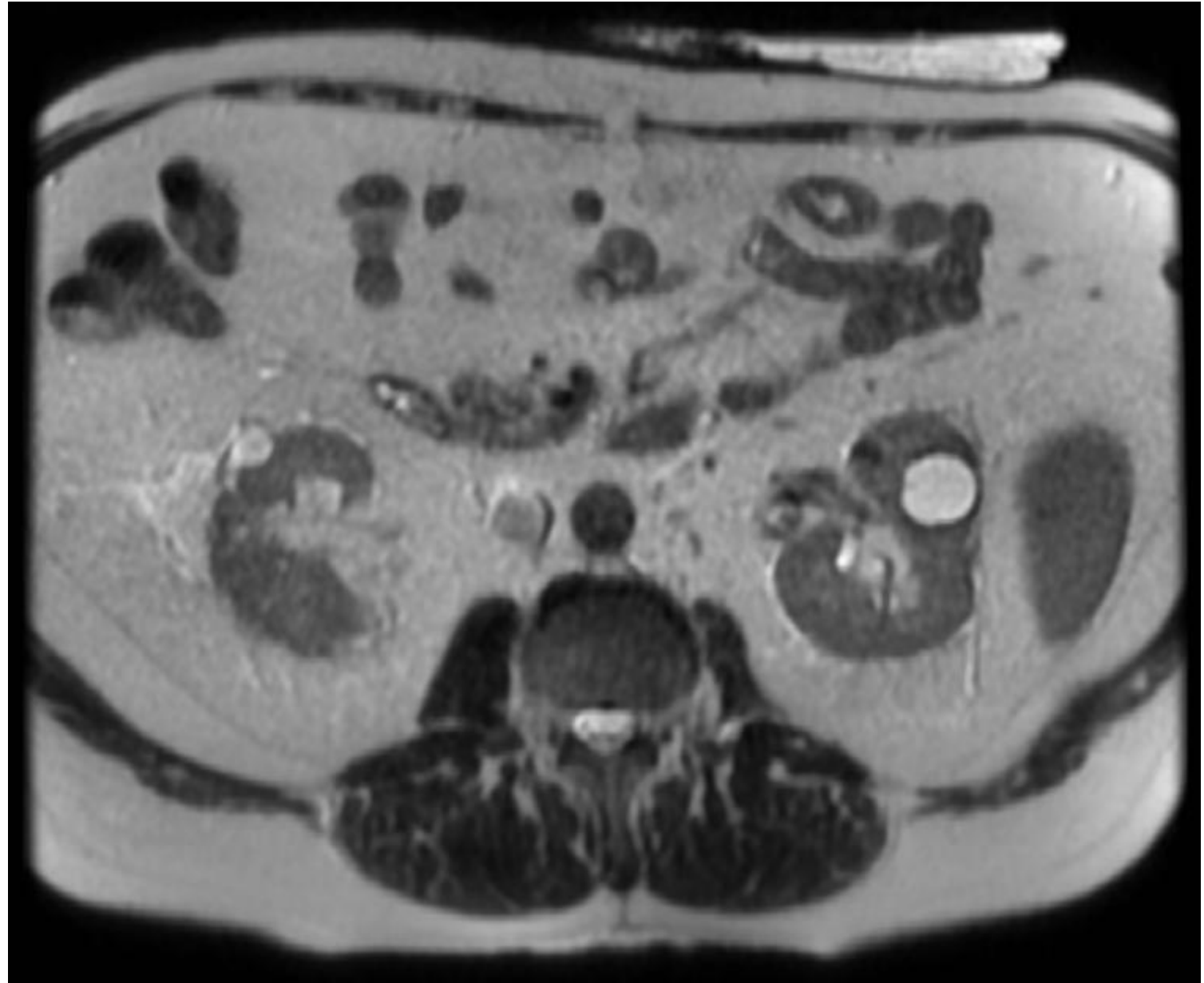
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Simple left renal cyst on MRI



<https://prod-images-static.radiopaedia.org/images/579579/e6576ceff5fe66072ab587865db5a7.jpg>



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CT

- Relatively quick test
- Used in the evaluation of renal colic (if suspecting stones order a non-contrast CT), abdominal trauma, detection and characterization of renal masses, polycystic kidney disease, and staging of renal, ureteral, or bladder malignancy

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Kidney stone on CT



<https://www.kidneystoners.org/information/kidney-stones-in-children/attachment/pediatric-kidney-stone-ct/>

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VCUG

- A VCUG (Voiding Cysto-Urethrogram) is a fluoroscopy procedure that uses x-rays and a contrasting agent to evaluate the bladder and urethra
- Used to detect vesicoureteral reflux and how the bladder fills and drains



https://www.researchgate.net/figure/VCUG-There-was-a-grade-3-reflux-low-grade-reflux-to-the-left-kidney_fig2_358373836

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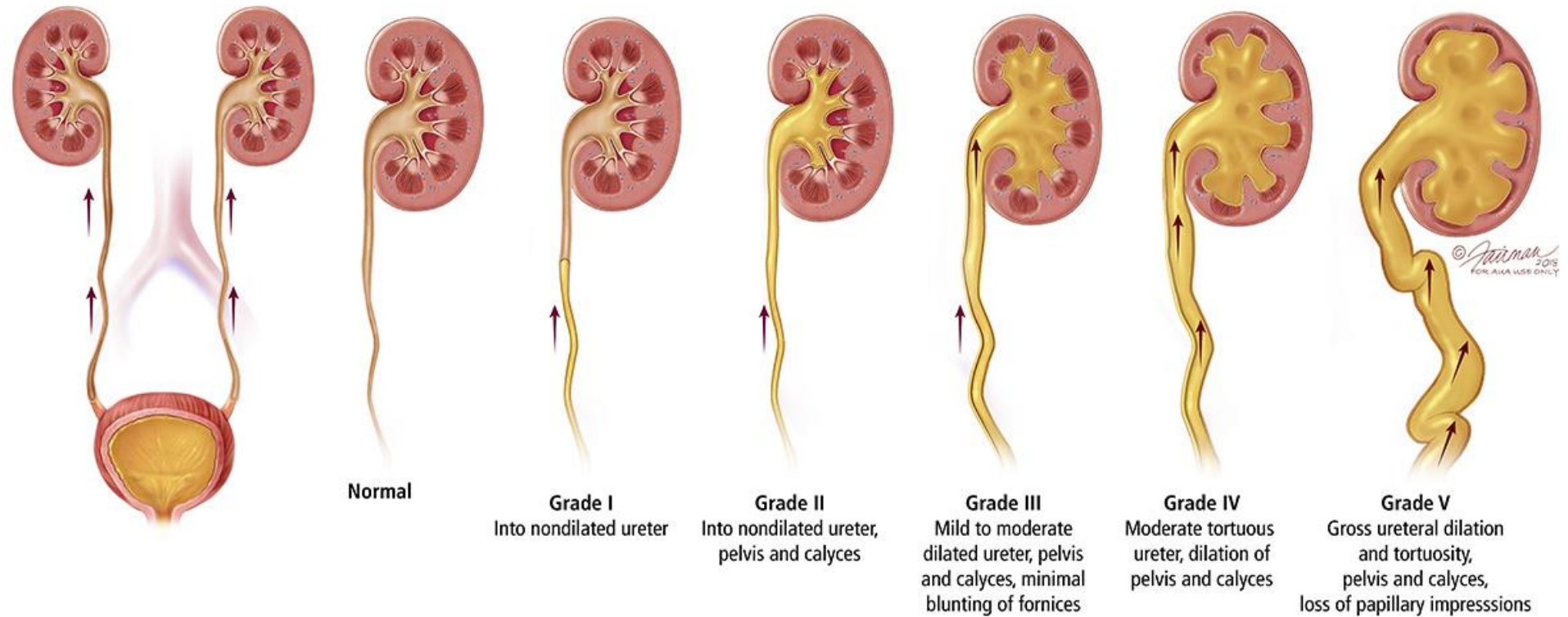
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Grades of VUR



<https://fity.club/lists/v/vesicoureteral-reflux-vur/>

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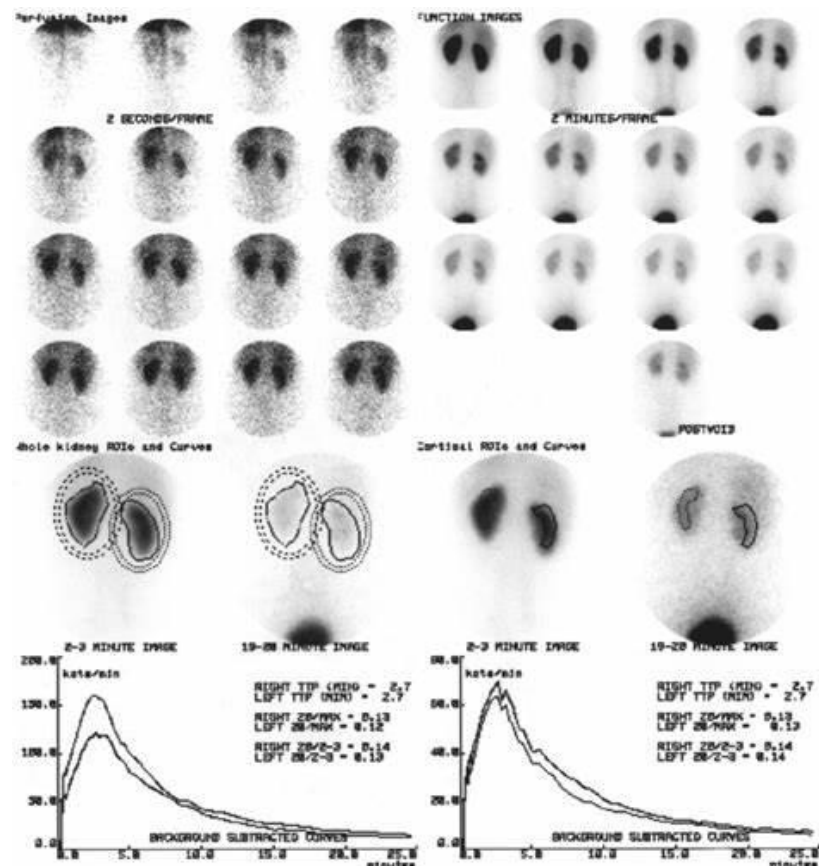
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Mag 3 Scan

- Nuclear medicine test (using mercaptoacetyltriglycine) that shows how the kidneys are functioning, blood supply to the kidneys, blockages, and urinary drainage
- “Top down” vs. “bottom up” VCUG



https://www.researchgate.net/figure/MAG3-renogram-in-an-individual-with-normal-kidneys-As-well-as-showing-the-progression-of_fig2_342087026

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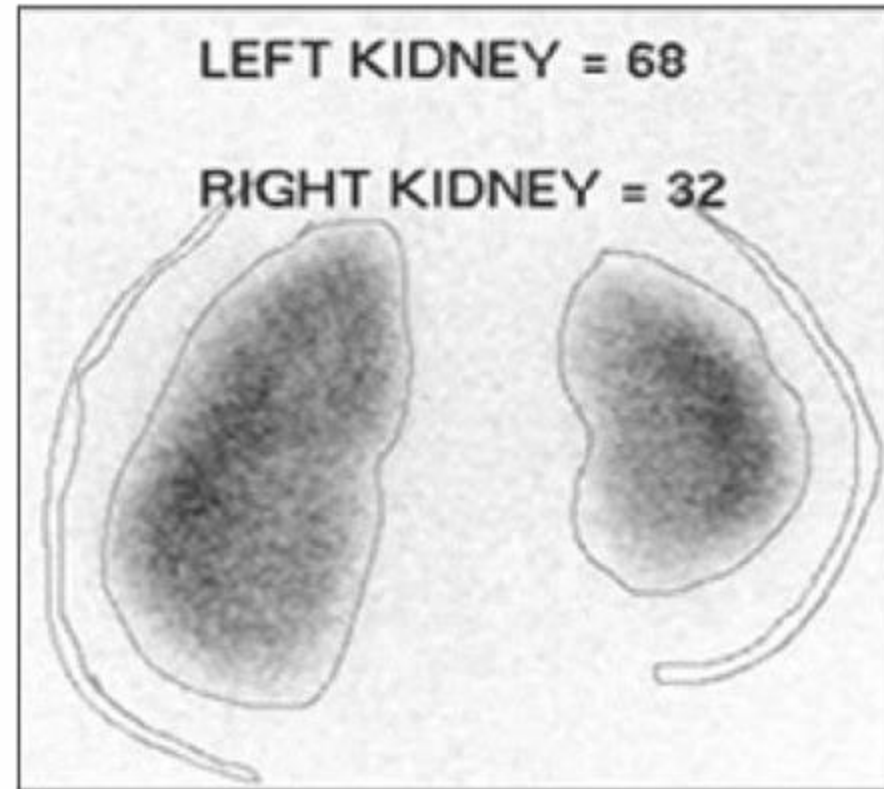
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DMSA

- Nuclear medicine test (using dimercaptosuccinic acid) that demonstrates how the kidneys are functioning
- Used to detect scarring, agenesis, and differential function



https://www.researchgate.net/figure/a-DMSA-scan-image-reveals-a-cold-spot-in-the-upper-pole-of-the-right-kidney-due-to_fig4_360499984

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Case 3

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Cystic Kidney Disease

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Case 5

You follow a 7-year-old female in Stone Clinic who has primary hyperoxaluria type 1 on treatment. Her most recent ultrasound does not show stones, but an incidental finding of a 3mm simple cyst in the upper pole of the right kidney. Her parents are very anxious about this new finding. What is your plan of action?

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Case 6

A 4-year-old female, well-known to your practice, arrives for her well-child check. She has left-sided multicystic dysplastic kidney that has been monitored over time. She has no complaints today, and her physical examination is unremarkable. Her parents once again ask about surgical removal of the multicystic dysplastic kidney. What do you advise?

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BOSNIAK CLASSIFICATION SYSTEM OF RENAL CYSTIC MASSES

WWW.OPENMED.CO.IN

CLASSIFICATION	DESCRIPTION	FEATURES	RISK OF MALIGNANCY	MANAGEMENT
I	Simple Cyst	Thin walled No septae, No calcifications, No enhancement 	None	No Treatment
II	Simple Cyst	Few hair-line septae Fine calcifications May be high-attenuation cysts < 3cm 	Minimal	No Treatment
II F	Minimally Complex Cyst	Multiple hairline septae Minimal smooth thickening of wall or septa. May have thick calcifications but no enhancement. cysts >3cm WWW.OPENMED.CO.IN 	3 - 10 %	Surveillance
III	Complex Cyst	Thicker or more irregular walls with measurable enhancement 	50 %	Surgical Excision
IV	Clearly Malignant	Class III + enhancing soft-tissue components 	75 - 90 %	Surgical Excision

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https://www.openmed.co.in/2022/08/bosniak-classification-system-of-renal.html#google_vign



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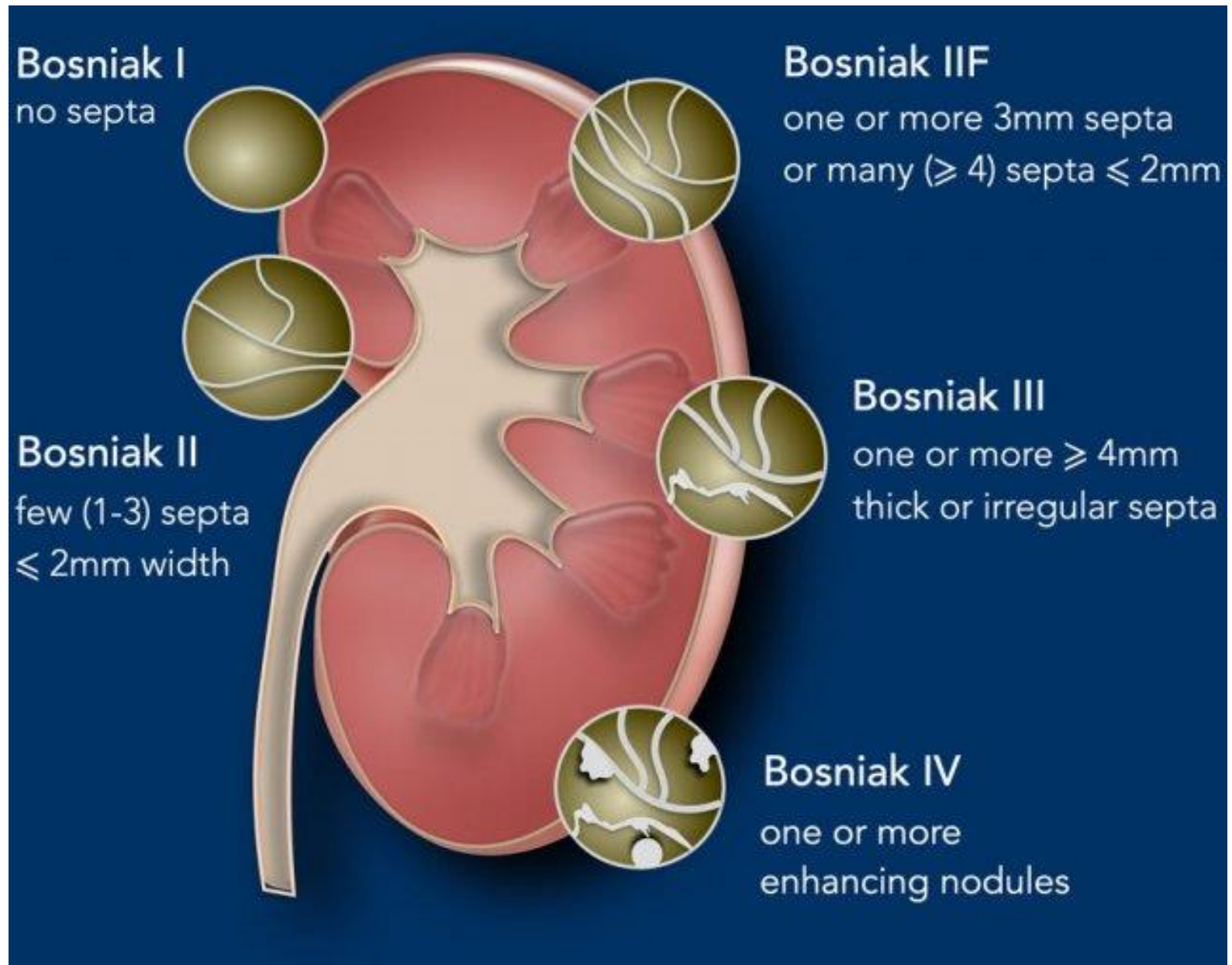
Bosniak I
no septa

Bosniak II
few (1-3) septa
 $\leq 2\text{mm}$ width

Bosniak IIF
one or more 3mm septa
or many (≥ 4) septa $\leq 2\text{mm}$

Bosniak III
one or more $\geq 4\text{mm}$
thick or irregular septa

Bosniak IV
one or more
enhancing nodules



Modified Bosniak Classification System for Pediatrics

- Takes into account US and/or CT characteristics to assess the risk of malignancy in pediatrics
- Attempting to decrease radiation exposure
- ?Validity and inter-rater reliability among radiologists

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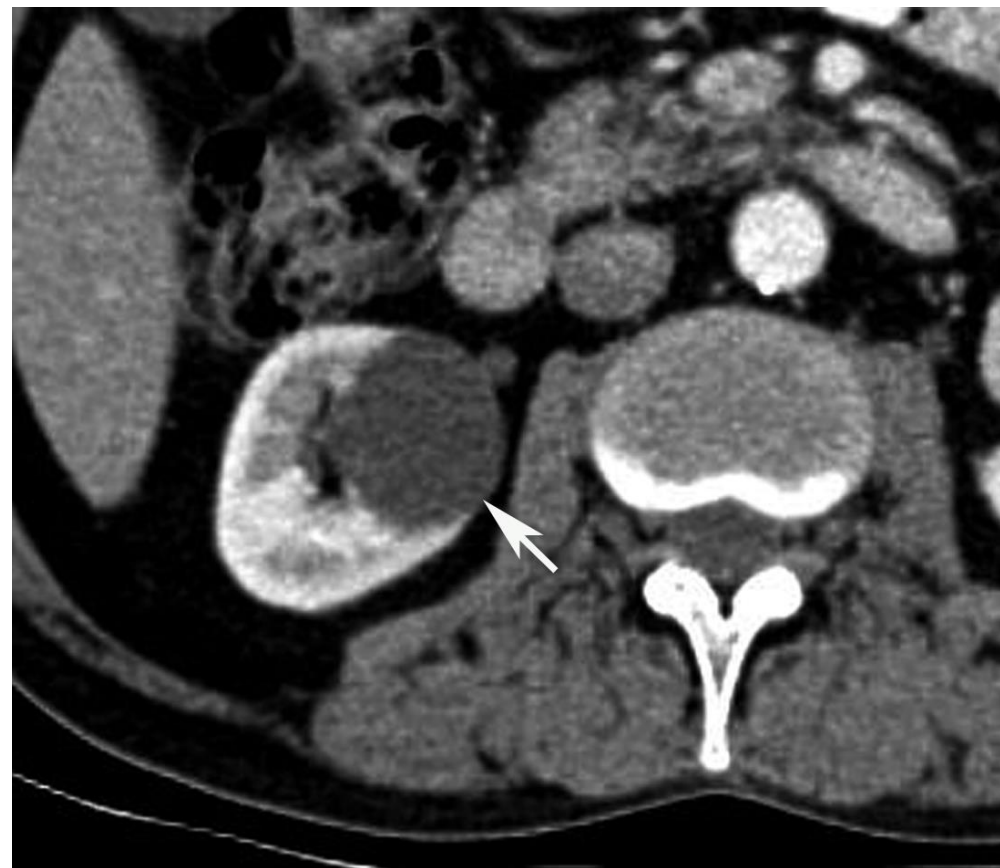
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Simple Cysts

- Fluid-filled sacs usually found incidentally
- Do not typically cause symptoms
- Consensus guidelines on management don't exist



<https://manju-imagingxpert.blogspot.com/2011/04/renal-cyst-ct.html>

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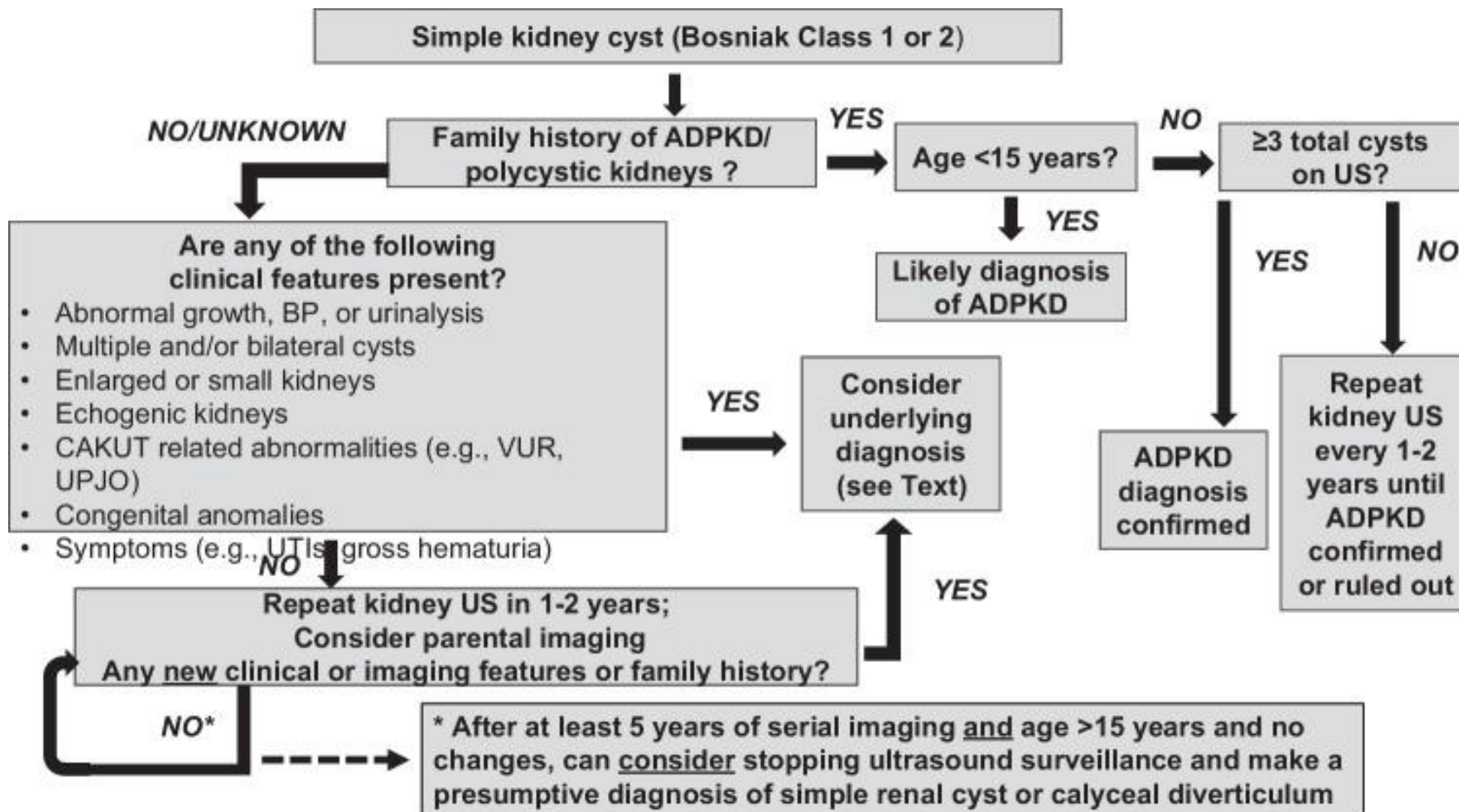
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Approach to simple kidney cysts in children

Katherine M Dell^{1,✉}, Erum A Hartung²



Autosomal Recessive Polycystic Kidney Disease

- Rare genetic disorder affecting the kidneys and liver causing renal cysts and congenital hepatic fibrosis
- Affects 1/20,000-40,000 live births
- Approximately 50% will require dialysis before the second decade of life
- No positive family history in 10-15% of cases (new mutation)

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<https://th.bing.com/th/id/OIP.in-qOFblwSiiatiA5q4FlgHaE7?w=264&h=180&c=7&r=0&o=5&dpr=1.5&pi d=1.7>



<https://pathology.or.jp/corepicturesEN/22/c01/01.html>



<https://ar.inspiredpencil.com/pictures-2023/infantile-polycystic-kidney-disease-ultrasound>

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Autosomal Dominant Polycystic Kidney Disease

- Genetic disorder affecting 1/400-1,000 people
- Symptoms typically present in the 3rd-5th decade of life
- Early onset hypertension is usually the initial finding
- Approximately 50% develop ESRD requiring dialysis and/or transplantation

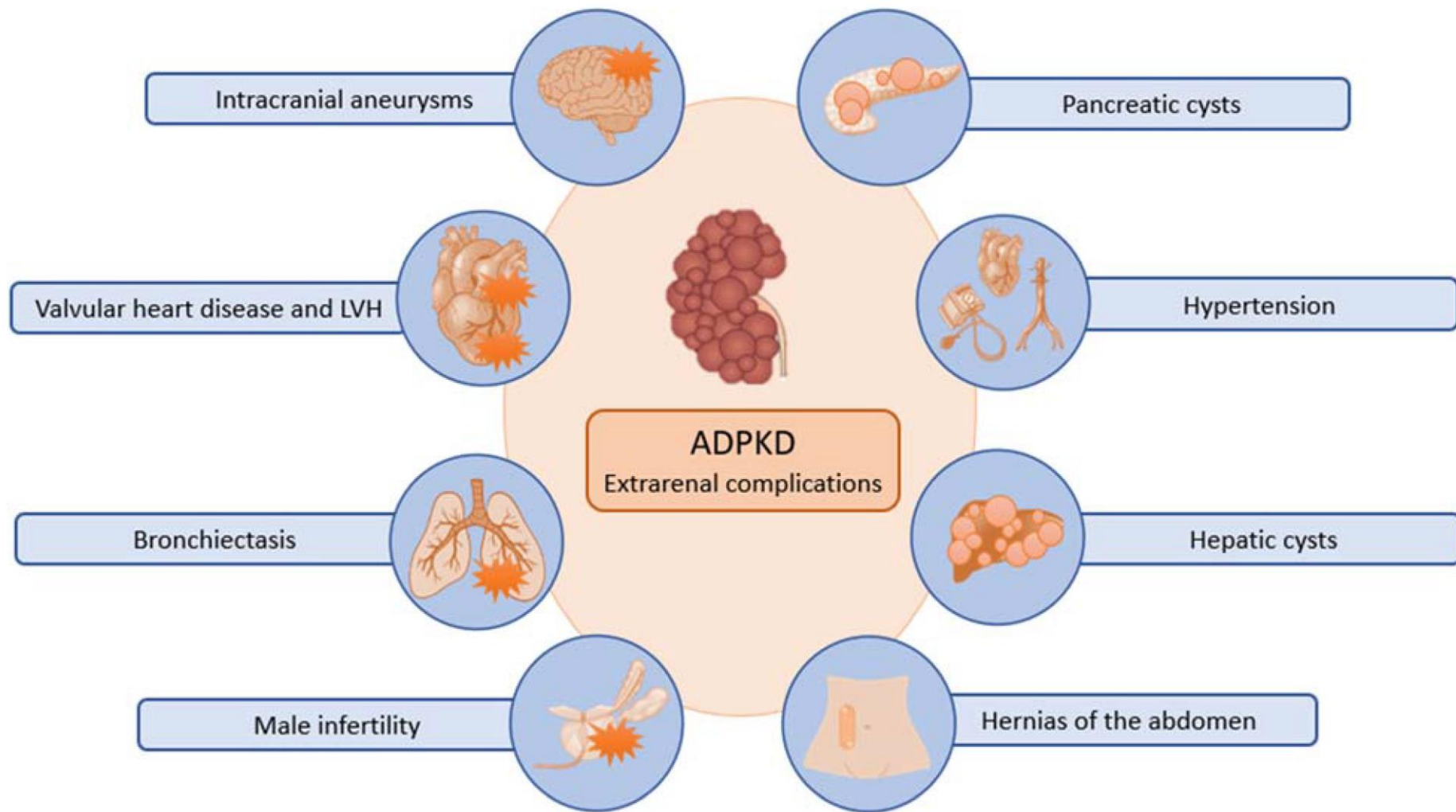
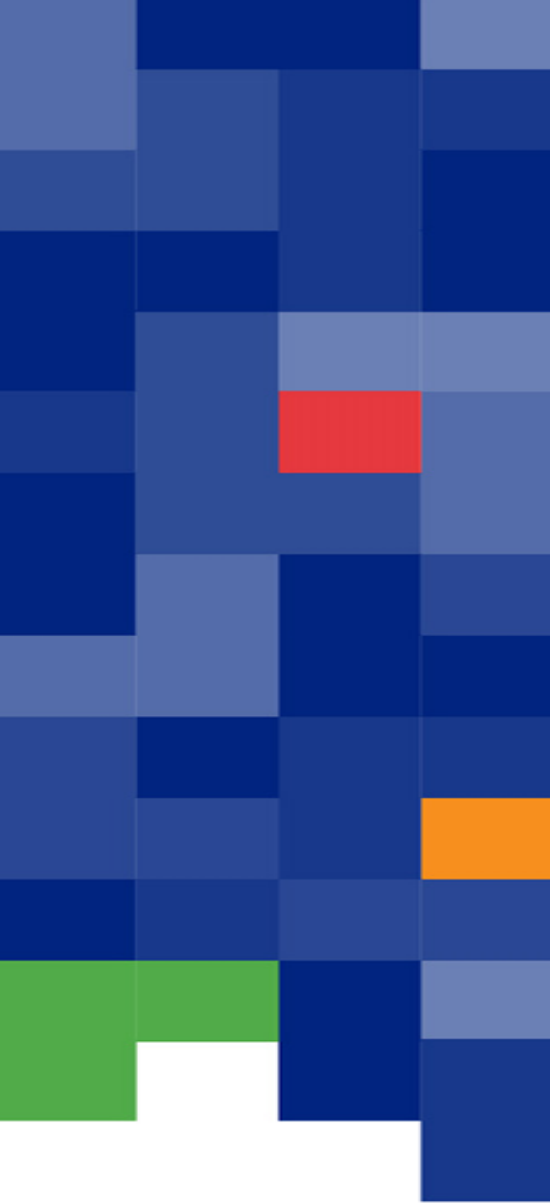
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<https://www.mdpi.com/1422-0067/24/19/14666>

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Multicystic Dysplastic Kidney

- Typically diagnosed in utero and is usually unilateral
- Described as a “sac of grapes” with the cysts various sizes and the intervening tissue non-functional
- Approximately 60% involute over time (may take up to 10 years) with compensatory hypertrophy of the remaining kidney
- Ultrasounds are typically performed every 6 months to 1 year
- Remaining kidney has a renal tract abnormality in 50% of cases including VUR, ureteral ectopia, UVJO
- Surgical removal is indicated if there is resistant hypertension, concerns for malignant transformation

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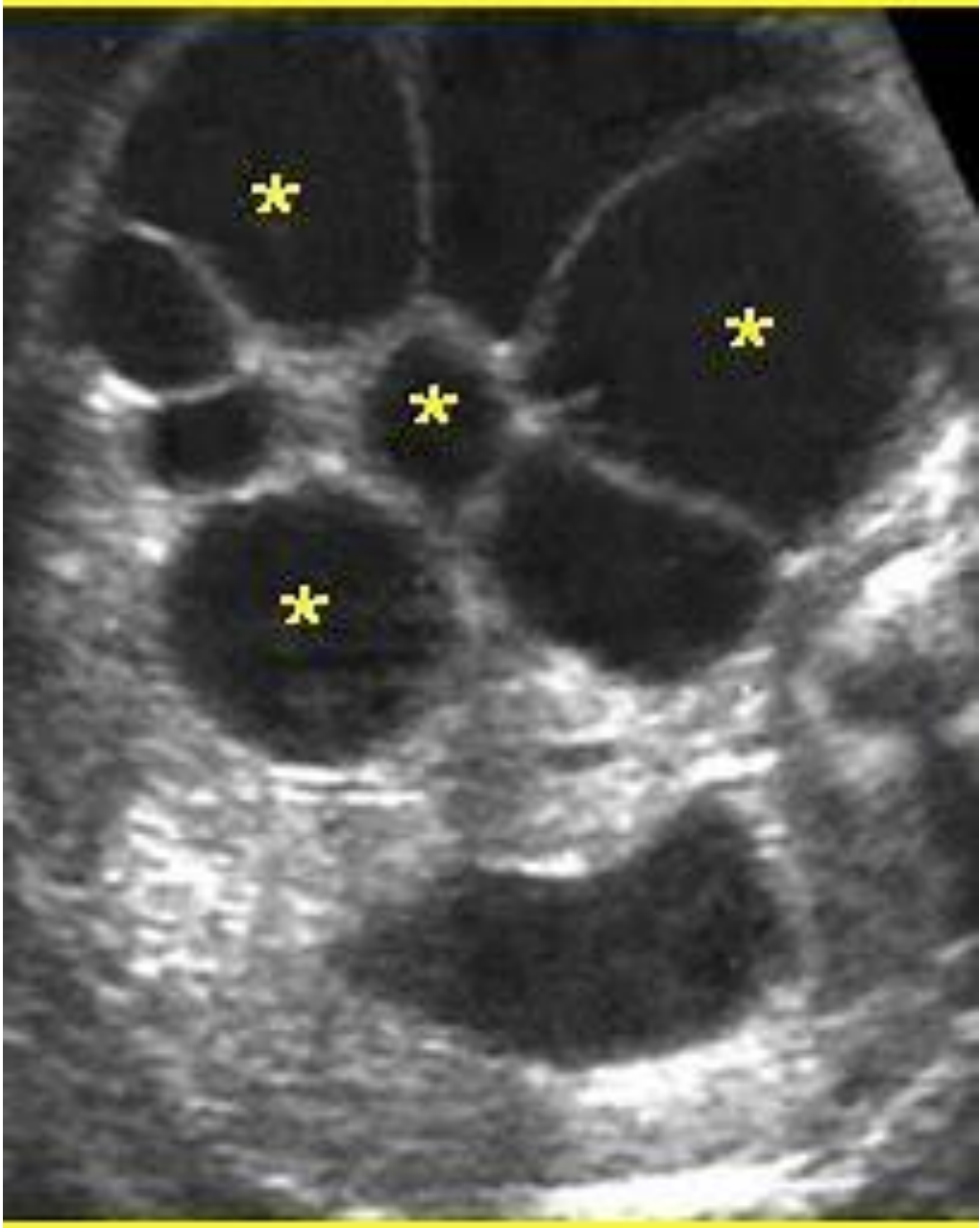




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<https://w1.med.cmu.ac.th/obgyn/lessons/multicystic-dysplastic-kidney-mcdk/>

Case 5

You follow a 7-year-old female in Stone Clinic who has primary hyperoxaluria type 1 on treatment. Her most recent ultrasound does not show stones, but an incidental finding of a 3mm simple cyst in the upper pole of the right kidney. Her parents are very anxious about this new finding. What is your plan of action?

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An Overview of Hydronephrosis

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Case 7

You are examining a 2-month-old in your office for his well-child check. He was found to have right-sided grade 2 hydronephrosis on his 20-week anatomy scan, and this was confirmed following a renal ultrasound last month. His parents ask about next steps and are asking if he needs prophylactic antibiotics for UTI risk. What do you tell them?

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What to do?

- **Prenatal (Antenatal) Period:**

- Detected on routine ultrasound during pregnancy
- Graded based on Society for Fetal Urology (SFU) or anteroposterior renal pelvic diameter (APRPD)

- **Postnatal Ultrasound Timing:**

- First postnatal ultrasound should be done 2-4 weeks after birth
- Earlier imaging (within 48 hours) only if bilateral hydronephrosis associated with ureteral dilation or a dilated bladder, and those with a hydronephrotic solitary kidney

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APRPD vs. SFU

- **APRPD (Anteroposterior Renal Pelvic Diameter):**
 - Mild (grades 1 and 2): <10 mm
 - Moderate (grade 3): 10–15 mm
 - Severe (grade 4): >15 mm
- **SFU Grades (Society for Fetal Urology):**
 - Grade 0: No dilation
 - Grade 1: Mild dilation of renal pelvis only
 - Grade 2: Dilation of pelvis and a few calyces
 - Grade 3: Dilation of all calyces, normal parenchyma
 - Grade 4: Severe dilation with thinning of parenchyma

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Imaging Frequency

Severity	Imaging Schedule	Notes
Mild	Ultrasound at 1 month post-natal and if stable, then repeat in 6-9 months	Often resolves without treatment but if worsens then refer to urology
Moderate	Refer to urology	Early urology referral recommended
Severe	Refer to urology	Early urology referral recommended

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Further Evaluation

- **VCUG Indicated for:**
 - Bilateral hydronephrosis
 - Ureteral dilation
 - Abnormal bladder on ultrasound
 - History of urinary tract infection (UTI)
- **Diuretic Renal Scintigraphy (MAG3 or DTPA):**
 - Evaluates drainage and differential renal function
 - Used in moderate to severe cases or when obstruction (e.g., UPJ obstruction) is suspected

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Management Guidelines

- Consider prophylactic antibiotics in selected cases (dilated ureters, enlarged bladder, bilateral UPJ obstruction, giant hydronephrosis RPD >30mm)
- **Surgical Intervention (e.g., pyeloplasty):**
 - Decreasing renal function
 - Worsening hydronephrosis
 - Recurrent UTIs
 - Obstruction confirmed by MAG3 scan

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Case 7

You are examining a 2-month-old in your office for his well-child check. He was found to have right-sided grade 2 hydronephrosis on his 20-week anatomy scan, and this was confirmed following a renal ultrasound last month. His parents ask about next steps and are asking if he needs prophylactic antibiotics for UTI risk. What do you tell them?

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Thank you!

Questions?

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