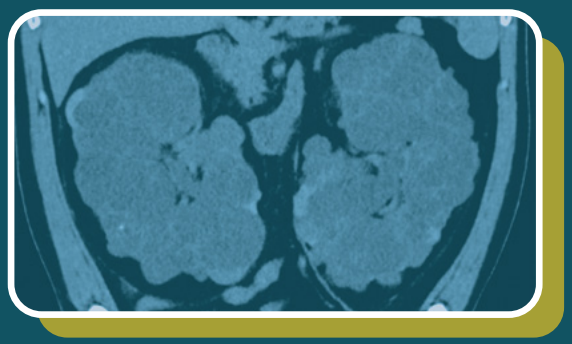
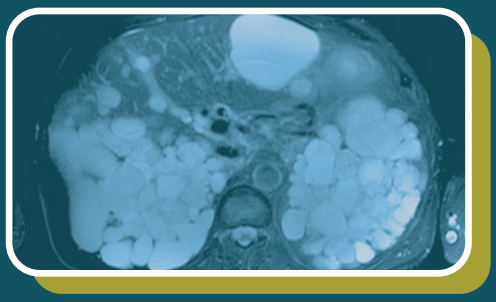
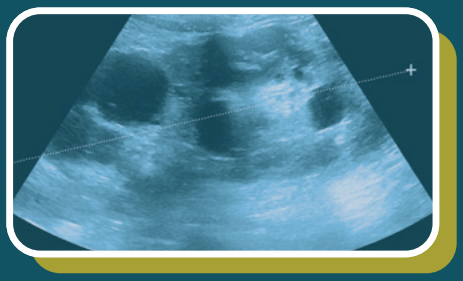
IMAGING THE KIDNEYS IN ADPKD

How imaging results can help assess disease progression







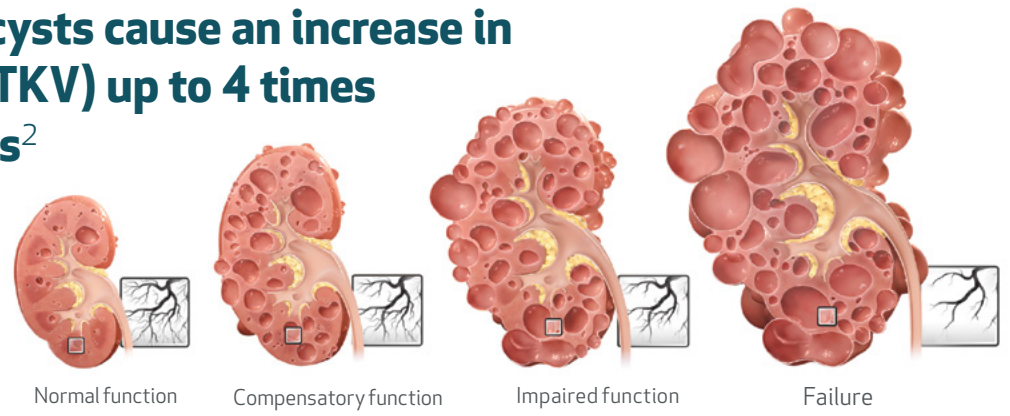
ADPKD=autosomal dominant polycystic kidney disease.

Understanding ADPKD

Autosomal dominant polycystic kidney disease (ADPKD) is a progressive and inherited kidney disease[1]

- ADPKD is a genetic disease characterized primarily by the development and progressive enlargement of fluid-filled renal cysts.[1]

Over time, enlarging cysts cause an increase in total kidney volume (TKV) up to 4 times that of normal kidneys[2]



- This contributes to compression and loss of the surrounding functional renal tissue, resulting in a progressive decline of renal function.[1,3]

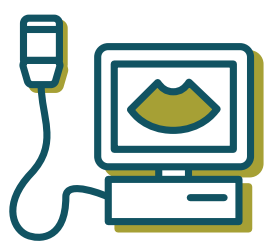
Nearly 50% of all patients with ADPKD will reach end-stage renal disease by age 60[4]

Each child of a person with ADPKD has a 50% chance of inheriting the abnormal gene[5]

Multiple techniques can be used to confirm a diagnosis of ADPKD[6]

Diagnosis of ADPKD is typically established on the basis of[6]:

Positive Family History

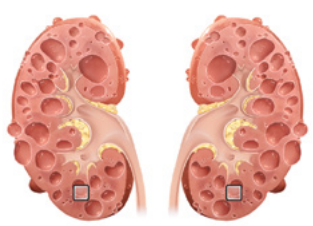


Imaging Studies

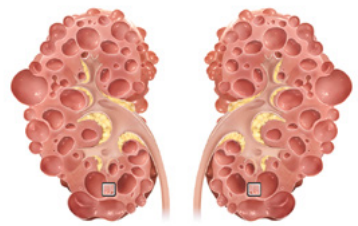
When there is no clear family history or when results from imaging studies are not consistent with ADPKD, genetic testing is available to help confirm a diagnosis.[6]

Ultrasound is the most commonly used imaging modality for diagnosis of ADPKD[7]

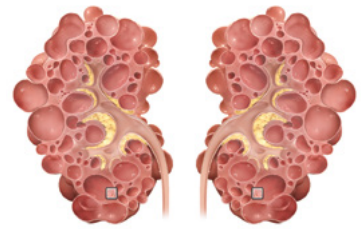
Unified ultrasonographic criteria for diagnosis of ADPKD in patients with positive family history (Pei criteria)[8]:



Criteria
15-39 YEARS
At least 3 renal cysts (unilateral or bilateral)



Criteria
40-59 YEARS
At least 2 cysts in each kidney



Criteria
≥60 YEARS
At least 4 cysts in each kidney

Criteria based on age and cyst count in patients with a positive family history.

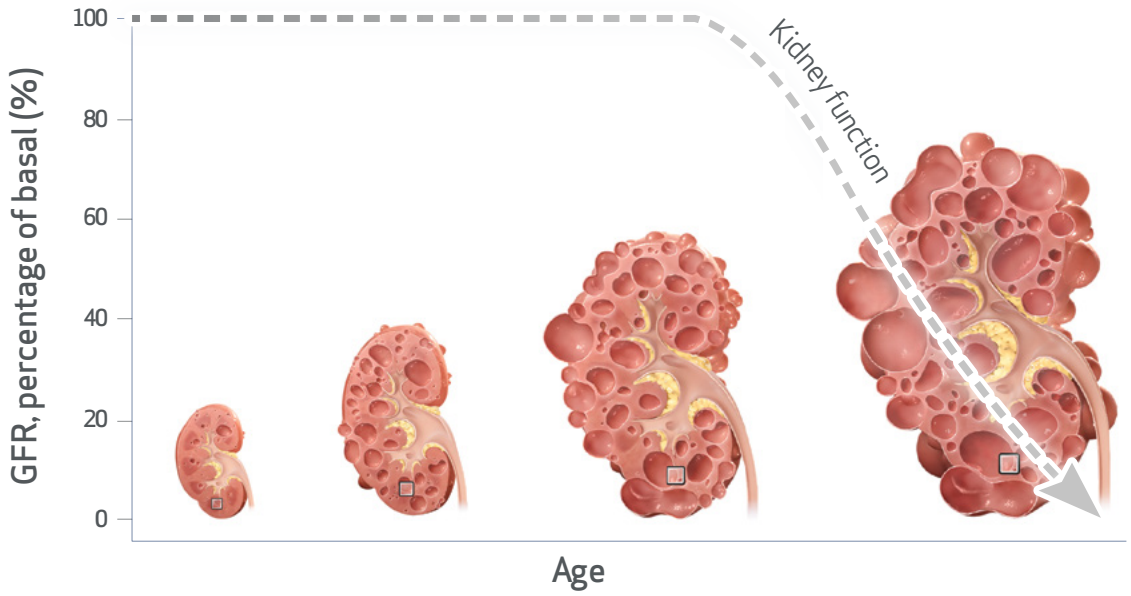
Looking beyond eGFR

TKV can help predict disease progression in ADPKD[9]

Even before eGFR levels begin to drop, TKV can provide an important predictor of[9,10]:

- Early-stage disease progression
- Future renal decline

Kidney growth and damage often occur before kidney function declines.[3]



Adapted from Grantham JJ, et al. *Nat Rev Nephrol*. 2011;7(10):556-566.

- Normal kidney function can mask the severity of disease progression until irreversible damage has already occurred.[11]
- In most ADPKD patients, eGFR levels do not decline until they are 40 or 50 years old, when the kidneys are grossly enlarged.[12]

Identifying a TKV greater than expected for age can provide an early and reliable marker for rapid disease progression in ADPKD.[4]

eGFR should continue to be used concomitantly with TKV to monitor renal function in your patients with ADPKD[4]

eGFR=estimated glomerular filtration rate.

TKV measurement techniques

TKV can be measured using magnetic resonance imaging (MRI), computed tomography (CT), and ultrasonography.[13]

Manual planimetry and the ellipsoid formula are 2 of the recommended techniques available for measuring TKV.[13]

Volume analysis[13]	Manual planimetry	Ellipsoid formula
Imaging modality	MRI and CT scan*	MRI, CT scan,* and ultrasound
Analysis time	40 minutes	5 minutes
Accuracy	100%†	87% (MRI, CT), 21% ultrasound†
Directions	• Trace kidney outline onto cross-sectional images • Multiply all traced areas by slice thickness • Combine slice volumes	• Measure length, width, and depth for both left and right kidneys • Calculate volume with ellipsoid formula -See page 8 for more information about the ellipsoid formula

According to the US Consortium for Radiologic Imaging Studies in Polycystic Kidney Disease (CRISP) cohort analysis published in *Kidney International*:

A one-time kidney size measurement can assess the rate of progression and predict the future decline of kidney function.[14]

*CT-related data were not available, but by approximation can be considered close to MRI methodology.[13]
†Measurement accuracy according to Mayo Clinic model classification.

Closer look at ADPKD imaging

ADPKD imaging modalities

There are advantages and drawbacks to each of the imaging modalities for measuring kidney and cyst volumes.[13]

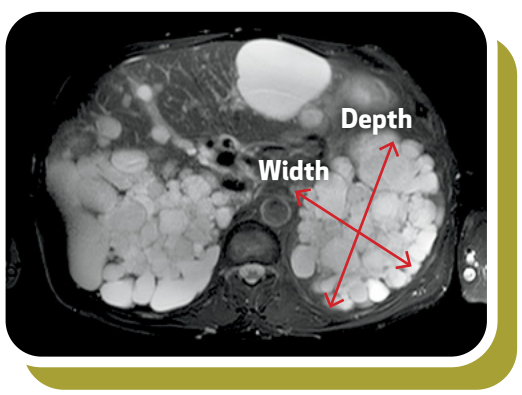
Imaging modality[13]	Abdominal MRI	Abdominal CT	Ultrasound
Measurement accuracy	Can detect cysts ≥2 mm in diameter	Can detect cysts ≥2 mm in diameter	Can detect cysts >1 cm in diameter
Advantages	• Can reliably measure kidney volume over short periods of time with minimal bias and low inter- and intraoperator variability • Allows segmentation of individual cysts providing quantitative assessment of disease	• Provides accurate and reliable measurement of TKV and cyst volume in ADPKD	• Does not require radiation • Widely available • Low cost
Drawbacks	• Cost • Lack of availability	• Potentially nephrotoxic contrast medium • Exposure to radiation	• Lacks precision and accuracy for detecting short-term changes in kidney volume • Highly operator-dependent

Ultrasound-derived kidney length has been proposed as a surrogate for MRI-measured TKV for predicting disease progression.[13,15]

Patients younger than 45 years and with an ultrasound kidney length >16.5 cm bilaterally should be considered at high risk of ADPKD progression. Kidney length >16.5 cm has been shown to predict the development of CKD stage 3 within 8 years in patients aged <45 years.[13,15]

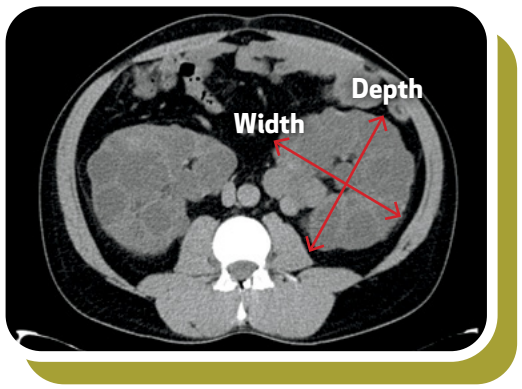
Imaging examples

Visualizing ADPKD using MRI, CT, and ultrasonography

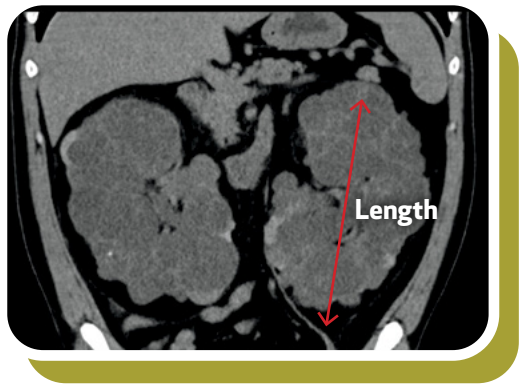


MRI: Axial slice, typical ADPKD presentation with bilateral, diffuse distribution of cysts

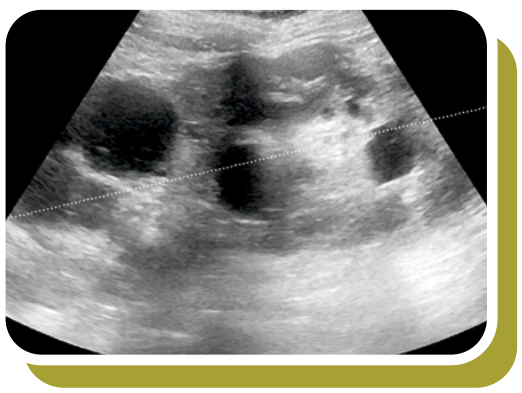
MRI: Coronal slice, typical ADPKD presentation with bilateral, diffuse distribution of cysts



CT image: Axial slice, typical ADPKD presentation with bilateral, diffuse distribution of cysts



CT image: Coronal slice, typical ADPKD presentation with bilateral, diffuse distribution of cysts



Ultrasound scan: Left kidney in typical ADPKD presentation with diffuse distribution of cysts

Using TKV to help predict disease progression

Calculating a TKV measurement

A single baseline htTKV measurement can help predict disease progression.[16]

Steps for ordering a TKV measurement

1 Perform abdominal/limited abdominal CT or MRI* scans or ultrasound[13]

2 Collect measurements needed to determine TKV

Measure both the left and right kidneys, cyst edge to cyst edge, and review image to determine typical† or atypical‡ PKD (if typical, calculate TKV)

- Maximal kidney length on the coronal plane
- Maximal kidney width on the transverse (axial) plane
- Maximal kidney depth on the transverse (axial) plane

3 Calculate TKV and htTKV

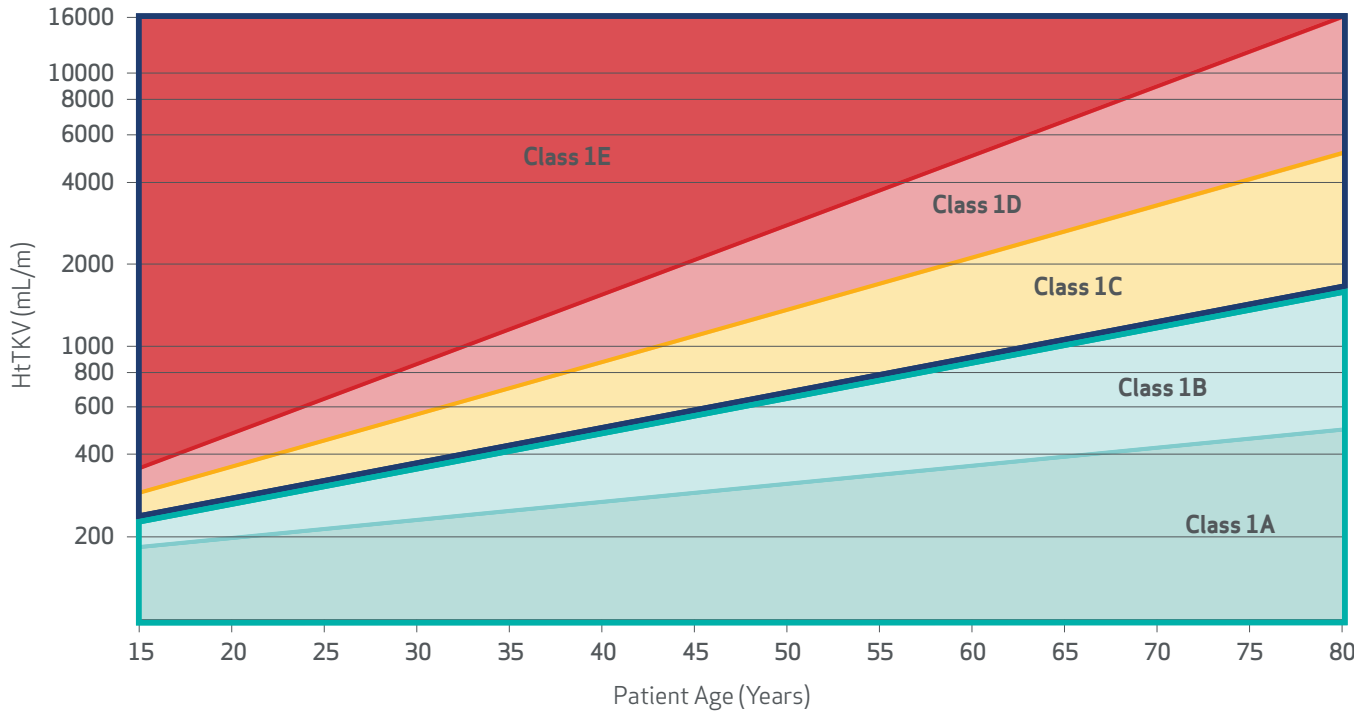
Skip the manual calculations with this electronic TKV and htTKV calculator
Scan the QR code or visit QxMD.com.

*MRI without gadolinium.
†Bilateral and diffuse distribution, with mild, moderate, or severe replacement of kidney tissue by cysts, where all cysts contribute similarly to TKV.[13]
‡Unilateral, segmental, asymmetric, or lopsided presentation or a bilateral presentation with acquired unilateral atrophy or bilateral kidney atrophy.[13]
PKD=polycystic kidney disease.

Assessing disease progression from htTKV

HtTKV acquired by MRI or CT can be used to determine a patient's ADPKD imaging classification and help identify adult patients at a high risk of rapid disease progression.[17]

ADPKD imaging classification by htTKV and age predicts the change in eGFR over time in patients with typical ADPKD.[17§]



§Bilateral and diffuse distribution, with mild, moderate, or severe replacement of kidney tissue by cysts, where all cysts contribute similarly to TKV.[17]

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Patient classification [17‖]

Class	1A	1B	1C	1D	1E
Estimated kidney growth rate: yearly percentage increase	<1.5%	1.5%-3%	3%-4.5%	4.5%-6%	>6%
Risk for eGFR decline	Low risk	Intermediate risk	High risk	High risk	High risk

‖Classification only applies to patients with typical morphology of ADPKD as defined by diffuse bilateral cystic involvement of the kidneys.[17]

What's inside:

- Understanding ADPKD progression
- TKV measurement techniques
- ADPKD imaging modalities and examples
- Predicting ADPKD progression using TKV

ADPKD=autosomal dominant polycystic kidney disease; TKV=total kidney volume.

References: 1. Patel V, Chowdhury R, Igarashi P. *Curr Opin Nephrol Hypertens*. 2009;18(2):99-106. doi:10.1097/MNH.0b013e3283262ab0 **2.** Braun WE. *Cleve Clin J Med*. 2009;76(2):97-104. **3.** Grantham JJ, Mulamalla S, Swenson-Fields KI. *Nat Rev Nephrol*. 2011;7(10):556-566. **4.** Chebib FT, Torres VE. *Am J Kidney Dis*. 2016;67(5):792-810. doi: 10.1053/j.ajkd.2015.07.037 **5.** Torres VE, Grantham JJ. In: Taal MW, Chertow GM, Mardsen PA, Skorecki K, Yu ASL, Brenner BM, eds. *Brenner & Rector's The Kidney*. Philadelphia, PA: Elsevier Saunders; 2012:1626-1667. **6.** Chebib FT, Perrone RD, Chapman AB, et al. *J Am Soc Nephrol*. 2018;29(10):2458-2470. doi:10.1681/ASN.2018060590 **7.** Pei YH, Hwang Y, Conklin J, et al. *J Am Soc Nephrol*. 2015;26(3):746-753. doi:10.1681/ASN.2014030297 **8.** Pei Y, Obaji J, Dupuis A, et al. *J Am Soc Nephrol*. 2009;20(1):205-212. doi:10.1681/ASN.2008050507 **9.** Grantham JJ, Torres VE. *Nat Rev Nephrol*. 2016;12(11):667-677. **10.** Perrone RD, Neville J, Chapman AB, et al. *Am J Kidney Dis*. 2015;66(4):583-590. doi:10.1053/j.ajkd.2015.04.044. **11.** Grantham JJ, Chapman AB, Torres VE. *Clin J Am Soc Nephrol*. 2006;1(1):148-157. **12.** Grantham JJ, Torres VE, Chapman AB, et al. *N Engl J Med*. 2006;354(20):2122-2130. **13.** Magistroni R, Corsi C, Martí T, Torra R. *Am J Nephrol*. 2018;48:67-78. doi:10.1159/000491022. **14.** Yu ASL, Shen C, Landsittel DP, et al; for the Consortium for Radiologic Imaging Studies of Polycystic Kidney Disease (CRISP). *Kidney Int*. 2019;95(5):1253-1261. **15.** Bhutani H, Smith V, Rahbari-Oskoui F, et al. *Kidney Int*. 2015;88(1):146-151. **16.** Yu ASL, Shen C, Landsittel DP, et al; for the Consortium for Radiologic Imaging Studies of Polycystic Kidney Disease (CRISP). *Kidney Int*. 2018;93(3):691-699. **17.** Irazabal MV, Rangel LJ, Bergstralh EJ, et al. *J Am Soc Nephrol*. 2015;26(1):160-172.

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