American College of Radiology
ACR Appropriateness Criteria®

Hydronephrosis on Prior Imaging-Unknown Cause

Variant: 1 Adult. Asymptomatic unilateral hydronephrosis with unknown cause. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
MRU without and with IV contrast	Usually Appropriate	O
MAG3 renal scan	Usually Appropriate	☢☢☢
CTU without and with IV contrast	Usually Appropriate	☢☢☢☢
US color Doppler kidneys and bladder retroperitoneal	May Be Appropriate	O
MRU without IV contrast	May Be Appropriate	O
CT abdomen and pelvis with IV contrast	May Be Appropriate (Disagreement)	☢☢☢
CT abdomen and pelvis without IV contrast	May Be Appropriate	☢☢☢
DTPA renal scan	May Be Appropriate (Disagreement)	☢☢☢
US abdomen	Usually Not Appropriate	O
Fluoroscopy voiding cystourethrography	Usually Not Appropriate	☢☢
Fluoroscopy antegrade pyelography	Usually Not Appropriate	☢☢☢
Radiography abdomen and pelvis	Usually Not Appropriate	☢☢☢
Radiography intravenous urography	Usually Not Appropriate	☢☢☢
MRI abdomen and pelvis without and with IV contrast	Usually Not Appropriate	O
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	O
MRI abdomen without and with IV contrast	Usually Not Appropriate	O
MRI abdomen without IV contrast	Usually Not Appropriate	O
CT abdomen with IV contrast	Usually Not Appropriate	☢☢☢
CT abdomen without IV contrast	Usually Not Appropriate	☢☢☢
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢
CT abdomen without and with IV contrast	Usually Not Appropriate	☢☢☢☢

Variant: 2 Adult. Asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
MRU without and with IV contrast	Usually Appropriate	O
MAG3 renal scan	Usually Appropriate	☢☢☢
MRU without IV contrast	May Be Appropriate	O
CT abdomen and pelvis with IV contrast	May Be Appropriate (Disagreement)	☢☢☢
CT abdomen and pelvis without IV contrast	May Be Appropriate	☢☢☢
DTPA renal scan	May Be Appropriate (Disagreement)	☢☢☢
CTU without and with IV contrast	May Be Appropriate (Disagreement)	☢☢☢☢
US abdomen	Usually Not Appropriate	O
US color Doppler kidneys and bladder retroperitoneal	Usually Not Appropriate	O
Fluoroscopy voiding cystourethrography	Usually Not Appropriate	☢☢
Fluoroscopy antegrade pyelography	Usually Not Appropriate	☢☢☢

Radiography abdomen and pelvis	Usually Not Appropriate	☢☢☢
Radiography intravenous urography	Usually Not Appropriate	☢☢☢
MRI abdomen and pelvis without and with IV contrast	Usually Not Appropriate	O
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	O
MRI abdomen without and with IV contrast	Usually Not Appropriate	O
MRI abdomen without IV contrast	Usually Not Appropriate	O
CT abdomen with IV contrast	Usually Not Appropriate	☢☢☢
CT abdomen without IV contrast	Usually Not Appropriate	☢☢☢
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢
CT abdomen without and with IV contrast	Usually Not Appropriate	☢☢☢☢

Variant: 3 Adult. Symptomatic hydronephrosis with unknown cause. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
US color Doppler kidneys and bladder retroperitoneal	Usually Appropriate	O
MRU without and with IV contrast	Usually Appropriate	O
MAG3 renal scan	Usually Appropriate	☢☢☢
CTU without and with IV contrast	Usually Appropriate	☢☢☢☢
US abdomen	May Be Appropriate (Disagreement)	O
MRI abdomen and pelvis without and with IV contrast	May Be Appropriate	O
MRI abdomen and pelvis without IV contrast	May Be Appropriate	O
MRU without IV contrast	May Be Appropriate	O
CT abdomen and pelvis with IV contrast	May Be Appropriate	☢☢☢
CT abdomen and pelvis without IV contrast	May Be Appropriate	☢☢☢
DTPA renal scan	May Be Appropriate	☢☢☢
Fluoroscopy voiding cystourethrography	Usually Not Appropriate	☢☢
Fluoroscopy antegrade pyelography	Usually Not Appropriate	☢☢☢
Radiography abdomen and pelvis	Usually Not Appropriate	☢☢☢
Radiography intravenous urography	Usually Not Appropriate	☢☢☢
MRI abdomen without and with IV contrast	Usually Not Appropriate	O
MRI abdomen without IV contrast	Usually Not Appropriate	O
CT abdomen with IV contrast	Usually Not Appropriate	☢☢☢
CT abdomen without IV contrast	Usually Not Appropriate	☢☢☢
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢
CT abdomen without and with IV contrast	Usually Not Appropriate	☢☢☢☢

Variant: 4 Adult. Asymptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
US color Doppler kidneys and bladder retroperitoneal	Usually Appropriate	O
US abdomen	May Be Appropriate	O
MRI abdomen and pelvis without IV contrast	May Be Appropriate (Disagreement)	O
MRU without IV contrast	May Be Appropriate	O
Fluoroscopy voiding cystourethrography	Usually Not Appropriate	☢☢
Fluoroscopy antegrade pyelography	Usually Not Appropriate	☢☢☢

Radiography abdomen and pelvis	Usually Not Appropriate	☢☢☢
Radiography intravenous urography	Usually Not Appropriate	☢☢☢
MRI abdomen and pelvis without and with IV contrast	Usually Not Appropriate	O
MRI abdomen without and with IV contrast	Usually Not Appropriate	O
MRI abdomen without IV contrast	Usually Not Appropriate	O
MRU without and with IV contrast	Usually Not Appropriate	O
CT abdomen and pelvis with IV contrast	Usually Not Appropriate	☢☢☢
CT abdomen and pelvis without IV contrast	Usually Not Appropriate	☢☢☢
CT abdomen with IV contrast	Usually Not Appropriate	☢☢☢
CT abdomen without IV contrast	Usually Not Appropriate	☢☢☢
DTPA renal scan	Usually Not Appropriate	☢☢☢
MAG3 renal scan	Usually Not Appropriate	☢☢☢
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢
CT abdomen without and with IV contrast	Usually Not Appropriate	☢☢☢☢
CTU without and with IV contrast	Usually Not Appropriate	☢☢☢☢

Variant: 5 Adult. Symptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
US color Doppler kidneys and bladder retroperitoneal	Usually Appropriate	O
MRU without IV contrast	Usually Appropriate	O
US abdomen	May Be Appropriate	O
MRI abdomen and pelvis without IV contrast	May Be Appropriate	O
CT abdomen and pelvis without IV contrast	May Be Appropriate	☢☢☢
Fluoroscopy voiding cystourethrography	Usually Not Appropriate	☢☢
Fluoroscopy antegrade pyelography	Usually Not Appropriate	☢☢☢
Radiography abdomen and pelvis	Usually Not Appropriate	☢☢☢
Radiography intravenous urography	Usually Not Appropriate	☢☢☢
MRI abdomen and pelvis without and with IV contrast	Usually Not Appropriate	O
MRI abdomen without and with IV contrast	Usually Not Appropriate	O
MRI abdomen without IV contrast	Usually Not Appropriate	O
MRU without and with IV contrast	Usually Not Appropriate	O
CT abdomen and pelvis with IV contrast	Usually Not Appropriate	☢☢☢
CT abdomen with IV contrast	Usually Not Appropriate	☢☢☢
CT abdomen without IV contrast	Usually Not Appropriate	☢☢☢
DTPA renal scan	Usually Not Appropriate	☢☢☢
MAG3 renal scan	Usually Not Appropriate	☢☢☢
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢
CT abdomen without and with IV contrast	Usually Not Appropriate	☢☢☢☢
CTU without and with IV contrast	Usually Not Appropriate	☢☢☢☢

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Summary of Literature Review

Introduction/Background

Hydronephrosis is unilateral or bilateral urine-filled aseptic dilation of the renal pelvis and calyces [1], generally a response to urinary obstruction or reflux [1]. Hydronephrosis should be considered in patients with abdominal or pelvic pathology because progressive dilation of the upper urinary tract can lead to acute kidney injury and, if not corrected, permanent nephron loss [1]. It may be identified incidentally through imaging requested to investigate a nonrelated intra-abdominal symptom, or in a symptomatic patient with flank or groin pain, infection, nausea, or urinary urgency. An elevated serum creatinine may exist with obstructive hydronephrosis, although it can be normal in unilateral hydronephrosis given contralateral kidney compensation. Prompt treatment can prevent permanent renal damage [1]. Incidental detection of hydronephrosis necessitates consideration of next steps in evaluation and management. Upper urinary tract deterioration in adults can often be silent and detected incidentally or with nonspecific symptoms. Additionally, chronic non–stone-related hydronephrosis from supravesical or bladder dysfunction in adults is often detected incidentally [2].

Hydronephrosis can be classified by cause and by unilateral versus bilateral involvement. Obstructive hydronephrosis can be further classified by level of obstruction, complete versus partial obstruction, and intrinsic versus extrinsic obstruction [1]. Causes of hydronephrosis include urolithiasis, malignant obstruction, stricture, upper urinary tract infection, traumatic or ischemic injury, postradiation changes, retroperitoneal fibrosis, supravesical or bladder dysfunction, bladder outlet obstruction as with prostatic hyperplasia, mechanical compression as with enlarged uterus or pelvic organ prolapse, endometriosis, schistosomiasis, drug effects as with cyclophosphamide or ketamine, vessel-related and/or congenital ureteropelvic junction obstruction, and congenital posterior urethral valves [1-3]. Hydronephrosis also occurs frequently during pregnancy; asymptomatic hydronephrosis occurs in an estimated 70% to 90% of pregnant patients, typically asymmetrically prominent on the right, due to a combination of mechanical obstruction from an enlarged uterus and collecting system smooth muscle relaxation due to progesterone [4]. Approximately 0.2% to 4.7% of pregnant patients experience symptomatic hydronephrosis, with the prevalence higher in advancing trimesters and in multiparous patients [5-9]. Symptomatic hydronephrosis may lead to preterm labor or maternal/fetal death when left untreated [9].

Special Imaging Considerations

Scintigraphic diuresis renography (DRG) uses nuclear medicine and the administration of a diuretic to differentiate nonobstructive hydronephrosis from hydronephrosis due to true functional obstruction. Administration of a selected radiotracer such as diethylenetriamine pentaacetic acid (DTPA) or mercaptoacetyltriglycine (MAG3) is used to demonstrate flow during the perfusion, extraction, and excretion phases. Delayed planar imaging can also be performed.

CT urography (CTU) is an imaging study that is tailored to improve visualization of both the upper and lower urinary tracts. There is variability in the specific parameters, but it usually involves unenhanced images followed by intravenous (IV) contrast-enhanced images, including nephrographic and excretory phases acquired at least 5 minutes after contrast injection. Alternatively, a split-bolus technique uses an

initial loading dose of IV contrast and then obtains a combined nephrographic-excretory phase after a second IV contrast dose; some sites include arterial phase. CTU should use thin-slice acquisition. Reconstruction methods commonly include maximum intensity projection or 3-D volume rendering. For the purposes of this document, we make a distinction between CTU and CT abdomen and pelvis without and with IV contrast. CT abdomen and pelvis without and with IV contrast is defined as any protocol not specifically tailored for evaluation of the upper and lower urinary tracts and without both the precontrast and excretory phases.

MR urography (MRU) is also tailored to improve imaging of the urinary system. Unenhanced MRU relies upon heavily T2-weighted imaging of the intrinsic high signal intensity from urine for evaluation of the urinary tract. IV contrast is administered to provide additional information regarding obstruction, urothelial thickening, focal lesions, and stones. A contrast-enhanced T1-weighted series should include corticomedullary, nephrographic, and excretory phase. Thin-slice acquisition and multiplanar imaging should be obtained. For the purposes of this document, we make a distinction between MRU and MRI abdomen and pelvis without and with IV contrast. MRI abdomen and pelvis without and with IV contrast is defined as any protocol not specifically tailored for evaluation of the upper and lower urinary tracts, without both the precontrast and excretory phases, and without heavily T2-weighted images of the urinary tract.

Initial Imaging Definition

Initial imaging is defined as imaging at the beginning of the care episode for the medical condition defined by the variant. More than one procedure can be considered usually appropriate in the initial imaging evaluation when:

- There are procedures that are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care)

OR

- There are complementary procedures (ie, more than one procedure is ordered as a set or simultaneously wherein each procedure provides unique clinical information to effectively manage the patient's care).

Discussion of Procedures by Variant

Variant 1: Adult. Asymptomatic unilateral hydronephrosis with unknown cause. Initial imaging.

Please note that this variant describes initial imaging evaluation after the discovery, by imaging or otherwise, of asymptomatic unilateral hydronephrosis with unknown cause. The choice of initial imaging in this situation is dependent on clinical context and on the information available from the means of hydronephrosis discovery (eg, CT, MR, ultrasound [US]).

Variant 1: Adult. Asymptomatic unilateral hydronephrosis with unknown cause. Initial imaging.

A. CT abdomen and pelvis with IV contrast

Although there is limited evidence to support the use of CT abdomen and pelvis with IV contrast (separate from CTU) for initial imaging of patients with asymptomatic unilateral hydronephrosis with unknown

cause, it may be useful in this setting in some clinical situations. A more comprehensive evaluation can often be achieved with CT, MRU, or renal scintigraphy.

Variant 1: Adult. Asymptomatic unilateral hydronephrosis with unknown cause. Initial imaging.
B. CT abdomen and pelvis without and with IV contrast

There is limited evidence to support the use of CT abdomen and pelvis without and with IV contrast (separate from CTU) for initial imaging of patients with asymptomatic unilateral hydronephrosis with unknown cause, and more comprehensive evaluation with CT, MRU, or renal scintigraphy is preferred.

Variant 1: Adult. Asymptomatic unilateral hydronephrosis with unknown cause. Initial imaging.
C. CT abdomen and pelvis without IV contrast

Although there is limited evidence to support the use of CT abdomen and pelvis without IV contrast (separate from CTU) for initial imaging of patients with asymptomatic unilateral hydronephrosis with unknown cause, it may be useful in this setting for some clinical situations. A more comprehensive evaluation can often be achieved with CT, MRU, or renal scintigraphy. CT abdomen and pelvis without IV contrast is particularly useful when obstructive urolithiasis is a primary concern.

Variant 1: Adult. Asymptomatic unilateral hydronephrosis with unknown cause. Initial imaging.
D. CT abdomen with IV contrast

There is limited evidence to support the use of CT abdomen with IV contrast for initial imaging (separate from CTU) of patients with asymptomatic unilateral hydronephrosis with unknown cause.

Variant 1: Adult. Asymptomatic unilateral hydronephrosis with unknown cause. Initial imaging.
E. CT abdomen without and with IV contrast

There is limited evidence to support the use of CT abdomen without and with IV contrast (separate from CTU) for initial imaging of patients with asymptomatic unilateral hydronephrosis with unknown cause.

Variant 1: Adult. Asymptomatic unilateral hydronephrosis with unknown cause. Initial imaging.
F. CT abdomen without IV contrast

There is limited evidence to support the use of CT abdomen without IV contrast (separate from CTU) for initial imaging of patients with asymptomatic unilateral hydronephrosis with unknown cause.

Variant 1: Adult. Asymptomatic unilateral hydronephrosis with unknown cause. Initial imaging.
G. CTU without and with IV contrast

Although there is limited evidence to support the use of CTU without and with IV contrast for initial imaging of patients with asymptomatic unilateral hydronephrosis with unknown cause, CTU is useful for investigating the etiology of hydronephrosis. CTU provides a near-comprehensive evaluation of the genitourinary tract including both morphological and functional information.

Variant 1: Adult. Asymptomatic unilateral hydronephrosis with unknown cause. Initial imaging.
H. DTPA renal scan

DRG is the de facto standard of care in diagnosis of renal obstruction [10] and can be used to determine

whether obstructive uropathy is truly present in cases of incidentally noted hydronephrosis [11]. However, tubular tracers (eg, MAG3 and ^{123}I) are much more efficiently extracted by the kidney than DTPA, and washout is therefore easier to evaluate with tubular tracers. Use of DTPA for diuretic renography may result in an equivocal or false-positive diuretic study compared with MAG3, particularly in patients with reduced function, and is not favored for imaging only studies [11,12]. DRG with DTPA is useful for estimating single-kidney glomerular filtration rate (GFR), although it may somewhat overestimate global GFR in the setting of obstructive hydronephrosis [13].

Variant 1: Adult. Asymptomatic unilateral hydronephrosis with unknown cause. Initial imaging.
I. Fluoroscopy antegrade pyelography

There is limited evidence to support the use of fluoroscopic antegrade pyelography for initial imaging of patients with asymptomatic unilateral hydronephrosis with unknown cause.

Variant 1: Adult. Asymptomatic unilateral hydronephrosis with unknown cause. Initial imaging.
J. Fluoroscopy voiding cystourethrography

There is limited evidence to support the use of fluoroscopic voiding cystourethrography for initial imaging of patients with asymptomatic unilateral hydronephrosis with unknown cause.

Variant 1: Adult. Asymptomatic unilateral hydronephrosis with unknown cause. Initial imaging.
K. MAG3 renal scan

DRG is the de facto standard of care in diagnosis of renal obstruction [10] and can be used to determine whether obstructive uropathy is truly present in cases of incidentally noted hydronephrosis [11]. Tubular tracers (eg, MAG3 and ^{123}I) are much more efficiently extracted by the kidney than DTPA, and washout is therefore easier to evaluate with tubular tracers. Tubular tracers such as MAG3 are favored over the use of DTPA for imaging only studies, because DTPA diuretic renography may result in an equivocal or false-positive diuretic study compared with MAG3, particularly in patients with reduced function [11,12].

Variant 1: Adult. Asymptomatic unilateral hydronephrosis with unknown cause. Initial imaging.
L. MRI abdomen and pelvis without and with IV contrast

Although there is limited evidence to support the use of MRI abdomen and pelvis without and with IV contrast (separate from MRU) for initial imaging of patients with asymptomatic unilateral hydronephrosis with unknown cause, it may be useful in this setting in some clinical situations. A more comprehensive evaluation can often be achieved with CT, MRU, or renal scintigraphy.

Variant 1: Adult. Asymptomatic unilateral hydronephrosis with unknown cause. Initial imaging.
M. MRI abdomen and pelvis without IV contrast

There is limited evidence to support the use of MRI abdomen and pelvis without IV contrast (separate from MRU) for initial imaging of patients with asymptomatic unilateral hydronephrosis with unknown cause.

Variant 1: Adult. Asymptomatic unilateral hydronephrosis with unknown cause. Initial imaging.
N. MRI abdomen without and with IV contrast

There is limited evidence to support the use of MRI abdomen without and with IV contrast (separate from MRU) for initial imaging of patients with asymptomatic unilateral hydronephrosis with unknown cause.

Variant 1: Adult. Asymptomatic unilateral hydronephrosis with unknown cause. Initial imaging.
O. MRI abdomen without IV contrast

There is limited evidence to support the use of MRI abdomen without IV contrast (separate from MRU) for initial imaging of patients with asymptomatic unilateral hydronephrosis with unknown cause.

Variant 1: Adult. Asymptomatic unilateral hydronephrosis with unknown cause. Initial imaging.
P. MRU without and with IV contrast

There is some evidence for use of MRU without and with IV contrast for initial imaging of patients with asymptomatic unilateral hydronephrosis with unknown cause. Although it can be performed independently, MRU can also be performed at the time of structural MRI. MRU without and with IV contrast is useful for investigating the etiology of hydronephrosis and, in combination with anatomical imaging, can provide a near-comprehensive evaluation of the genitourinary tract including both morphological and functional information.

In a prospective study, Claudon et al [14] compared MRU without and with IV contrast with MAG3 or DTPA DRG in 295 adult and pediatric patients with hydronephrosis and clinical suspicion for chronic or intermittent obstruction, including both symptomatic and asymptomatic patients and excluding those with acute urinary obstruction or solitary or transplant kidney. They reported equivalence of MRU with renal scintigraphy for diagnostic evaluation of split renal function in moderately dilated kidneys, with a standard deviation of approximately 12% between the two; for severely dilated kidneys, they note a mean underestimation by MRU of split renal function by 4%. They conclude that substitution of DRG by MRU is acceptable for moderately dilated kidneys but remains questionable for severely dilated kidneys. Notably, most of the included patients were children <2 years of age, and the MRU technique used included a diuretic component.

In a prospective study of 13 people without and 15 people with hydronephrosis, Wang et al [13] reported significant correlation between MRU and DRG estimations of single-kidney GFR and that MRU is comparable to DRG for estimation of GFR in the setting of hydronephrosis. They note that both MRU and DRG may somewhat overestimate global GFR in the setting of obstructive hydronephrosis.

Variant 1: Adult. Asymptomatic unilateral hydronephrosis with unknown cause. Initial imaging.
Q. MRU without IV contrast

Although there is limited evidence to support the use of MRU without IV contrast for initial imaging of patients with asymptomatic unilateral hydronephrosis with unknown cause, MRU without IV contrast is, in general, preferred over CTU in patients with renal impairment [15]. MRU without IV contrast is useful for investigating the etiology of hydronephrosis and can be combined with anatomical imaging to provide more information than anatomical imaging alone but does not provide the level of functional imaging attainable with MRU without and with IV contrast.

Variant 1: Adult. Asymptomatic unilateral hydronephrosis with unknown cause. Initial imaging.
R. Radiography abdomen and pelvis

There is limited evidence to support the use of radiography of the abdomen and pelvis for initial imaging of patients with asymptomatic unilateral hydronephrosis with unknown cause. Radiography of the abdomen and pelvis is not useful in this setting, and CT is more sensitive for obstructive urolithiasis.

Variant 1: Adult. Asymptomatic unilateral hydronephrosis with unknown cause. Initial imaging.

S. Radiography intravenous urography

There is limited evidence to support the use of radiography with IV urography (IVU) (also referred to as IV pyelogram [IVP]) for initial imaging of patients with asymptomatic unilateral hydronephrosis with unknown cause.

Variant 1: Adult. Asymptomatic unilateral hydronephrosis with unknown cause. Initial imaging.

T. US abdomen

There is relatively limited evidence to support the use of US of the abdomen for initial imaging of patients with asymptomatic unilateral hydronephrosis with unknown cause. Although US allows evaluation for increased renal echogenicity, which is nonspecific, but can be helpful in assessing for chronic kidney disease, US abdomen is a less comprehensive examination of the genitourinary system than CT or MRU, renal scintigraphy, or US color Doppler kidneys and bladder retroperitoneal.

Variant 1: Adult. Asymptomatic unilateral hydronephrosis with unknown cause. Initial imaging.

U. US color Doppler kidneys and bladder retroperitoneal

Although there is limited evidence to support the use of US of the abdomen for initial imaging of patients with asymptomatic unilateral hydronephrosis with unknown cause, it may be useful in this setting in some clinical situations. Although renal US can identify and grade hydronephrosis, it is less useful for identification of etiology. US does allow evaluation for increased renal echogenicity, which, although nonspecific, can be helpful in assessing for chronic kidney disease. Additionally, US color Doppler kidneys and bladder retroperitoneal allows evaluation of ureteral jets, bladder distension, and postvoid residual bladder volume and can allow measurement of the prostate to evaluate for prostatomegaly. Unilateral elevation of resistive indices is nonspecific but can be seen in the setting of obstruction. However, more comprehensive evaluation can often be achieved with CT, MRU, or renal scintigraphy.

Variant 2: Adult. Asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause. Initial imaging.

Please note that this variant describes initial imaging evaluation after the discovery, by imaging or otherwise, of asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause. The choice of initial imaging in this situation is dependent on clinical context and on the information available from the means of hydronephrosis discovery (eg, CT, MR, US).

Variant 2: Adult. Asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause. Initial imaging.

A. CT abdomen and pelvis with IV contrast

Although there is limited evidence to support the use of CT abdomen and pelvis with IV contrast (separate from CTU) for initial imaging of patients with asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause, it may be useful in this setting in some clinical situations. The addition of IV contrast is helpful in assessment for pelvic masses as a cause of bilateral hydronephrosis. More comprehensive evaluation can often be achieved with CT, MRU, or renal scintigraphy.

Variant 2: Adult. Asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause. Initial imaging.

B. CT abdomen and pelvis without and with IV contrast

There is limited evidence to support the use of CT abdomen and pelvis without and with IV contrast (separate from CTU) for initial imaging of patients with asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause, and more comprehensive evaluation with CT, MRU, or renal scintigraphy is preferred.

Variant 2: Adult. Asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause. Initial imaging.
C. CT abdomen and pelvis without IV contrast

Although there is limited evidence to support the use of CT abdomen and pelvis without IV contrast (separate from CTU) for initial imaging of patients with asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause, it may be useful in the setting of some clinical situations. A more comprehensive evaluation can often be achieved with CT, MRU, or renal scintigraphy. CT abdomen and pelvis without IV contrast is particularly useful when obstructive urolithiasis is a primary concern, although this etiology is less likely in the setting of bilateral hydronephrosis.

Variant 2: Adult. Asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause. Initial imaging.
D. CT abdomen with IV contrast

There is limited evidence to support the use of CT abdomen with IV contrast (separate from CTU) for initial imaging of patients with asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause.

Variant 2: Adult. Asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause. Initial imaging.
E. CT abdomen without and with IV contrast

There is limited evidence to support the use of CT abdomen without and with IV contrast (separate from CTU) for initial imaging of patients with asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause.

Variant 2: Adult. Asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause. Initial imaging.
F. CT abdomen without IV contrast

There is limited evidence to support the use of CT abdomen without IV contrast (separate from CTU) for initial imaging of patients with asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause.

Variant 2: Adult. Asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause. Initial imaging.
G. CTU without and with IV contrast

Although there is limited evidence to support the use of CTU without and with IV contrast for initial imaging of patients with asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause, CTU is useful for investigating the etiology of hydronephrosis. CTU provides a near-comprehensive evaluation of the genitourinary tract including both morphological and functional information.

Variant 2: Adult. Asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause. Initial imaging.
H. DTPA renal scan

DRG is the de facto standard of care in diagnosis of renal obstruction [10] and can be used to determine

whether obstructive uropathy is truly present in cases of incidentally noted hydronephrosis [11]. However, tubular tracers (eg, MAG3 and ^{123}I) are much more efficiently extracted by the kidney than DTPA, and washout is therefore easier to evaluate with tubular tracers. Use of DTPA for diuretic renography may result in an equivocal or false-positive diuretic study compared with MAG3, particularly in patients with reduced function, and is not favored for imaging only studies [11,12]. DRG with DTPA is useful for estimating single-kidney GFR, although it may somewhat overestimate global GFR in the setting of obstructive hydronephrosis [13].

Variant 2: Adult. Asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause. Initial imaging.
I. Fluoroscopy antegrade pyelography

There is limited evidence to support the use of fluoroscopic antegrade pyelography for initial imaging of patients with asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause.

Variant 2: Adult. Asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause. Initial imaging.
J. Fluoroscopy voiding cystourethrography

There is limited evidence to support the use of fluoroscopic voiding cystourethrography for initial imaging of patients with asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause.

Variant 2: Adult. Asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause. Initial imaging.
K. MAG3 renal scan

DRG is the de facto standard of care in diagnosis of renal obstruction [10] and can be used to determine whether obstructive uropathy is truly present in cases of incidentally noted hydronephrosis or in suspected obstruction of renal transplant [11]. Further, DRG with urethral catheter has been suggested for patients with bilateral hydronephrosis or hydroureteronephrosis with postvoid residual <150 mL to help differentiate potential etiologies [2]. Tubular tracers (eg, MAG3 and ^{123}I) are much more efficiently extracted by the kidney than DTPA, and washout is therefore easier to evaluate with tubular tracers. Tubular tracers such as MAG3 are favored over the use of DTPA for imaging only studies, because DTPA DRG may result in an equivocal or false-positive diuretic study compared with MAG3, particularly in patients with reduced function [11,12].

Variant 2: Adult. Asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause. Initial imaging.
L. MRI abdomen and pelvis without and with IV contrast

Although there is limited evidence to support the use of MRI abdomen and pelvis without and with IV contrast (separate from MRU) for initial imaging of patients with asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause, it may be useful in this setting in some clinical situations. More comprehensive evaluation can often be achieved with CT, MRU, or renal scintigraphy.

Variant 2: Adult. Asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause. Initial imaging.
M. MRI abdomen and pelvis without IV contrast

There is limited evidence to support the use of MRI abdomen and pelvis without IV contrast (separate from

MRU) for initial imaging of patients with asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause.

Variant 2: Adult. Asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause. Initial imaging.
N. MRI abdomen without and with IV contrast

There is limited evidence to support the use of MRI abdomen without and with IV contrast (separate from MRU) for initial imaging of patients with asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause.

Variant 2: Adult. Asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause. Initial imaging.
O. MRI abdomen without IV contrast

There is limited evidence to support the use of MRI abdomen without IV contrast (separate from MRU) for initial imaging of patients with asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause.

Variant 2: Adult. Asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause. Initial imaging.
P. MRU without and with IV contrast

There is some evidence for use of MRU without and with IV contrast for initial imaging of patients with asymptomatic unilateral hydronephrosis with unknown cause. Although it can be performed independently, MRU can also be performed at the time of structural MRI. MRU without and with IV contrast is useful for investigating the etiology of hydronephrosis and in combination with anatomical imaging can provide a near-comprehensive evaluation of the genitourinary tract including both morphological and functional information.

In a prospective study, Claudon et al [14] compared MRU without and with IV contrast with MAG3 or DTPA DRG in 295 adult and pediatric patients with hydronephrosis and clinical suspicion for chronic or intermittent obstruction, including both symptomatic and asymptomatic patients and excluding those with acute urinary obstruction or solitary or transplant kidney. They reported equivalence of MRU with renal scintigraphy for diagnostic evaluation of split renal function in moderately dilated kidneys, with a standard deviation of approximately 12% between the two; for severely dilated kidneys, they note a mean underestimation by MRU of split renal function by 4%. They conclude that substitution of DRG by MRU is acceptable for moderately dilated kidneys but remains questionable for severely dilated kidneys. Notably, most of the included patients were children <2 years of age, and the MRU technique used included a diuretic component.

In a prospective study of 13 people without and 15 people with hydronephrosis, Wang et al [13] reported significant correlation between MRU and DRG estimations of single-kidney GFR and that MRU is comparable to DRG for estimation of GFR in the setting of hydronephrosis. They note that both MRU and DRG may somewhat overestimate global GFR in the setting of obstructive hydronephrosis.

Variant 2: Adult. Asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause. Initial imaging.
Q. MRU without IV contrast

Although there is limited evidence to support the use of MRU without IV contrast for initial imaging of patients with asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney

with unknown cause, MRU without IV contrast is, in general, preferred over CTU in patients with renal impairment [15]. MRU without IV contrast is useful for investigating the etiology of hydronephrosis and can be combined with anatomical imaging to provide more information than anatomical imaging alone but does not provide the level of functional imaging attainable with MRU without and with IV contrast.

Variant 2: Adult. Asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause. Initial imaging.
R. Radiography abdomen and pelvis

There is limited evidence to support the use of radiography of the abdomen and pelvis for initial imaging of patients with asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause. Radiography of the abdomen and pelvis is not considered useful in this setting.

Variant 2: Adult. Asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause. Initial imaging.
S. Radiography intravenous urography

There is limited evidence to support the use of radiography with IVU (also referred to as IVP) for initial imaging of patients with asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause.

Variant 2: Adult. Asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause. Initial imaging.
T. US abdomen

There is relatively limited evidence to support the use of US of the abdomen for initial imaging of patients with asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause. Although US allows evaluation for increased renal echogenicity, which is nonspecific, but can be helpful in assessing for chronic kidney disease, US abdomen is a less comprehensive examination of the genitourinary system than CT, MRU, renal scintigraphy, or US color Doppler kidneys and bladder retroperitoneal.

Variant 2: Adult. Asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause. Initial imaging.
U. US color Doppler kidneys and bladder retroperitoneal

Although there is limited evidence to support the use of US of the abdomen for initial imaging of patients with asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause, it may be useful in this setting in some clinical situations. Although renal US can identify and grade hydronephrosis, it is less useful for identification of etiology. US does allow evaluation for increased renal echogenicity, which, although nonspecific, can be helpful in assessing for chronic kidney disease. Additionally, US Color Doppler kidneys and bladder retroperitoneal allows evaluation of ureteral jets, bladder distension, and postvoid residual bladder volume and can allow measurement of the prostate to evaluate for prostatomegaly. Elevation of resistive indices is nonspecific but can be seen in the setting of obstruction. However, more comprehensive evaluation can often be achieved with CT, MRU, or renal scintigraphy.

Variant 3: Adult. Symptomatic hydronephrosis with unknown cause. Initial imaging.

Please note that this variant describes initial imaging evaluation after the discovery, by imaging or otherwise, of symptomatic hydronephrosis with unknown cause. The choice of initial imaging in this situation is dependent on clinical context and on the information available from the means of hydronephrosis discovery (eg, CT, MR, US).

Variant 3: Adult. Symptomatic hydronephrosis with unknown cause. Initial imaging. A. CT abdomen and pelvis with IV contrast

Although there is relatively limited evidence to support the use of CT abdomen and pelvis with IV contrast (separate from CTU) for initial imaging of patients with symptomatic hydronephrosis with unknown cause, it may be useful in this setting in some clinical situations. A more comprehensive evaluation can often be achieved with CT, MRU, or renal scintigraphy. CT can be useful in patients with renal colic and moderate to severe hydronephrosis by US, because these patients can be at higher risk of stone passage failure [16], although some authors suggest CT should be reserved in renal colic patients for when US is nondiagnostic or when an alternative diagnosis is suspected [17]. In cases of suspected infection, it can be difficult to distinguish pyonephrosis from hydronephrosis even by CT, although collecting system content density may be helpful [18,19]; notably recent contrast administration can also affect this density. CT abdomen and pelvis with IV contrast can also be useful in the setting of flank pain in general. In a study of 350 patients with flank pain, 15% of those with negative urinalysis and without a history of urolithiasis had diagnoses best characterized by CT abdomen and pelvis with IV contrast; notably these patients did not have known hydronephrosis on prior imaging [20]. However, a prospective observational study on 93 patients with renal colic found that CT did not change management when the patient's provider did not expect it would; notably, 49 of 50 patients with symptomatic stone(s) had some degree of hydronephrosis [21].

Pathan et al [22] reviewed 651 patients with point-of-care US (POCUS) and CT in the setting of renal colic, finding that moderate to severe hydronephrosis on POCUS examination in patients with moderate or high risk of ureteric calculi, provided a more definitive answer regarding the presence of a stone without the need for high-dose CT scanning. In such patients, they advised a low-dose CT scan if the size and location of the stone is desired to plan surgical management.

Variant 3: Adult. Symptomatic hydronephrosis with unknown cause. Initial imaging. B. CT abdomen and pelvis without and with IV contrast

There is relatively limited evidence to support the use of CT abdomen and pelvis without and with IV contrast (separate from CTU) for initial imaging of patients with symptomatic hydronephrosis with unknown cause, and more comprehensive evaluation with CT, MRU, or renal scintigraphy is preferred. CT can be useful in patients with renal colic and moderate to severe hydronephrosis by US, because these patients can be at higher risk of stone passage failure [16], although some authors suggest CT should be reserved in renal colic patients for when US is nondiagnostic or when an alternative diagnosis is suspected [17]. In cases of suspected infection, it can be difficult to distinguish pyonephrosis from hydronephrosis even by CT, although collecting system content density may be helpful [18,19]; notably recent contrast administration can also affect this density. CT abdomen and pelvis without and with IV contrast may also be useful in the setting of flank pain in general. In a study of 350 patients with flank pain, 15% of those with negative urinalysis and without a history of urolithiasis had diagnoses best characterized by CT abdomen and pelvis with IV contrast; notably these patients did not have known hydronephrosis on prior imaging [20]. In a study of 835 symptomatic patients who underwent POCUS prior to CT of the abdomen and pelvis without IV contrast, there were 54 acutely important alternate findings identified on CT, including 8.3%, 9.0%, and 1.8% of patients in the clinically low, moderate, and high risk groups for calculus, respectively. Notably, the presence of hydronephrosis (as identified on POCUS) reduced the risk of alternate diagnosis being identified (odds ratio [OR] 0.31; 95% confidence interval [CI], 0.16-0.60) [23]. However, a prospective observational study on 93 patients with renal colic found that CT did not change management when the patient's provider did not expect it would; notably, 49 of 50 patients with symptomatic stone(s) had some degree of hydronephrosis [21].

Pathan et al [22] reviewed 651 patients with POCUS and CT in the setting of renal colic, finding that moderate to severe hydronephrosis on POCUS examination in patients with moderate or high risk of ureteric calculi, provided a more definitive answer regarding the presence of a stone without the need for high-dose CT scanning. In such patients, they advised a low-dose CT scan if the size and location of the stone is desired to plan surgical management.

Variant 3: Adult. Symptomatic hydronephrosis with unknown cause. Initial imaging. C. CT abdomen and pelvis without IV contrast

Although there is some evidence to support the use of CT abdomen and pelvis without IV contrast (separate from CTU) for initial imaging of patients with symptomatic hydronephrosis with unknown cause, it may be useful in this setting in some clinical situations. A more comprehensive evaluation can often be achieved with CT, MRU, or renal scintigraphy. In particular, this procedure is suitable for evaluating symptomatic patients when US is inconclusive [24]. CT abdomen and pelvis without IV contrast is particularly useful when obstructive urolithiasis is a primary concern.

CT can be useful in patients with renal colic and moderate to severe hydronephrosis by US, because these patients can be at higher risk of stone passage failure [16], although some authors suggest CT should be reserved in renal colic patients for when US is nondiagnostic or when an alternative diagnosis is suspected [17]. In cases of suspected infection, it can be difficult to distinguish pyonephrosis from hydronephrosis even by CT, although collecting system content density may be helpful [18,19]; notably, recent contrast administration can also affect this density.

Hydronephrosis can help predict likelihood of ureteral stone on subsequent CT. A study of 166 patients with a diagnosis of renal colic undergoing noncontrast CT found that any degree of hydronephrosis noted on emergency physician US makes the presence of a ureteral stone on CT more likely (positive predicative value [PPV] 88%, likelihood ratio [LR] +2.91), but a lack of hydronephrosis did not rule out the diagnosis (negative predicative value [NPV] 65%, LR −0.22), although 39 (13%) participants had a nonurolithiasis diagnostic finding on CT, including 21 (7%) who required additional management [25]. In a retrospective study of 666 patients with CT for renal colic, CT hydronephrosis had sensitivity 88.0% (84.2-91.1), specificity 85.0% (80.9-88.5), PPV 85.7% (82.4-88.5), and NPV 87.4% (84.0-90.2) for predicting ureteric and obstructing renal pelvic calculi on CT; the authors also noted NPV for combined lack of hydronephrosis and lack of hematuria was 96.4% for ureteral stone [26]. Notably, in a retrospective study of 80 patients with obstructive urolithiasis, Lotan et al [27] explored the correlation between specific noncontrast CT findings and the choice of conservative versus interventional management and found no significant difference in grade of hydronephrosis between the groups but note that hydronephrosis could be useful as a supportive finding.

Pathan et al [22] reviewed 651 patients with POCUS and CT in the setting of renal colic, finding that moderate to severe hydronephrosis on POCUS examination in patients with moderate or high risk of ureteric calculi provided a more definitive answer regarding the presence of a stone without the need for high-dose CT scanning. In such patients, they advised a low-dose CT scan if the size and location of the stone is desired to plan surgical management.

CT abdomen and pelvis without IV contrast can also be useful in the setting of flank pain in general. In a study of 835 symptomatic patients who underwent POCUS prior to CT of the abdomen and pelvis without IV contrast, there were 54 acutely important alternate findings identified on CT, including 8.3%, 9.0%, and 1.8% of patients in the clinically low, moderate, and high risk groups for calculus, respectively. Notably, the

presence of hydronephrosis (as identified on POCUS) reduced the risk of alternate diagnosis being identified (OR 0.31; 95% CI, 0.16-0.60) [23]. However, a prospective observational study on 93 patients with renal colic found that CT did not change management when the patient's provider did not expect it would; notably, 49 of 50 patients with symptomatic stone(s) had some degree of hydronephrosis [21].

Variant 3: Adult. Symptomatic hydronephrosis with unknown cause. Initial imaging. D. CT abdomen with IV contrast

There is limited evidence to support the use of CT abdomen with IV contrast (separate from CTU) for initial imaging of patients with symptomatic hydronephrosis with unknown cause.

Variant 3: Adult. Symptomatic hydronephrosis with unknown cause. Initial imaging. E. CT abdomen without and with IV contrast

There is limited evidence to support the use of CT abdomen without and with IV contrast (separate from CTU) for initial imaging of patients with symptomatic hydronephrosis with unknown cause.

Variant 3: Adult. Symptomatic hydronephrosis with unknown cause. Initial imaging. F. CT abdomen without IV contrast

There is limited evidence to support the use of CT abdomen without IV contrast (separate from CTU) for initial imaging of patients with symptomatic hydronephrosis with unknown cause.

Variant 3: Adult. Symptomatic hydronephrosis with unknown cause. Initial imaging. G. CTU without and with IV contrast

Although there is relatively limited evidence to support the use of CTU without and with IV contrast for initial imaging of patients with symptomatic hydronephrosis with unknown cause, CTU is useful for investigating the etiology of hydronephrosis. CTU provides a near-comprehensive evaluation of the genitourinary tract including both morphological and functional information. In a prospective study evaluating 70 patients with renal colic or hematuria, CTU was performed after hydronephrosis was confirmed with US and was able to detect 100% of renal calculi but was less sensitive in detection of other causes of obstruction [28].

Variant 3: Adult. Symptomatic hydronephrosis with unknown cause. Initial imaging. H. DTPA renal scan

DRG is the de facto standard of care in diagnosis of renal obstruction [10] and can be used to determine whether obstructive uropathy is truly present in cases of incidentally noted hydronephrosis [11]. However, tubular tracers (eg, MAG3 and ^{123}I) are much more efficiently extracted by the kidney than DTPA, and washout is therefore easier to evaluate with tubular tracers. Use of DTPA for diuretic renography may result in an equivocal or false-positive diuretic study compared with MAG3, particularly in patients with reduced function, and is not favored for imaging only studies [11,12]. DRG with DTPA is useful for estimating single-kidney GFR, although it may somewhat overestimate global GFR in the setting of obstructive hydronephrosis [13].

Variant 3: Adult. Symptomatic hydronephrosis with unknown cause. Initial imaging. I. Fluoroscopy antegrade pyelography

There is limited evidence to support the use of fluoroscopic antegrade pyelography for initial imaging of patients with symptomatic hydronephrosis with unknown cause.

Variant 3: Adult. Symptomatic hydronephrosis with unknown cause. Initial imaging. J. Fluoroscopy voiding cystourethrography

There is limited evidence to support the use of fluoroscopic voiding cystourethrography for initial imaging

of patients with symptomatic hydronephrosis with unknown cause.

Variant 3: Adult. Symptomatic hydronephrosis with unknown cause. Initial imaging. K. MAG3 renal scan

DRG is the de facto standard of care in diagnosis of renal obstruction [10] and can be used to determine whether obstructive uropathy is truly present in cases of incidentally noted hydronephrosis or in suspected obstruction of renal transplant [11]. Further, DRG with urethral catheter has been suggested for patients with bilateral hydronephrosis or hydroureteronephrosis with postvoid residual <150 mL to help differentiate potential etiologies [2]. Tubular tracers (eg, MAG3 and ^{123}I) are much more efficiently extracted by the kidney than DTPA, and washout is therefore easier to evaluate with tubular tracers. Tubular tracers such as MAG3 are favored over the use of DTPA for imaging only studies, because DTPA DRG may result in an equivocal or false-positive diuretic study compared with MAG3, particularly in patients with reduced function [11,12].

Variant 3: Adult. Symptomatic hydronephrosis with unknown cause. Initial imaging. L. MRI abdomen and pelvis without and with IV contrast

Although there is limited evidence to support the use of MRI abdomen and pelvis without and with IV contrast (separate from MRU) for initial imaging of patients with symptomatic hydronephrosis with unknown cause, it may be useful in this setting in some clinical situations. A more comprehensive evaluation can often be achieved with CT, MRU, or renal scintigraphy.

Variant 3: Adult. Symptomatic hydronephrosis with unknown cause. Initial imaging. M. MRI abdomen and pelvis without IV contrast

Although there is limited evidence to support the use of MRI abdomen and pelvis without IV contrast (separate from MRU) for initial imaging of patients with symptomatic hydronephrosis with unknown cause, it may be useful in this setting in some clinical situations. More comprehensive evaluation can often be achieved with CT, MRU, or renal scintigraphy.

Variant 3: Adult. Symptomatic hydronephrosis with unknown cause. Initial imaging. N. MRI abdomen without and with IV contrast

There is limited evidence to support the use of MRI abdomen without and with IV contrast (separate from MRU) for initial imaging of patients with symptomatic hydronephrosis with unknown cause.

Variant 3: Adult. Symptomatic hydronephrosis with unknown cause. Initial imaging. O. MRI abdomen without IV contrast

There is limited evidence to support the use of MRI abdomen without IV contrast (separate from MRU) for initial imaging of patients with symptomatic hydronephrosis with unknown cause.

Variant 3: Adult. Symptomatic hydronephrosis with unknown cause. Initial imaging. P. MRU without and with IV contrast

There is some evidence for use of MRU without and with IV contrast for initial imaging of patients with symptomatic hydronephrosis with unknown cause. Although it can be performed independently, MRU can also be performed at the time of structural MRI. MRU without and with IV contrast is useful for investigating the etiology of hydronephrosis and in combination with anatomical imaging can provide a near-comprehensive evaluation of the genitourinary tract including both morphological and functional information.

Multiple studies report similar findings between MRU and DRG for diagnostic evaluation of hydronephrosis. In a prospective study, Claudon et al [14] compared MRU without and with IV contrast

with MAG3 or DTPA DRG in 295 adult and pediatric patients with hydronephrosis and clinical suspicion for chronic or intermittent obstruction, including both symptomatic and asymptomatic patients and excluding those with acute urinary obstruction or solitary or transplant kidney. They reported equivalence of MRU with renal scintigraphy for diagnostic evaluation of split renal function in moderately dilated kidneys, with a standard deviation of approximately 12% between the two; for severely dilated kidneys, they note a mean underestimation by MRU of split renal function by 4%. They conclude that substitution of DRG by MRU is acceptable for moderately dilated kidneys but remains questionable for severely dilated kidneys. Notably, most of the included patients were children <2 years of age, and the MRU technique used included a diuretic component.

In a prospective study of 13 people without and 15 people with hydronephrosis, Wang et al [13] reported significant correlation between MRU and DRG estimations of single-kidney GFR and that MRU is comparable to DRG for estimation of GFR in the setting of hydronephrosis. They note that both MRU and DRG may somewhat overestimate global GFR in the setting of obstructive hydronephrosis.

MRU can be used in complex situations in which US and multidetector CT fail to explain the patient's symptoms [17]. In a study evaluating symptomatic patients, MRU with and without IV contrast was performed after hydronephrosis was confirmed with US and detected 100% of cases of noncalculus related obstruction but only detected 78.9% of obstructive calculi [28]. MRU combined with structural imaging can also demonstrate complications in the setting of renal colic, such as pyelonephritis [29].

Variant 3: Adult. Symptomatic hydronephrosis with unknown cause. Initial imaging. Q. MRU without IV contrast

There is some evidence for use of MRU without IV contrast for initial imaging of patients with symptomatic hydronephrosis with unknown cause. Although it can be performed independently, MRU can also be performed at the time of structural MRI. MRU without IV contrast is useful for investigating the etiology of hydronephrosis and can be combined with anatomical imaging to provide more information than anatomical imaging alone but does not provide the level of functional imaging attainable with MRU without and with IV contrast.

MRU without IV contrast is, in general, preferred over CTU in patients with renal impairment [15]. MRU can be used in complex situations in which US and CT fail to explain the patient's symptoms [17]. MRU combined with structural imaging can also demonstrate complications in the setting of renal colic, such as pyelonephritis [29].

In a prospective study of 55 patients with hydronephrosis detected on US for urologic symptoms, excluding patients with abnormal renal function given contraindication for IVU, Muthusami et al [30] compared static heavily T2-weighted MRU to reference IVU and determined that MRU had high sensitivity and specificity for detecting (95% and 100%, respectively) and grading (Spearman correlation coefficient 0.92) hydronephrosis, as well as identifying the location of obstruction (90% and 99%, respectively) if present. The authors conclude that static MRU can replace IVU when the latter is contraindicated or technically difficult. The authors note that MRU sensitivity for hydronephrosis grading increased with grade of obstruction.

MRU can be useful in patients with renal colic and concern for obstruction. Semins et al [31], in a prospective study of 22 patients with renal colic, concluded that noncontrast half-Fourier acquisition single-shot turbo spin-echo MRU can reliably detect presence of upper tract obstruction using visualization

of a stone and secondary signs of obstruction; using CT as the reference standard, the combination of stone or perinephric fluid and ureteral dilation gave MRU a sensitivity of 84 %, specificity of 100 %, and accuracy of 86 % (95 % CI 0.72-1.0).

Variant 3: Adult. Symptomatic hydronephrosis with unknown cause. Initial imaging. R. Radiography abdomen and pelvis

There is relatively limited evidence to support the use of radiography of the abdomen and pelvis for initial imaging of patients with symptomatic hydronephrosis with unknown cause. CT is more sensitive for obstructive urolithiasis.

Innes et al [32] performed a retrospective multicenter observational cohort study of 1,026 patients with renal colic, finding that adding radiography to screening for hydronephrosis (in this study, by CT) increased sensitivity in all stone categories, specifically from 39% to 68% for large stones and from 60% to 82% for interventional stones. They conclude that this level of sensitivity may be sufficient to reassure physicians about a renal colic diagnosis in the setting of known hydronephrosis without CT imaging for many patients.

In a retrospective study of 939 patients with renal colic, Abdel-Gawad et al [33] reported that KUB had limited sensitivity of 53% to 62% and specificity of 67% to 69% for the detection of ureteral calculi. Notably, 90% of stones are radio-opaque, consisting of calcium oxalate, calcium phosphate, and struvite. Although KUB may be comparatively insensitive for stones <4 mm and those in the mid and distal ureters, its use may improve stone detection rates at the margins where obstruction is not readily demonstrated with US [34].

Some studies of patients with renal colic have investigated the combination of radiography and US. Some of these have shown that combining US findings with complementary KUB improved the sensitivity for urolithiasis and had acceptable specificity when compared with either modality alone [34]. In a prospective study of 206 patients with renal colic and suspected urolithiasis, Faget et al [35] found that the combination of radiograph of the abdomen and pelvis and US enabled identification of 50% of the stones that had been identified via CT, and 68% of the stones treated by urological procedures.

Variant 3: Adult. Symptomatic hydronephrosis with unknown cause. Initial imaging. S. Radiography intravenous urography

There is limited evidence to support the use of radiography with IVU (also referred to as IVP) for initial imaging of patients with symptomatic hydronephrosis with unknown cause.

Historically, IVP was used to evaluate hydronephrosis, but this study is considered obsolete in many settings [6].

Variant 3: Adult. Symptomatic hydronephrosis with unknown cause. Initial imaging. T. US abdomen

There is relatively limited evidence to support the use of US of the abdomen for initial imaging of patients with symptomatic hydronephrosis with unknown cause. Although US allows evaluation for increased renal echogenicity, which is nonspecific but can be helpful in assessing for chronic kidney disease, US Abdomen is a less comprehensive examination of the genitourinary system than CT, MRU, renal scintigraphy, or US Color Doppler Kidneys and Bladder Retroperitoneal.

Variant 3: Adult. Symptomatic hydronephrosis with unknown cause. Initial imaging. U. US color Doppler kidneys and bladder retroperitoneal

There is substantial literature on the use of US of the kidneys in the setting of renal colic, including for initial imaging of patients with symptomatic hydronephrosis with unknown cause, and it may be useful in this setting in some clinical situations. Although renal US can identify and grade hydronephrosis, it is less useful for identification of etiology. US does allow evaluation for increased renal echogenicity, which, although nonspecific, can be helpful in assessing for chronic kidney disease. Additionally, US color Doppler kidneys and bladder retroperitoneal allows evaluation of ureteral jets, bladder distension, and postvoid residual bladder volume and can allow measurement of the prostate to evaluate for prostatomegaly. Unilateral elevation of resistive indices is nonspecific but can be seen in the setting of obstruction. However, more comprehensive evaluation can often be achieved with CT, MRU, or renal scintigraphy.

If the degree of hydronephrosis is unknown in a patient with hydronephrosis and renal colic, US may be useful to determine degree of hydronephrosis and therefore the likelihood of symptomatic renal stone [36]. Multiple reports indicate the diagnosis of obstructing stone can be made without further imaging after identification of hydronephrosis [37] or urolithiasis [33] in patients with renal colic. A meta-analysis by Wong et al [36] found that in patients with renal colic, moderate or greater hydronephrosis on POCUS was highly specific (94.4%) for presence of symptomatic renal stone, although they noted that severe hydronephrosis is rare and should prompt consideration of alternate causes. Similarly, Taylor et al [38] found in a study of 483 patients that US finding of either at least stones or moderate to severe hydronephrosis was 97% sensitive and 28.1% specific in predicting need for urologic intervention, noting that all 3 cases with severe hydronephrosis underwent intervention. An additional study evaluating 384 patients with unilateral flank pain found that the degree of hydronephrosis was strongly correlated with the number of calculi but weakly correlated with the size of the calculus [39].

One retrospective review of 125 patients with renal colic found overall sensitivity of a positive bedside US finding of either hydronephrosis or visualized stones was 82.4% for stones present on CT [37]. The authors noted 100% sensitivity for stones ≥6 mm using a combination of positive US and/or hematuria. A multi-institutional retrospective review study of 144 adults with renal colic by Sternberg et al [40] found that hydronephrosis on US had a PPV of 77% for presence of ureteral stone and an NPV of 71% for absence thereof. They concluded that patients may benefit from other studies such as KUB or noncontrast CT to confirm presence or absence of ureteral stone. Additionally, they noted that stone was seen by US in only 25.9% of cases with confirmed ureteral stone by CT, of which 48.4% were ≥5 mm.

Innes et al [16] report that patients with renal colic and with absent to mild hydronephrosis were deemed less likely to have stone passage failure and therefore do not need further imaging, although they note that CT can be useful in the setting of renal colic with moderate to severe hydronephrosis by US because these patients can be at higher risk of stone passage failure. CT is also better able to identify nonurolithiasis findings requiring additional management than US [25].

Pathan et al [22] reviewed 651 patients with POCUS and CT in the setting of renal colic, finding that moderate to severe hydronephrosis on POCUS examination in patients with moderate or high risk of ureteric calculi, provided a more definitive answer regarding the presence of a stone without the need for high-dose CT scanning. In such patients, they advised a low-dose CT scan if the size and location of the stone is desired to plan surgical management.

One prospective study of 46 patients with renal colic, documented ureteral stones, and identifiable ureterovesical jet investigated differences in color Doppler US after oral hydration between these presumed obstructed ureters and their nonobstructed contralateral counterparts, finding significant

differences of jet frequency, duration, and peak velocity [41].

Renal and ureteral US with color Doppler can identify calculi as well as hydronephrosis in patients with renal colic, although patients who undergo US for initial evaluation are at increased likelihood of undergoing additional imaging [17]. In a prospective study of 206 patients with renal colic and suspected urolithiasis, Faget et al [35] found that the combination of radiography of the abdomen and pelvis and US enabled identification of 50% of the stones that had been identified via CT and 68% of the stones treated by urological procedures.

Variant 4: Adult. Asymptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.

Please note that this variant describes initial imaging evaluation after the discovery, by imaging or otherwise, of asymptomatic hydronephrosis in a pregnant patient with unknown cause. The choice of initial imaging in this situation is dependent on clinical context and on the information available from the means of hydronephrosis discovery (eg, CT, MR, US).

Variant 4: Adult. Asymptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
A. CT abdomen and pelvis with IV contrast

There is limited evidence to support the use of CT abdomen and pelvis with IV contrast (separate from CTU) for initial imaging of pregnant patients with asymptomatic hydronephrosis with unknown cause.

Variant 4: Adult. Asymptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
B. CT abdomen and pelvis without and with IV contrast

There is limited evidence to support the use of CT abdomen and pelvis without and with IV contrast (separate from CTU) for initial imaging of pregnant patients with asymptomatic hydronephrosis with unknown cause.

Variant 4: Adult. Asymptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
C. CT abdomen and pelvis without IV contrast

There is limited evidence to support the use of CT abdomen and pelvis without IV contrast (separate from CTU) for initial imaging of pregnant patients with asymptomatic hydronephrosis with unknown cause.

Variant 4: Adult. Asymptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
D. CT abdomen with IV contrast

There is limited evidence to support the use of CT abdomen with IV contrast (separate from CTU) for initial imaging of pregnant patients with asymptomatic hydronephrosis with unknown cause.

Variant 4: Adult. Asymptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
E. CT abdomen without and with IV contrast

There is limited evidence to support the use of CT abdomen without and with IV contrast (separate from CTU) for initial imaging of pregnant patients with asymptomatic hydronephrosis with unknown cause.

Variant 4: Adult. Asymptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
F. CT abdomen without IV contrast

There is limited evidence to support the use of CT abdomen without IV contrast (separate from CTU) for initial imaging of pregnant patients with asymptomatic hydronephrosis with unknown cause.

Variant 4: Adult. Asymptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
G. CTU without and with IV contrast

There is limited evidence to support the use of CTU without and with IV contrast for initial imaging of pregnant patients with asymptomatic hydronephrosis with unknown cause.

Variant 4: Adult. Asymptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
H. DTPA renal scan

Although DRG is the de facto standard of care in diagnosis of renal obstruction [10] and can be used to determine whether obstructive uropathy is truly present in cases of incidentally noted hydronephrosis or in suspected obstruction of renal transplant [11], DRG is not preferred for initial imaging in pregnant patients.

Note that use of DTPA for diuretic renography may result in an equivocal or false-positive diuretic study compared with MAG3, particularly in patients with reduced function, and is not favored [11,12]. DRG with DTPA can also be used to estimate single-kidney GFR but may somewhat overestimate global GFR in the setting of obstructive hydronephrosis [13].

Variant 4: Adult. Asymptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
I. Fluoroscopy antegrade pyelography

There is limited evidence to support the use of fluoroscopic antegrade pyelography for initial imaging of pregnant patients with asymptomatic hydronephrosis with unknown cause.

Variant 4: Adult. Asymptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
J. Fluoroscopy voiding cystourethrography

There is limited evidence to support the use of fluoroscopic voiding cystourethrography for initial imaging of pregnant patients with asymptomatic hydronephrosis with unknown cause.

Variant 4: Adult. Asymptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
K. MAG3 renal scan

Although DRG is the de facto standard of care in diagnosis of renal obstruction [10] and can be used to determine whether obstructive uropathy is truly present in cases of incidentally noted hydronephrosis or in suspected obstruction of renal transplant [11], DRG is not preferred for initial imaging in pregnant patients.

Variant 4: Adult. Asymptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
L. MRI abdomen and pelvis without and with IV contrast

There is limited evidence to support the use of MRI abdomen and pelvis without and with IV contrast (separate from MRU) for initial imaging of pregnant patients with asymptomatic hydronephrosis with unknown cause. Gadolinium contrast administration is avoided during pregnancy and should be considered only if the imaging is essential and cannot be delayed [42] or replaced by alternative imaging.

Variant 4: Adult. Asymptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
M. MRI abdomen and pelvis without IV contrast

Although there is limited evidence to support the use of MRI abdomen and pelvis without IV contrast (separate from MRU) for initial imaging of pregnant patients with asymptomatic hydronephrosis with unknown cause, it may be useful in this setting in some clinical situations. MRU without IV contrast may provide additional information in this setting.

Variant 4: Adult. Asymptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
N. MRI abdomen without and with IV contrast

There is limited evidence to support the use of MRI abdomen without and with IV contrast (separate from MRU) for initial imaging of pregnant patients with asymptomatic hydronephrosis with unknown cause. Gadolinium contrast administration is avoided during pregnancy and should be considered only if the imaging is essential and cannot be delayed [42] or replaced by alternative imaging.

Variant 4: Adult. Asymptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
O. MRI abdomen without IV contrast

There is limited evidence to support the use of MRI abdomen without IV contrast (separate from MRU) for initial imaging of pregnant patients with asymptomatic hydronephrosis with unknown cause.

Variant 4: Adult. Asymptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
P. MRU without and with IV contrast

There is limited evidence to support the use of MRU without and with IV contrast for initial imaging of pregnant patients with asymptomatic hydronephrosis with unknown cause. Gadolinium contrast administration is avoided during pregnancy and should be considered only if the imaging is essential and cannot be delayed [42] or replaced by alternative imaging.

Variant 4: Adult. Asymptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
Q. MRU without IV contrast

Although there is limited evidence to support the use of MRU without IV contrast for initial imaging of pregnant patients with asymptomatic hydronephrosis with unknown cause, MRU without IV contrast is preferred over CTU in pregnant patients [15]. MRU without IV contrast may be useful in this setting in some clinical situations and can be combined with anatomical imaging to provide more information than anatomical imaging alone.

Variant 4: Adult. Asymptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
R. Radiography abdomen and pelvis

There is limited evidence to support the use of radiography of the abdomen and pelvis for initial imaging of pregnant patients with asymptomatic hydronephrosis with unknown cause.

Variant 4: Adult. Asymptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
S. Radiography intravenous urography

There is limited evidence to support the use of radiography with IVU (also referred to as IVP) for initial

imaging of pregnant patients with asymptomatic hydronephrosis with unknown cause.
Historically, IVP was used to evaluate hydronephrosis, but this study is considered obsolete in many settings [6].

Variant 4: Adult. Asymptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
T. US abdomen

There is relatively limited evidence to support the use of US of the abdomen for initial imaging of pregnant patients with asymptomatic hydronephrosis with unknown cause. It may be useful if there is clinical concern for specific causes identifiable by transabdominal US, although the gravid uterus may limit sonographic evaluation of abdominopelvic structures. US abdomen is a less comprehensive examination of the genitourinary system than MRU without IV contrast or US color Doppler kidneys and bladder retroperitoneal.

Variant 4: Adult. Asymptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
U. US color Doppler kidneys and bladder retroperitoneal

US is the first-line study for diagnosis of maternal hydronephrosis or renal anatomic abnormalities [5,17,43]. Measurement of renal resistive indices (RI) on renal US may be useful for distinguishing between benign pregnancy-related hydronephrosis and pathologic causes of urinary tract dilation. RI elevations over 0.70 are suggestive of underlying kidney dysfunction in pregnant patients and an RI difference of ≥0.04 between normal and abnormal kidneys has been reported as being consistent with pathologic urinary tract obstruction [43]. A combination of RI measurement and ureteral jet evaluation may also help distinguish between obstructive and nonobstructive hydronephrosis in pregnant women with and without renal colic [4].

Variant 5: Adult. Symptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.

Please note that this variant describes initial imaging evaluation after the discovery, by imaging or otherwise, of symptomatic hydronephrosis in a pregnant patient with unknown cause. The choice of initial imaging in this situation is dependent on clinical context and on the information available from the means of hydronephrosis discovery (eg, CT, MR, US).

Variant 5: Adult. Symptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
A. CT abdomen and pelvis with IV contrast

There is limited evidence to support the use of CT abdomen and pelvis with IV contrast (separate from CTU) for initial imaging of pregnant patients with symptomatic hydronephrosis with unknown cause. CT should be reserved for problematic situations in which a diagnosis cannot be made on US or MRI [17]. When CT is required, a low-dose CT protocol should be used [6].

Variant 5: Adult. Symptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
B. CT abdomen and pelvis without and with IV contrast

There is limited evidence to support the use of CT abdomen and pelvis without and with IV contrast (separate from CTU) for initial imaging of pregnant patients with symptomatic hydronephrosis with unknown cause. CT should be reserved for problematic situations in which a diagnosis cannot be made on US or MRI [17]. When CT is required, a low-dose CT protocol should be used [6].

Variant 5: Adult. Symptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
C. CT abdomen and pelvis without IV contrast

There is limited evidence to support the use of CT abdomen and pelvis without IV contrast (separate from CTU) for initial imaging of pregnant patients with symptomatic hydronephrosis with unknown cause. CT should be reserved for problematic situations in which a diagnosis cannot be made on US or MRI [17]. When CT is required, a low-dose CT protocol should be used [6].

Variant 5: Adult. Symptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
D. CT abdomen with IV contrast

There is limited evidence to support the use of CT abdomen with IV contrast (separate from CTU) for initial imaging of pregnant patients with symptomatic hydronephrosis with unknown cause.

Variant 5: Adult. Symptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
E. CT abdomen without and with IV contrast

There is limited evidence to support the use of CT abdomen without and with IV contrast (separate from CTU) for initial imaging of pregnant patients with symptomatic hydronephrosis with unknown cause.

Variant 5: Adult. Symptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
F. CT abdomen without IV contrast

There is limited evidence to support the use of CT abdomen without IV contrast (separate from CTU) for initial imaging of pregnant patients with symptomatic hydronephrosis with unknown cause.

Variant 5: Adult. Symptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
G. CTU without and with IV contrast

There is limited evidence to support the use of CTU without and with IV contrast for initial imaging of pregnant patients with symptomatic hydronephrosis with unknown cause. CT should be reserved for problematic situations in which a diagnosis cannot be made on US or MRI [17]. When CT is required, a low-dose CT protocol should be used [6].

Variant 5: Adult. Symptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
H. DTPA renal scan

Although DRG is the de facto standard of care in diagnosis of renal obstruction [10] and can be used to determine whether obstructive uropathy is truly present in cases of incidentally noted hydronephrosis or in suspected obstruction of renal transplant [11], DRG is not preferred for initial imaging in pregnant patients.

Note that use of DTPA for diuretic renography may result in an equivocal or false-positive diuretic study compared with MAG3, particularly in patients with reduced function, and is not favored [11,12]. DRG with DTPA can also be used to estimate single-kidney GFR but may somewhat overestimate global GFR in the setting of obstructive hydronephrosis [13].

Variant 5: Adult. Symptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.

I. Fluoroscopy antegrade pyelography

There is limited evidence to support the use of fluoroscopic antegrade pyelography for initial imaging of pregnant patients with symptomatic hydronephrosis with unknown cause.

Variant 5: Adult. Symptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
J. Fluoroscopy voiding cystourethrography

There is limited evidence to support the use of fluoroscopic voiding cystourethrography for initial imaging of pregnant patients with symptomatic hydronephrosis with unknown cause.

Variant 5: Adult. Symptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
K. MAG3 renal scan

Although DRG is the de facto standard of care in diagnosis of renal obstruction [10] and can be used to determine whether obstructive uropathy is truly present in cases of incidentally noted hydronephrosis or in suspected obstruction of renal transplant [11], DRG is not preferred for initial imaging in pregnant patients.

Variant 5: Adult. Symptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
L. MRI abdomen and pelvis without and with IV contrast

There is limited evidence to support the use of MRI abdomen and pelvis without and with IV contrast (separate from MRU) for initial imaging of pregnant patients with symptomatic hydronephrosis with unknown cause. Gadolinium contrast administration is avoided during pregnancy and should be considered only if the imaging is essential and cannot be delayed [42] or replaced by alternative imaging.

Variant 5: Adult. Symptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
M. MRI abdomen and pelvis without IV contrast

There is limited evidence to support the use of MRI abdomen and pelvis without IV contrast (separate from MRU) for initial imaging of pregnant patients with symptomatic hydronephrosis with unknown cause, although MRI can play a useful adjunct role in pregnant patients with renal colic and equivocal or nondiagnostic initial US findings [17].

Variant 5: Adult. Symptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
N. MRI abdomen without and with IV contrast

There is limited evidence to support the use of MRI abdomen without and with IV contrast (separate from MRU) for initial imaging of pregnant patients with symptomatic hydronephrosis with unknown cause. Gadolinium contrast administration is avoided during pregnancy and should be considered only if the imaging is essential and cannot be delayed [42] or replaced by alternative imaging.

Variant 5: Adult. Symptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
O. MRI abdomen without IV contrast

There is limited evidence to support the use of MRI abdomen without IV contrast (separate from MRU) for initial imaging of pregnant patients with symptomatic hydronephrosis with unknown cause, although MRI can play a useful adjunct role in pregnant patients with renal colic and equivocal or nondiagnostic initial US findings [17].

Variant 5: Adult. Symptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
P. MRU without and with IV contrast

There is limited evidence to support the use of MRU without and with IV contrast for initial imaging of pregnant patients with symptomatic hydronephrosis with unknown cause. Gadolinium contrast administration is avoided during pregnancy and should be considered only if the imaging is essential and cannot be delayed [42] or replaced by alternative imaging.

Variant 5: Adult. Symptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
Q. MRU without IV contrast

There is some evidence for use of MRU without IV contrast for initial imaging of pregnant patients with symptomatic hydronephrosis with unknown cause. Although it can be performed independently, MRU can also be performed at the time of structural MRI.

In a study of 24 pregnant patients with symptomatic hydronephrosis, MRU was noted to show different appearances in physiologic hydronephrosis and pathologic obstruction [44]. Multiple authors suggest that noncontrast MRU should be considered after an equivocal or nondiagnostic US in symptomatic pregnant patients with suspected urolithiasis [6,17].

MRU without IV contrast is, in general, preferred over CTU in patients with renal impairment [15]. MRU can be used in complex situations in which US and CT fail to explain the patient's symptoms [17]. MRU combined with structural imaging can also demonstrate complications in the setting of renal colic, such as pyelonephritis [29].

In a prospective study of 55 nonpregnant patients with hydronephrosis detected on US for urologic symptoms, excluding patients with abnormal renal function given contraindication for IVU, Muthusami et al [30] compared static heavily T2-weighted MRU to reference IVU and determined that MRU had high sensitivity and specificity for detecting (95% and 100%, respectively) and grading (Spearman correlation coefficient 0.92) hydronephrosis, as well as identifying the location of obstruction (90% and 99%, respectively) if present. The authors conclude that static MRU can replace IVU when the latter is contraindicated or technically difficult. The authors note that MRU sensitivity for hydronephrosis grading increased with grade of obstruction.

Variant 5: Adult. Symptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
R. Radiography abdomen and pelvis

There is limited evidence to support the use of radiography of the abdomen and pelvis for initial imaging of pregnant patients with symptomatic hydronephrosis with unknown cause.

Variant 5: Adult. Symptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
S. Radiography intravenous urography

There is limited evidence to support the use of radiography with IVU (also referred to as IVP) for initial imaging of pregnant patients with symptomatic hydronephrosis with unknown cause.

Historically, IVP was used to evaluate symptomatic pregnant patients suspected to have renal obstruction; however, due to radiation exposure, IV contrast administration and increased usage of cross-sectional

imaging, this study is considered obsolete in many settings [6].

Variant 5: Adult. Symptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
T. US abdomen

There is relatively limited evidence to support the use of US of the abdomen for initial imaging of pregnant patients with symptomatic hydronephrosis with unknown cause. It may be useful if there is clinical concern for specific causes identifiable by transabdominal US, although the gravid uterus may limit sonographic evaluation of abdominopelvic structures. US abdomen is a less comprehensive examination of the genitourinary system than MRU without IV contrast or US color Doppler kidneys and bladder retroperitoneal.

Variant 5: Adult. Symptomatic hydronephrosis in a pregnant patient with unknown cause. Initial imaging.
U. US color Doppler kidneys and bladder retroperitoneal

US is the first-line study for diagnosis of maternal hydronephrosis or renal anatomic abnormalities [5,17,43]. In the pregnant patient with known, symptomatic hydronephrosis, specific findings on US including anteroposterior diameter of the renal pelvis and renal RI can help differentiate benign pregnancy-related hydronephrosis and pathologic obstruction and can help predict the need for intervention.

In a prospective single-center study of 1,026 pregnant patients including 295 with hydronephrosis, Bayraktar et al [5] reported a correlation between anteroposterior diameter of the renal pelvis on US and requirement for intervention for symptomatic patients. Ercil et al [9] report the same finding in a retrospective single-center series of 246 pregnant patients with symptomatic hydronephrosis, noting that a diameter above 21 mm on the right had a sensitivity of 91% and a specificity of 84% for predicting intervention, and a diameter above 25 mm on the left had a sensitivity and specificity of 100%. Demir et al [45] reported in a study of 227 pregnant women with symptomatic hydronephrosis that intervention was found to be necessary with renal pelvis anteroposterior diameter >16.5 mm in the first two trimesters and >27.5 mm in the third trimester.

In the pregnant patient with hydronephrosis, RI elevations over 0.70 are reported to be suggestive of underlying kidney dysfunction, and an RI difference of ≥0.04 between normal and abnormal kidneys has been reported as being consistent with pathologic urinary tract obstruction [6,43]. Nuri Bodakci et al [46] performed a prospective study of 27 pregnant women with symptomatic unilateral hydronephrosis eventually requiring intervention and 38 pregnant women with asymptomatic, nonhematuric hydronephrosis presumed incidental hydronephrosis of pregnancy, finding that RI ≥0.70 had a sensitivity of 44% and a specificity of 92.1% for predicting intervention. A difference-in-RI cutoff of ≥0.04 between hydronephrotic kidney and same-patient nonhydronephrotic contralateral kidney in the symptomatic group had a sensitivity 88.9%, a specificity 89.5%, a PPV 85.7%, and an NPV 91.9% for predicting intervention. Notably, the initial diagnosis of obstruction was made with US, but only those with persistent symptoms or hydronephrosis following conservative treatment underwent intervention. Obstruction was found in all 22 of the 27 symptomatic women who underwent ureteroscopy; causes included stones, stricture, ureteral invagination at the pelvic brim, and excessive uterine compression. A combination of RI measurement and ureteral jet evaluation may also help distinguish between obstructive and nonobstructive hydronephrosis in pregnant women with and without renal colic [4].

US can also sometimes be useful for directly visualizing causative ureteral stones in the setting of symptomatic hydronephrosis of pregnancy. In a retrospective study of 36 pregnant patients with symptomatic hydronephrosis, Dell'Atti [47] reported sensitivity and specificity of US for diagnosis of causative ureteral stone were 83% and 91%, respectively.

US is considered to be the imaging method of choice for routine evaluations of renal colic in pregnant women because it has no risk of radiation exposure. Moreover, in the diagnosis of urolithiasis, transabdominal US has an appropriate sensitivity of 34% and a specificity of 86% [48]. Renal US has a reported PPV of 77% for obstructing ureteral stone in symptomatic pregnant patients; however, physiologic hydronephrosis may lower the sensitivity to 74% and the specificity to 67% [6]. In a study evaluating pregnant patients with renal colic, renal and bladder US identified 29% of distal ureteral calculi, whereas transvaginal US identified 94%, and the combined imaging modalities demonstrated a sensitivity of 89%, a specificity 100%, and an NPV of 98% for presence of distal ureteral stones [49].

Summary of Highlights

- **Variant 1:** MRU without and with IV contrast or MAG3 renal scan or CTU without and with IV contrast is usually appropriate for the initial imaging of asymptomatic unilateral hydronephrosis with unknown cause. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care). Although the panel did not agree on recommending CT abdomen and pelvis with IV contrast or DTPA renal scan because there is insufficient medical literature to conclude whether these patients would benefit from the procedure, its use may be appropriate.
- **Variant 2:** MRU without and with IV contrast or MAG3 renal scan is usually appropriate for the initial imaging of asymptomatic bilateral hydronephrosis or asymptomatic hydronephrosis in a solitary kidney with unknown cause. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care). Although the panel did not agree on recommending CT abdomen and pelvis with IV contrast or DTPA renal scan because there is insufficient medical literature to conclude whether these patients would benefit from the procedure, its use may be appropriate.
- **Variant 3:** US color Doppler kidneys and bladder retroperitoneal or MRU without and with IV contrast or MAG3 renal scan or CTU without and with IV contrast is usually appropriate for the initial imaging of symptomatic hydronephrosis with unknown cause. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care). Although the panel did not agree on recommending US abdomen because there is insufficient medical literature to conclude whether these patients would benefit from the procedure, its use may be appropriate.
- **Variant 4:** US color Doppler kidneys and bladder retroperitoneal is usually appropriate for the initial imaging of asymptomatic hydronephrosis in a pregnant patient with unknown cause. Although the panel did not agree on recommending MRI abdomen and pelvis without IV contrast because there is insufficient medical literature to conclude whether these patients would benefit from the procedure, its use may be appropriate.
- **Variant 5:** US color Doppler kidneys and bladder retroperitoneal or MRU without IV contrast is usually appropriate for the initial imaging of symptomatic hydronephrosis in a pregnant

patient with unknown cause. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).

Supporting Documents

The evidence table, literature search, and appendix for this topic are available at https://acsearch.acr.org/list. The appendix includes the strength of evidence assessment and the final rating round tabulations for each recommendation.

For additional information on the Appropriateness Criteria methodology and other supporting documents, please go to the ACR website at https://www.acr.org/Clinical-Resources/Clinical-Tools-and-Reference/Appropriateness-Criteria.

Safety Considerations in Pregnant Patients

Imaging of the pregnant patient can be challenging, particularly with respect to minimizing radiation exposure and risk. For further information and guidance, see the following ACR documents:

- ACR–SPR Practice Parameter for the Safe and Optimal Performance of Fetal Magnetic Resonance Imaging (MRI)
- ACR-SPR Practice Parameter for Imaging Pregnant or Potentially Pregnant Patients with Ionizing Radiation
- ACR-ACOG-AIUM-SMFM-SRU Practice Parameter for the Performance of Standard Diagnostic Obstetrical Ultrasound
- ACR Manual on Contrast Media
- ACR Manual on MR Safety

Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be

		unfavorable.

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, because of both organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared with those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document.

Relative Radiation Level Designations

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
O	0 mSv	0 mSv
☢	<0.1 mSv	<0.03 mSv
☢☢	0.1-1 mSv	0.03-0.3 mSv
☢☢☢	1-10 mSv	0.3-3 mSv
☢☢☢☢	10-30 mSv	3-10 mSv
☢☢☢☢☢	30-100 mSv	10-30 mSv

*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (e.g., region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as “Varies.”

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Disclaimer

The ACR Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.

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