

ACR Appropriateness Criteria[®] Suspected and Known Renal or Splanchnic Artery Aneurysm

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Abstract

Renal and splanchnic artery aneurysms are clinically significant vascular abnormalities with potential for life-threatening complications, including rupture. Accurate imaging is essential for initial detection, risk stratification, treatment planning purposes, and longitudinal surveillance. This document provides evidence-based recommendations for imaging evaluation of suspected and known renal and/or

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ACR Appropriateness Criteria[®] Suspected and Known Renal or Splanchnic Artery Aneurysm.

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.

splanchnic artery aneurysms across four clinical scenarios: adults undergoing initial evaluation, adults under active surveillance, pregnant patients with suspected aneurysm, and pregnant patients undergoing surveillance. The roles of CTA, MRA, ultrasound (including duplex Doppler and contrast-enhanced techniques), and catheter angiography are reviewed with attention to diagnostic performance and safety considerations. CTA and MRA are generally preferred in nonpregnant adults, whereas ultrasound and non-contrast MRA are favored in pregnancy to minimize radiation and contrast exposure. These document aims to optimize imaging utilization, enhance diagnostic accuracy, and support safe, patient-centered management of renal and/or splanchnic artery aneurysms.

The American College of Radiology Appropriateness Criteria are evidence-based guidelines for specific clinical conditions that are reviewed annually by a multidisciplinary expert panel. The guideline development and revision process support the systematic analysis of the medical literature from peer reviewed journals. Established methodology principles such as Grading of Recommendations Assessment, Development, and Evaluation or GRADE are adapted to evaluate the evidence. The RAND/UCLA Appropriateness Method User Manual provides the methodology to determine the appropriateness of imaging and treatment procedures for specific clinical scenarios. In those instances where peer reviewed literature is lacking or equivocal, experts may be the primary evidentiary source available to formulate a recommendation.

Key Words: Aneurysm detection, aneurysm evaluation, aneurysm surveillance, Appropriateness Criteria, Appropriate Use Criteria, AUC, renal artery aneurysm, splanchnic artery aneurysm

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ACR Appropriateness Criteria® Suspected and Known Renal or Splanchnic Artery Aneurysm. [Variants 1 to 4](#) and [Tables 1 and 2](#).

Variant 1. Adult. Suspected splanchnic or renal artery aneurysm. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
MRA abdomen and pelvis with IV contrast	Usually Appropriate	○
MRA abdomen and pelvis without and with IV contrast	Usually Appropriate	○
MRA abdomen with IV contrast	Usually Appropriate	○
MRA abdomen without and with IV contrast	Usually Appropriate	○
CTA abdomen with IV contrast	Usually Appropriate	⦿⦿⦿
CTA abdomen and pelvis with IV contrast	Usually Appropriate	⦿⦿⦿⦿
CTA abdomen and pelvis without and with IV contrast	Usually Appropriate	⦿⦿⦿⦿
US aorta abdomen with IV contrast	May Be Appropriate	○
US duplex Doppler aorta abdomen	May Be Appropriate	○
MRA abdomen and pelvis without IV contrast	May Be Appropriate	○
MRA abdomen without IV contrast	May Be Appropriate	○
CT abdomen and pelvis with IV contrast	May Be Appropriate	⦿⦿⦿
CT abdomen with IV contrast	May Be Appropriate	⦿⦿⦿
CT abdomen and pelvis without and with IV contrast	May Be Appropriate	⦿⦿⦿⦿
CT abdomen without and with IV contrast	May Be Appropriate	⦿⦿⦿⦿
Arteriography abdomen	Usually Not Appropriate	⦿⦿⦿
Arteriography abdomen and pelvis	Usually Not Appropriate	⦿⦿⦿⦿
MRI abdomen and pelvis without and with IV contrast	Usually Not Appropriate	○
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	○
MRI abdomen without and with IV contrast	Usually Not Appropriate	○
MRI abdomen without IV contrast	Usually Not Appropriate	○
CT abdomen and pelvis without IV contrast	Usually Not Appropriate	⦿⦿⦿
CT abdomen without IV contrast	Usually Not Appropriate	⦿⦿⦿

Variant 2. Adult. Known splanchnic or renal artery aneurysm. Active surveillance.

Procedure	Appropriateness Category	Relative Radiation Level
MRA abdomen and pelvis with IV contrast	Usually Appropriate	○
MRA abdomen and pelvis without and with IV contrast	Usually Appropriate	○
MRA abdomen with IV contrast	Usually Appropriate	○
MRA abdomen without and with IV contrast	Usually Appropriate	○
CTA abdomen with IV contrast	Usually Appropriate	⦿⦿⦿
CTA abdomen and pelvis with IV contrast	Usually Appropriate	⦿⦿⦿⦿
US aorta abdomen with IV contrast	May Be Appropriate	○
US duplex Doppler aorta abdomen	May Be Appropriate	○
MRA abdomen and pelvis without IV contrast	May Be Appropriate	○
MRA abdomen without IV contrast	May Be Appropriate	○
CT abdomen and pelvis with IV contrast	May Be Appropriate	⦿⦿⦿
CT abdomen with IV contrast	May Be Appropriate	⦿⦿⦿
CT abdomen and pelvis without and with IV contrast	May Be Appropriate	⦿⦿⦿⦿
CT abdomen without and with IV contrast	May Be Appropriate	⦿⦿⦿⦿
Arteriography abdomen	Usually Not Appropriate	⦿⦿⦿
Arteriography abdomen and pelvis	Usually Not Appropriate	⦿⦿⦿⦿
MRI abdomen and pelvis without and with IV contrast	Usually Not Appropriate	○
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	○
MRI abdomen without and with IV contrast	Usually Not Appropriate	○
MRI abdomen without IV contrast	Usually Not Appropriate	○
CT abdomen and pelvis without IV contrast	Usually Not Appropriate	⦿⦿⦿
CT abdomen without IV contrast	Usually Not Appropriate	⦿⦿⦿

Variant 3. Pregnant. Suspected splanchnic or renal artery aneurysm. Initial imaging.

Procedure	Appropriateness Category	Relative Radiation Level
US aorta abdomen with IV contrast	Usually Appropriate	○
US duplex Doppler aorta abdomen	Usually Appropriate	○
MRA abdomen and pelvis without IV contrast	May Be Appropriate	○
MRA abdomen without IV contrast	May Be Appropriate	○
CTA abdomen with IV contrast	May Be Appropriate	☢☢☢
CTA abdomen and pelvis with IV contrast	May Be Appropriate	☢☢☢☢
Arteriography abdomen	Usually Not Appropriate	☢☢☢
Arteriography abdomen and pelvis	Usually Not Appropriate	☢☢☢☢
MRA abdomen and pelvis with IV contrast	Usually Not Appropriate	○
MRA abdomen and pelvis without and with IV contrast	Usually Not Appropriate	○
MRA abdomen with IV contrast	Usually Not Appropriate	○
MRA abdomen without and with IV contrast	Usually Not Appropriate	○
MRI abdomen and pelvis without and with IV contrast	Usually Not Appropriate	○
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	○
MRI abdomen without and with IV contrast	Usually Not Appropriate	○
MRI abdomen without IV contrast	Usually Not Appropriate	○
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	☢☢☢
CT abdomen and pelvis without and with IV contrast	Usually Not Appropriate	☢☢☢☢
CT abdomen without and with IV contrast	Usually Not Appropriate	☢☢☢☢

Variant 4. Pregnant. Known splanchnic or renal artery aneurysm. Active surveillance.

Procedure	Appropriateness Category	Relative Radiation Level
US aorta abdomen with IV contrast	Usually Appropriate	○
US duplex Doppler aorta abdomen	Usually Appropriate	○
MRA abdomen and pelvis without IV contrast	May Be Appropriate	○
MRA abdomen without IV contrast	May Be Appropriate	○
CT abdomen with IV contrast	May Be Appropriate	⚠⚠⚠
CTA abdomen with IV contrast	May Be Appropriate	⚠⚠⚠
CTA abdomen and pelvis with IV contrast	May Be Appropriate	⚠⚠⚠⚠
Arteriography abdomen	Usually Not Appropriate	⚠⚠⚠
Arteriography abdomen and pelvis	Usually Not Appropriate	⚠⚠⚠⚠
MRA abdomen and pelvis with IV contrast	Usually Not Appropriate	○
MRA abdomen and pelvis without and with IV contrast	Usually Not Appropriate	○
MRA abdomen with IV contrast	Usually Not Appropriate	○
MRA abdomen without and with IV contrast	Usually Not Appropriate	○
MRI abdomen and pelvis without and with IV contrast	Usually Not Appropriate	○
MRI abdomen and pelvis without IV contrast	Usually Not Appropriate	○
MRI abdomen without and with IV contrast	Usually Not Appropriate	○
MRI abdomen without IV contrast	Usually Not Appropriate	○
CT abdomen and pelvis with IV contrast	Usually Not Appropriate	⚠⚠⚠
CT abdomen and pelvis without 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	⚠⚠⚠⚠

Table 1. 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.

Table 2. Relative radiation level designations.

RRL	Adult Effective Dose Estimate Range (mSv)	Pediatric Effective Dose Estimate Range (mSv)
0	0	0
⊕	<0.1	<0.03
⊕⊕	0.1-1	0.03-0.3
⊕⊕⊕	1-10	0.3-3
⊕⊕⊕⊕	10-30	3-10
⊕⊕⊕⊕⊕	30-100	10-30

Note: Relative radiation level (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 (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "varies."

SUMMARY OF LITERATURE REVIEW

Introduction/Background

Renal and/or splanchnic aneurysms are rare, though important vascular anomalies affecting the arterial system supplying abdominal organs. These aneurysms occur most frequently in the branches of the celiac, superior mesenteric, and inferior mesenteric arteries, with splenic artery aneurysms representing the most common entity, accounting for approximately 60% of cases, whereas renal artery aneurysms are the second most common entity, accounting for approximately 15% to 20% [1-4].

The overall prevalence of abdominal visceral aneurysms in the general population has been estimated between 0.1% and 2% [5].

The etiology of renal or splanchnic aneurysms is multifactorial, including atherosclerotic disease, trauma, infections, fibromuscular dysplasia, as well as connective tissue disorders, such as Marfan syndrome and Ehlers-Danlos syndrome. Certain conditions, such as pregnancy, portal hypertension, and history of liver transplantation further increase the risk of

developing these aneurysms [3,4,6-9]. These aneurysms tend to be asymptomatic and are typically discovered during imaging examinations performed for unrelated reasons. However, patients may present more acutely with abdominal pain, bleeding, or jaundice, requiring urgent endovascular or surgical intervention. The primary clinical concern of asymptomatic renal or splanchnic aneurysms is rupture, which is associated with life-threatening hemorrhage and carries a high mortality rate, ranging from 20% to 70%. The risk of rupture is impacted by certain factors, such as aneurysm size, growth rate, and specific patient conditions. For instance, splenic artery aneurysms carry a baseline rupture risk of 10% to 20% and this rupture risk increases significantly during pregnancy [10].

Management strategies for renal or splanchnic aneurysms depend on the size of the aneurysm, associated symptomatology, and overall rupture risk. Small, asymptomatic aneurysms, which are defined as <2 cm in diameter, are usually managed conservatively with routine imaging surveillance to monitor for growth or changes in

morphology. However, endovascular or surgical intervention is warranted for larger aneurysms, symptomatic cases, or those deemed to have an increased rupture risk. Although endovascular techniques, such as coil embolization and covered stent placement, are the standard of care for the majority of patients with renal or splanchnic aneurysms, surgical techniques such as aneurysmectomy, arterial reconstruction, and/or bypass grafting can be performed in selected cases when an endovascular approach is not feasible [11-13].

Renal or splanchnic aneurysms, although rare, are clinically significant due to the potential risk of rupture. A variety of imaging modalities play a pivotal role in the initial detection, ongoing surveillance, preprocedural planning, and/or postprocedural follow-up of these lesions. In the following sections imaging modalities such as CT, CT angiography (CTA), MR angiography (MRA), abdominal ultrasound (US), and invasive angiography will be outlined for imaging of these renal or splanchnic aneurysms and the appropriate choice of modality for different clinical variants will be discussed.

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. Suspected splanchnic or renal artery aneurysm. Initial imaging.

The initial presentations of symptomatic renal or splanchnic aneurysms may overlap with other acute intra-abdominal pathologies, including nonspecific abdominal pain [14]. In these settings, please refer to the ACR Appropriateness Criteria[®] topic on "Acute Nonlocalized Abdominal Pain" for further details [15].

In addition, in certain patient populations, screening imaging examinations may be performed to assess for the presence of visceral aneurysms. For example, per the Society for Vascular Surgery recommendation, patients with a celiac

artery aneurysm should undergo a one-time screening test to assess for presence of other visceral artery aneurysms [11].

Once a renal or splanchnic aneurysm is discovered on cross-sectional imaging, dedicated imaging techniques are warranted to determine the etiology, anatomic location, and extent of the disease, which includes size and morphology of the lesion. More dedicated imaging may not be pursued in cases in which the initial imaging modality has determined the aforementioned parameters of the renal or splanchnic aneurysm.

MRA Abdomen and Pelvis With IV Contrast. MRA is gaining increasing recognition in the detection and assessment of renal or splanchnic aneurysms. Unlike CTA, which relies on iodinated contrast agents, MRA uses gadolinium-based agents, which are not nephrotoxic [16].

Additionally, noncontrast MRA techniques have proven effective for vascular imaging [17]. MRA can provide dynamic, 3-D imaging of blood vessels, allowing for precise characterization of aneurysms, including size, location, and involvement of adjacent structures [18]. The ability to image vessels in multiple planes and generate 3-D reconstructions provides detailed insights into aneurysmal morphology, feeding arteries, and branch involvement. This level of detail obtained via MRA is crucial for planning surgical or endovascular interventions. MRA also allows for the detection of secondary vascular features, such as intramural thrombi or wall irregularities, which are important imaging parameters of aneurysm stability and risk of rupture [18,19]. Techniques such as time-of-flight (ToF) and contrast-enhanced MRA further improve diagnostic accuracy by enhancing the visibility of smaller vasculature [20,21]. It needs to be emphasized that MRA is a primarily intraluminal modality.

Perhaps the most important drawback of MRA techniques is its lower spatial resolution in comparison to CTA or catheter angiography. Modern-day MRA techniques can generate voxel sizes as small as 1 mm but this is still inferior compared to CTA. In addition, although modern MRA techniques, such as time-resolved MRA, have greatly reduced the acquisition time, it is still a significantly lengthier examination compared to CTA, thus rendering it less useful in emergent settings such as for concern of bleeding renal or splanchnic aneurysms [18,20,22,23]. It should be noted that there is a paucity of direct comparison studies between MRA and catheter angiography or CTA in the splanchnic circulation, particularly related to aneurysm detection and assessment. Extrapolating from available literature in mesenteric stenosis, a article from 2000 compared contrast-enhanced MRA to catheter angiography in the evaluation of the mesenteric circulation revealing a moderate agreement

between the two modalities ($\kappa = 0.53$). The overall agreement was better in the proximal, larger mesenteric vasculature including the hepatic artery, superior mesenteric artery, splenic artery, and the portal vein with κ co-efficient ranging between 0.8 to 0.9. However, the overall agreement was poor in the distal arteries ($\kappa = 0.01$), likely secondary to the limited spatial resolution of MRA [24]. That being said, the majority of clinically relevant visceral aneurysms typically affect the larger mesenteric and renal vasculature. Similarly, a 2001 study has shown that the cumulative accuracies for detecting significant stenosis was above 95% for at least moderate stenosis in the mesenteric circulation, with an interobserver agreement of approximately 0.9, except for the inferior mesenteric artery (interobserver agreement of 0.48) [25]. This study is again suggestive for MRA being less sensitive in the distal and smaller arterial territories.

Similarly, there is a lack of data comparing different MRA techniques in the setting of renal or splanchnic artery aneurysms. The three most commonly used MR sequences in this setting include ToF, phase-contrast, and contrast-enhanced MRA. A detailed discussion of various MR techniques are beyond the scope of this document but in general, both phase-contrast and ToF MRA require longer acquisition times and are more prone to motion artifacts in comparison to contrast-enhanced MRA [22]. Again extrapolating from the literature on mesenteric stenosis/ischemia, a 1997 study has shown that contrast-enhanced MRA had a sensitivity of 100% and a specificity of 95% in diagnosing severe stenosis or occlusion within the mesenteric arterial circulation [26]. In contrast, a 1996 study has shown that phase-contrast MRA only identified 66% of the stenotic disease seen on catheter angiography [27]. These two studies are somewhat dated and MRA techniques have markedly evolved since then. In summary, for the diagnosis of renal or splanchnic artery aneurysm, contrast-enhanced MRA technique is currently superior to noncontrast MRA techniques.

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reconstructions provides detailed insights into aneurysmal morphology, feeding arteries, and branch involvement. This level of detail obtained via MRA is crucial for planning surgical or endovascular interventions. MRA also allows for the detection of secondary vascular features, such as intramural thrombi or wall irregularities, which are important imaging parameters of aneurysm stability and risk of rupture [18,19]. Techniques such as ToF and contrast-enhanced MRA further improve diagnostic accuracy by enhancing the visibility of smaller vasculature [20,21]. It needs to be emphasized that MRA is a primarily intraluminal modality.

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The location of the suspected renal or splanchnic aneurysm needs to be taken into consideration in order to decide whether MRA abdomen with IV contrast is sufficient for imaging as opposed to an MRA abdomen and pelvis with IV contrast.

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CTA, which relies on iodinated contrast agents, MRA uses gadolinium-based agents, which are not nephrotoxic [16].

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Perhaps the most important drawback of MRA techniques is its lower spatial resolution in comparison to CTA or catheter angiography. Modern-day MRA techniques can generate voxel sizes as small as 1 mm but this is still inferior compared to CTA. In addition, although modern MRA techniques, such as time-resolved MRA, have greatly reduced the acquisition time, it is still a significantly lengthier examination compared to CTA, thus rendering it less useful in emergent settings such as for concern of bleeding renal or splanchnic aneurysms [18,20,22,23]. It should be noted that there is a paucity of direct comparison studies between MRA and catheter angiography or CTA in the splanchnic circulation, particularly related to aneurysm detection and assessment. Extrapolating from available literature in mesenteric stenosis, a article from 2000 compared contrast-enhanced MRA to catheter angiography in the evaluation of the mesenteric circulation revealing a moderate agreement between the two modalities ($\kappa = 0.53$). The overall agreement was better in the proximal, larger mesenteric vasculature including the hepatic artery, superior mesenteric artery, splenic artery, and the portal vein with κ co-efficient ranging between 0.8 to 0.9. However, the overall agreement was poor in the distal arteries ($\kappa = 0.01$), likely secondary to the limited spatial resolution of MRA [24]. That being said, the majority of clinically relevant visceral aneurysms typically affect the larger mesenteric and renal vasculature. Similarly, a 2001 study has shown that the cumulative accuracies for detecting significant stenosis was above 95% for at least moderate stenosis in the mesenteric circulation, with an interobserver agreement of approximately 0.9, except for the inferior mesenteric

artery (interobserver agreement of 0.48) [25]. This study is again suggestive for MRA being less sensitive in the distal and smaller arterial territories.

Similarly, there is a lack of data comparing different MRA techniques in the setting of renal or splanchnic artery aneurysms. The three most commonly used MR sequences in this setting include ToF, phase-contrast, and contrast-enhanced MRA. A detailed discussion of various MR techniques are beyond the scope of this document but in general, both phase-contrast and ToF MRA require longer acquisition times and are more prone to motion artifacts in comparison to contrast-enhanced MRA [22]. Again extrapolating from the literature on mesenteric stenosis/ ischemia, a 1997 study has shown that contrast-enhanced MRA had a sensitivity of 100% and a specificity of 95% in diagnosing severe stenosis or occlusion within the mesenteric arterial circulation [26]. In contrast, a 1996 study has shown that phase-contrast MRA only identified 66% of the stenotic disease seen on catheter angiography [27]. These two studies are somewhat dated and MRA techniques have markedly evolved since then. In summary, for the diagnosis of renal or splanchnic artery aneurysm, contrast-enhanced MRA technique is currently superior to noncontrast MRA techniques.

The location of the suspected renal or splanchnic aneurysm needs to be taken into consideration in order to decide whether MRA abdomen without and with IV contrast is sufficient for imaging as opposed to an MRA abdomen and pelvis without and with IV contrast.

CTA Abdomen With IV Contrast. CTA is widely considered the primarily preferred noninvasive initial imaging modality for diagnosing and evaluating renal or splanchnic aneurysms due to its high spatial resolution, rapid acquisition, and comprehensive vascular assessment. It enables visualization of the vascular anatomy in detail including accurate diagnosis and procedural treatment planning [28,29]. CTA is a valuable tool for noninvasive evaluation of renal or splanchnic aneurysms with high sensitivity and specificity, including assessment of small and complex aneurysmal lesions aneurysms.

There are a limited number of comparison studies between catheter angiography and CTA. A small study from 1996 has shown significant correlation between CT and catheter arteriography [30]. With the advancement in detector and scanning technology, the diagnostic effectiveness and reliability of CTA have significantly improved over the past two decades and various studies have demonstrated its effectiveness in characterization of small aneurysms [31,32].

In addition, multiple acquisition and postprocessing techniques can be used to improve visualization of aneurysms

and associated complications. For example, thin-slice acquisition at 0.75 mm enables creation of high-quality isotropic datasets. Multiplanar reconstruction and 3-D volume rendering allow superior characterization of the aneurysmal sac and its relationship to adjacent organs structures. The maximum intensity projection technique can accentuate smaller aneurysms in the distal circulation. In a recent study, CTA was able to visualize the thrombosed false lumen in dissecting mesenteric aneurysms at a higher rate than compared to catheter angiography ($P < .001$). In addition, CTA showed superior performance for the detection of entry points, intimal flaps, and branch vessel involvement [33].

The ability of CTA to provide 3-D rendering of vascular structures enables precise evaluation of aneurysm size, shape, wall characteristics, and relationship to adjacent organs. This capability is particularly beneficial for planning interventions, as it aids in the selection of appropriate treatment options, such as coil embolization, stent graft placement, or surgical repair. In particular, splanchnic aneurysms that are amenable to endovascular interventions include those with a narrow neck, adequate collateral flow, and favorable landing zone for stent graft placement or coil deployment [34]. Moreover, multiphase CTA reliably detects associated complications, including active contrast extravasation in cases of rupture or pseudoaneurysm formation, making it invaluable in the acute setting [35]. The rapid acquisition is another significant benefit of CTA, especially in hemodynamically borderline stable or unstable patients, in whom timely diagnosis with subsequent initiation of treatment can be lifesaving [36].

CTA surpasses other imaging modalities such as US or MRI in terms of diagnostic accuracy and ability to evaluate the entire vascular tree simultaneously. Although conventional angiography remains the reference standard, it is invasive and limited to pure intraluminal vascular imaging, rendering CTA a more versatile choice for initial assessment including intraluminal and extraluminal evaluation. Recent advancements in CTA technology, such as dual-energy and photon-counting, have further improved the safety profile of CTA while maintaining diagnostic accuracy [37].

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There is an added benefit to provide temporal information of native imaging, particularly useful in the setting of active arterial extravasation. In addition, triple-phase acquisition with precontrast, arterial, and venous phases can discern arterial from venous source of bleeding, and therefore this is the preferred protocol approach compared to CTA abdomen and pelvis with IV contrast though without native imaging [38].

US Aorta Abdomen With IV Contrast. Contrast-enhanced US (CEUS) is an evolving imaging modality for the detection and evaluation of renal or splanchnic aneurysms, offering a noninvasive alternative to CTA. The contrast agent is nonnephrotoxic and is excreted through the respiratory tract. Conventional US uses high-frequency sound waves to generate real-time images of abdominal structures, providing valuable information about aneurysm size, shape, and vascular flow patterns. Doppler US further enhances the technique by assessing blood flow dynamics and identifying turbulent or abnormal flow patterns within aneurysms [39,40]. Furthermore, the addition of intravascular contrast agents have enhanced the usefulness of multiparametric US in this context. Widely adopted for aortic applications, CEUS employs microbubble-based contrast agents to improve visualization of blood vessels, allowing for a more detailed assessment of aneurysmal morphology and flow characteristics. This is particularly beneficial for small or complex aneurysms that may be challenging to evaluate using conventional US techniques. CEUS also enables the detection of associated complications, such as aneurysm rupture or pseudoaneurysm formation by identifying active extravasation or subtle wall irregularities [41,42]. US remains one of the first-line imaging modalities, especially in hemodynamically stable patients. The addition of contrast agents for US imaging is currently under development.

The use of sonography in renal or splanchnic aneurysm is limited by unfavorable patient body habitus. Larger

patients and overshadowing bowel gas may preclude sonographic assessment. Therefore, the use of CEUS is mostly limited to vascular territories that can be reliably assessed by US, such as the distal splenic artery and hepatic artery. Furthermore, there has been no direct comparison study between US and other imaging modalities in the setting of splanchnic artery aneurysm evaluation. To date, only small case series have been reported in the literature, which have generally shown that US (including CEUS) could be used successfully for the detection of renal or splanchnic artery aneurysms [39,40,43,44].

US Duplex Doppler Aorta Abdomen. Conventional US uses high-frequency sound waves to generate real-time images of abdominal structures, providing valuable information about aneurysm size, shape, and vascular flow patterns. Doppler US further enhances the technique by assessing blood flow dynamics and identifying turbulent or abnormal flow patterns within aneurysms [39,40]. US remains one of the first-line imaging modalities, especially in hemodynamically stable patients. However, the use of sonography in renal or splanchnic aneurysm is limited by unfavorable patient body habitus. Larger patients and overshadowing bowel gas may preclude sonographic assessment. Furthermore, there has been no direct comparison study between US and other imaging modalities in the setting of splanchnic artery aneurysm evaluation. To date, only small case series have been reported in the literature, which have demonstrated that US (including CEUS) could be used successfully for the detection of renal or splanchnic artery aneurysms [39,40,43,44].

MRA Abdomen and Pelvis Without IV Contrast. No currently available literature supports the use of MRA abdomen and pelvis without IV contrast for initial imaging in patients with suspected renal or splanchnic aneurysm. Some studies have demonstrated the feasibility of noncontrast MRA sequences for imaging visceral or renal aneurysms in smaller patient populations [45-47]. One study with 30 patients revealed a good diagnostic performance of unenhanced MRA abdomen compared to contrast-enhanced MRA for general evaluation of the abdominal arterial vasculature [48].

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MRA abdomen compared to contrast-enhanced MRA for general evaluation of the abdominal arterial vasculature [48]. MRA abdomen without IV contrast may be an option for patients with contraindications for MRI and CT contrast agent if technique and local expertise are available.

CT Abdomen and Pelvis With IV Contrast. CT abdomen and pelvis with intravenous (IV) contrast could be one of the useful imaging modalities for evaluating suspected renal or splanchnic aneurysms. Its rapid acquisition and high-resolution imaging capabilities render it a valuable tool in clinical practice. Contrast-enhanced CT offers detailed anatomical visualization of the vascular system and surrounding structures, thereby allowing for precise localization and characterization of the renal or splanchnic aneurysms. It provides critical information regarding the size, shape, wall characteristics, and associated thrombus or calcification within the aneurysm, as well as its relationship with adjacent organs [28,49].

As previously mentioned, the presentation of symptomatic renal or splanchnic aneurysm overlaps with that of other intra-abdominal pathologies; please refer to the ACR Appropriateness Criteria® topic on “Acute Nonlocalized Abdominal Pain” for further details [15].

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Arteriography Abdomen. Invasive angiography remains the reference standard for the diagnosis of visceral aneurysms due to its superior spatial and temporal resolution, dynamic evaluation capabilities, and potential for concurrent endovascular therapeutic intervention [17]. However, it should be noted that invasive angiography is typically reserved for cases of diagnostic uncertainty after performance of cross-sectional imaging or planned concurrent endovascular therapy.

Unlike noninvasive imaging modalities such as CTA and MRA, invasive angiography offers real-time visualization of blood flow dynamics and precise delineation of the vascular anatomy, thereby providing highly advantageous information in complex or ambiguous cases. The high spatial and temporal resolution is critical for identifying small aneurysms or subtle vascular abnormalities that might be missed or misinterpreted on other noninvasive imaging modalities [10,50].

As previously mentioned, invasive angiography can offer concurrent endovascular therapeutic interventions. For example, once an aneurysm is identified, embolization and/or stent graft placement can be performed during the

same session, thereby reducing the need for additional procedures and minimizing delays in treatment. This is particularly relevant in cases of symptomatic or ruptured renal or splanchnic aneurysms [51-57].

However, invasive angiography is associated with complications, such as vascular injury, access site complications, and contrast load. In addition, invasive angiography is time and labor intensive. Therefore, it should be reserved for cases where initial imaging has concerning findings for impending rupture or ongoing bleeding of the detected renal or splanchnic aneurysm or for those cases where high-risk features exist, such as large size, accelerated growth over time, or significant size with concurrent pregnancy.

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MRI Abdomen and Pelvis Without and With IV Contrast. No currently available literature supports the use of MRI abdomen and pelvis without and with IV

contrast for evaluating patients with suspected renal or splanchnic artery aneurysm. In all clinically relevant situations, an MRA would be better suited for this indication.

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CT Abdomen and Pelvis Without IV Contrast. The current literature does not support the use of CT abdomen and pelvis without IV contrast for evaluating patients with suspected renal or splanchnic artery aneurysm. Opacification of the arterial system is required for proper diagnosis and assessment of renal or splanchnic aneurysms.

CT Abdomen Without IV Contrast. The current literature does not support the use of CT abdomen without IV contrast for evaluating patients with suspected renal or splanchnic artery aneurysm. Opacification of the arterial system is required for proper diagnosis and assessment of renal or splanchnic aneurysms.

Variant 2: Adult. Known splanchnic or renal artery aneurysm. Active surveillance.

Once detected, renal or splanchnic artery aneurysms require close follow-up and surveillance due to their potential for life-threatening complications, such as rupture or thrombosis. The risk of rupture increases with aneurysm size, growth rate, pregnancy status, and certain locations. Studies indicate that aneurysms >2 cm or those exhibiting rapid growth are at significantly higher risk for rupture, warranting vigilant monitoring along with clear management strategies [58-60].

Regular surveillance contributes to identifying subtle changes in aneurysm size and morphology, enabling timely intervention. Advanced imaging modalities, such as CTA, MRA, and US with or without IV contrast, are used to

evaluate the stability of the aneurysm and to detect complications. These evaluations are particularly crucial for asymptomatic aneurysms under conservative management. Monitoring also ensures that emerging technologies or less invasive (endovascular) treatment approaches can be considered when appropriate.

Posttreatment follow-up is critical as well. Endovascular procedures, such as coil embolization or stent grafting, carry risks of complications, such as development of endoleaks or stent graft migration [61]. Surveillance imaging ensures that these matters are promptly addressed, thereby preserving the long-term success of the intervention. Additionally, follow-up helps to track the development of new aneurysms in patients with underlying high-risk conditions, such as connective tissue disorders or vasculitis.

MRA Abdomen and Pelvis With IV Contrast. MRA has become an integral tool in the surveillance of renal or splanchnic artery aneurysms due to its superior imaging capabilities and noninvasive nature. In addition, CTA can be limited by metal artifacts in cases of transcatheter embolization of renal or splanchnic artery aneurysms (eg, splenic artery aneurysm), which may affect MRA images to a lesser degree depending on the deployed coil material. Recent studies have shown that platinum-based coils produce decreased amounts of artifact on MRA, thereby enabling assessment of postembolization success [62].

Various MRA techniques have been evaluated in the literature and no standard protocol has been established yet. Nonenhanced MRA typically uses ToF and steady-state free precession sequences to assess for blood flow in the excluded or nonexcluded aneurysmal sac. A recent study has shown that unenhanced MRA could be used to assess for treatment response in patients who underwent endovascular embolization. Minimal artifacts were noted and MRA was able to detect the remnant aneurysmal sac, persistent perfusion, or patent unaffected vasculature [45]. Similarly, contrast-enhanced MRA techniques have been reported in the literature. One recent study has compared contrast-enhanced MRA to digital subtraction angiography (DSA). MRA was able to detect 11 complete occlusions and four residual leaks, whereas DSA was able to visualize 12 complete occlusions and three residual leaks, with an overall agreement of 93% between both modalities. In the neurovascular literature, MRA turned out to be more sensitive than DSA in detecting slow flow reperfusion, possibly secondary to imaging subtraction artifacts affecting DSA images [63,64].

There is currently no direct comparison study between nonenhanced and enhanced MRA in surveying renal or splanchnic artery aneurysms. However, previous studies evaluating a variety of MRA techniques have shown that at

higher magnetic field strength (3T) contrast-enhanced MRA was superior at the appropriate classifications of larger aneurysm remnants [65].

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The location of the known renal or splanchnic aneurysm needs to be taken into consideration in order to decide whether MRA abdomen with IV contrast is sufficient for imaging as opposed to an MRA abdomen and pelvis with IV contrast.

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CTA Abdomen With IV Contrast. CTA has emerged as the imaging modality of choice for the surveillance of known renal or splanchnic aneurysms due to its high spatial resolution, rapid acquisition time, as well as its ability to provide detailed anatomical and vascular information. The modality enables monitoring of aneurysm growth and identify complications, such as risk of rupture, thrombus formation, or incomplete treatment.

One of the primary advantages of CTA is its ability to capture detailed arterial-phase imaging. This is especially valuable in surveillance, as it allows for the longitudinal detection of subtle changes in aneurysm size or morphology over time. The arterial phase also enhances visualization of the feeding vasculature of the aneurysm and associated collateral circulation, thereby aiding in planning for future interventions as clinically warranted [66]. Compared to other modalities, such as US, CTA offers superior diagnostic sensitivity and specificity for identifying small aneurysms or complex vascular anatomy [67].

CTA is particularly beneficial in the follow-up of patients who have undergone surgical or endovascular

treatment for renal or splanchnic aneurysms. This is important, as the natural history of renal or splanchnic aneurysms posttreatment (especially endovascular treatment) is still under investigation. Thrombosed aneurysmal sacs may continue to expand secondary to adjacent high arterial pressure [50,68,69]. Further, CTA can effectively detect complications, such as endoleaks, stent graft migration, or incomplete aneurysm exclusion [66,70-73]. These postprocedural complications are often subtle and require the high-resolution imaging provided by CTA to guide further management. The ability to generate 3-D reconstruction images also facilitates a comprehensive assessment of the vascular anatomy, which is essential for the evaluation of treatment efficacy and for planning of potential reinterventions.

Another advantage of CTA is its standardized imaging protocols. This ensures consistency in serial imaging studies, an important factor in monitoring aneurysms over time and across different facilities. The reproducibility of CTA measurements also aids in assessing the natural history of the aneurysm, evaluating treatment outcomes, and determining the timing of potential interventions.

Various follow-up surveillance protocols have been described in the literature but no standardized protocol has been established yet. The follow-up interval can be as short as 3 months and as long as 1 year, with most studies reporting a minimum of 1 year follow-up and preferably 2 to 3 years follow-up to detect accelerated growth and any delayed complications [49,61,74,75]. Serial surveillance imaging appears to be a safe and effective tool, based on a large published series from the Cleveland Clinic and Mayo Clinic [71,74].

The location of the known renal or splanchnic aneurysm needs to be taken into consideration in order to decide whether CTA abdomen with IV contrast is sufficient for imaging as opposed to a CTA abdomen and pelvis with IV contrast.

CTA Abdomen and Pelvis With IV Contrast. CTA has emerged as the imaging modality of choice for the surveillance of known renal or splanchnic aneurysms due to its high spatial resolution, rapid acquisition time, as well as its ability to provide detailed anatomical and vascular information. The modality enables monitoring of aneurysm growth and identify complications, such as risk of rupture, thrombus formation, or incomplete treatment.

One of the primary advantages of CTA is its ability to capture detailed arterial-phase imaging. This is especially valuable in surveillance, as it allows for the longitudinal detection of subtle changes in aneurysm size or morphology over time. The arterial phase also enhances visualization of the feeding vasculature of the aneurysm and associated

collateral circulation, thereby aiding in planning for future interventions as clinically warranted [66]. Compared to other modalities, such as US, CTA offers superior diagnostic sensitivity and specificity for identifying small aneurysms or complex vascular anatomy [67].

CTA is particularly beneficial in the follow-up of patients who have undergone surgical or endovascular treatment for renal or splanchnic aneurysms. This is important, as the natural history of renal or splanchnic aneurysms posttreatment (especially endovascular treatment) is still under investigation. Thrombosed aneurysmal sacs may continue to expand secondary to adjacent high arterial pressure [50,68,69]. Further, CTA can effectively detect complications, such as endoleaks, stent graft migration, or incomplete aneurysm exclusion [66,70-73]. These postprocedural complications are often subtle and require the high-resolution imaging provided by CTA to guide further management. The ability to generate 3-D reconstruction images also facilitates a comprehensive assessment of the vascular anatomy, which is essential for evaluating treatment efficacy and for planning potential reinterventions.

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US Aorta Abdomen With IV Contrast. US is a valuable imaging modality for the surveillance of known renal or splanchnic artery aneurysms, offering a noninvasive alternative to cross-sectional imaging. If the aneurysm is visible, US, particularly when combined with Doppler imaging provides a practical solution for both initial evaluation and routine follow-up of these aneurysms.

The real-time imaging capability of US enables clinicians to assess aneurysm morphology, measure its size, and monitor changes over time [73,76]. The use of Doppler US enhances its usefulness by providing functional information with regard to blood flow patterns, velocities, and turbulence within the known renal or splanchnic aneurysm.

As previously discussed, an US examination can be affected by the body habitus. Therefore, it is likely more useful in certain splanchnic aneurysms with favorable superficial location enabling visualization, such as more distal splenic artery aneurysms. Its noninvasive nature make it a safer option for vulnerable populations, such as pregnant or young patients. Furthermore, advancements in US technology, such as CEUS, have significantly improved its diagnostic accuracy [39,40,43,44]. CEUS uses microbubble contrast agents to enhance vascular imaging, providing a clear delineation of the aneurysm wall from surrounding structures and enabling evaluation of perfusion patterns without the risks associated with iodinated or gadolinium-based contrast agents. Elimination of the gas-containing lipid microspheres is mediated via hepatic breakdown of the phospholipid shell via endogenous phospholipid metabolic pathways followed by eventual pulmonary diffusion of the internal high-density gas within minutes of contrast administration.

US Duplex Doppler Aorta Abdomen. Conventional US uses high-frequency sound waves to generate real-time images of abdominal structures, providing valuable information about aneurysm size, shape, and vascular flow patterns. Doppler US further enhances the technique by assessing blood flow dynamics and identifying turbulent or abnormal flow patterns within aneurysms [39,40]. US remains one of the first-line imaging modalities, especially in hemodynamically stable patients. However, the use of sonography in renal or splanchnic aneurysm is limited by unfavorable patient body habitus. Larger patients and overshadowing bowel gas may preclude sonographic assessment. Furthermore, there has been no direct comparison study between US and other imaging modalities in the setting of splanchnic artery aneurysm evaluation. To date, only small case series have been reported in the literature, which have generally shown that US (including CEUS) could be used successfully for the detection of renal or splanchnic artery aneurysms [39,40,43,44].

MRA Abdomen and Pelvis Without IV Contrast. No currently available literature supports the use of MRA abdomen and pelvis without IV contrast for active surveillance of renal or splanchnic aneurysm. Limited case series have been published describing the role of MRA without contrast for splanchnic or renal aneurysms post endovascular treatment. One case series demonstrated the feasibility of noncontrast MRA after coil embolization in a small patient group with renal and splenic aneurysms [45]. One recent case series with five patients after coil embolization of visceral artery aneurysms describes unenhanced MRA as a feasible tool for follow-up

evaluation with fewer susceptibility artifacts compared to contrast enhanced MRA [77].

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CT Abdomen and Pelvis With IV Contrast. Contrast-enhanced CT is a valuable imaging modality for the surveillance of renal or splanchnic aneurysms due to its high spatial resolution and ability to provide detailed anatomical and functional information. One of the primary advantages of contrast-enhanced CT for surveillance is its ability to delineate the relationship between the aneurysm and adjacent organs or structures [49]. This is necessary in assessing growth patterns and determining the potential impact on the nearby vascular and visceral systems. The modality also enables the detection of secondary imaging features such as intraluminal thrombus, calcification, or wall irregularities, which may indicate an increased risk of rupture [78].

However, it should be noted that contrast-enhanced CT is usually performed in the portal venous phase and therefore not tailored to examine the arterial vasculature precisely unlike multiphase CTA. As will be discussed in the following section, CTA is superior in the delineation of the vascular anatomy and assessment of treatment response.

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vasculature precisely unlike multiphase CTA. As will be discussed in the following section, CTA is superior in the delineation of the vascular anatomy and assessment of treatment response.

The location of the known renal or splanchnic aneurysm needs to be considered to decide whether CT abdomen with IV contrast is sufficient for imaging as opposed to a CT abdomen and pelvis with IV contrast.

CT Abdomen and Pelvis Without and With IV Contrast. Contrast-enhanced CT is a valuable imaging modality for the surveillance of renal or splanchnic aneurysms due to its high spatial resolution, and ability to provide detailed anatomical and functional information. One of the primary advantages of contrast-enhanced CT for surveillance is its ability to delineate the relationship between the aneurysm and adjacent organs or structures [49]. This is necessary in assessing growth patterns and determining the potential impact on the nearby vascular and visceral systems. The modality also enables the detection of secondary imaging features such as intraluminal thrombus, calcification, or wall irregularities, which may indicate an increased risk of rupture [78]. However, it should be noted that contrast-enhanced CT is usually performed in the portal venous phase and therefore not tailored to examine the arterial vasculature precisely unlike multiphase CTA. As will be discussed in the following section, CTA is superior in the delineation of the vascular anatomy and assessment of treatment response.

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The location of the known renal or splanchnic aneurysm needs to be considered to decide whether CT

abdomen without and with IV contrast is sufficient for imaging as opposed to a CT abdomen and pelvis without and with IV contrast.

Arteriography Abdomen. Although arteriography remains the reference standard for aneurysmal assessment, routine arteriography is not useful for aneurysm surveillance given its invasive nature and resource intensiveness. Routine arteriography is only useful if concomitant endovascular treatment is planned.

Arteriography Abdomen and Pelvis. Although arteriography remains the reference standard for aneurysmal assessment, routine arteriography is not useful for aneurysm surveillance given its invasive nature and resource intensiveness. Routine arteriography is only useful if concomitant endovascular treatment is planned.

MRI Abdomen and Pelvis Without and With IV Contrast. MRA has become an integral tool in the surveillance of renal or splanchnic artery aneurysms due to its superior imaging capabilities and noninvasive nature. In addition, CTA can be limited by metal artifacts in cases of transcatheter embolization of renal or splanchnic artery aneurysms (eg, splenic artery aneurysm), which may affect MRA images to a lesser degree depending on the deployed coil material. Recent studies have shown that platinum-based coils produce decreased amounts of artifact on MRA, thereby enabling assessment of postembolization success [62].

However, without a dedicated angiographic vascular imaging component, MRI is likely less sensitive in detecting interval changes in comparison to MRA. There is currently no direct comparison studies between the two modalities.

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However, without a dedicated angiographic vascular imaging component, MRI is likely less sensitive in detecting interval changes in comparison to MRA. There is currently no direct comparison studies between the two modalities.

CT Abdomen and Pelvis Without IV Contrast. There is no relevant literature to support the use of CT abdomen and pelvis without IV contrast for surveillance in patients with known renal or splanchnic artery aneurysms.

CT Abdomen Without IV Contrast. The current literature does not support the use of CT abdomen without IV contrast for surveillance in patients with known renal or splanchnic artery aneurysm.

Variant 3: Pregnant. Suspected splanchnic or renal artery aneurysm. Initial imaging.

As previously discussed, renal or splanchnic artery aneurysms are often found incidentally on cross-sectional imaging performed for other clinical indications and this is especially true for those patients who have asymptomatic renal or splanchnic aneurysms [14]. On the other hand, the initial presentations of symptomatic renal or splanchnic aneurysms overlap with other intra-abdominal pathologies, including nonspecific abdominal pain. In

such settings, please refer to the ACR Appropriateness Criteria® topic on “Acute Nonlocalized Abdominal Pain” for further details [15]. US is usually recommended as the first-line imaging modality for nonlocalized abdominal pain in pregnancy, followed by MRI without IV contrast. CTA is often contraindicated given the radiation exposure and MRI with contrast is contraindicated given the IV gadolinium administration.

Once a renal or splanchnic aneurysm is discovered on US or other cross-sectional imaging, more dedicated imaging is warranted to determine the etiology and anatomic location of the disease, including dedicated angiographic vascular imaging to assess the size and morphology of the lesion, if these aspects remain unclear based on initial imaging.

US Aorta Abdomen With IV Contrast. US is the preferred first-line imaging modality for assessing renal or splanchnic artery aneurysms in pregnancy due to its safety profile, noninvasive nature, and lack of ionizing radiation exposure. Pregnancy poses unique challenges in imaging, as the physiological changes, including increased blood volume and vessel wall stress may exacerbate the risk of aneurysm growth and rupture [79-81]. US provides a practical and dynamic tool for evaluating these vascular abnormalities without exposing the fetus to potential harm. Per the Society of Vascular Surgery and the European Society of Vascular Surgery recommendations, US remains the first-line diagnostic modality in assessing renal or splanchnic artery aneurysms [82,83].

Although there exists a paucity of literature on the use of US in assessment of splanchnic artery aneurysms in pregnant patients, this modality allows for the assessment of aneurysm size, shape, and location [39,40]. Doppler US enhances this usefulness by providing functional information about blood flow patterns and velocities within the aneurysm, which may enable assessment of rupture risk or other complications [40]. US is likely more effective for more superficial vasculature, such as the splenic arterial system. It should be noted that US would be the most suitable to perform in the first trimester or first half of the second trimester. At the end of the second and the entirety of third trimester, it may be very challenging to evaluate splanchnic and renal aneurysms as the gravid uterus will obscure evaluation of the central and mesenteric vasculature.

Despite its advantages, US has inherent limitations in assessing deeply located aneurysms, such as those in the celiac axis or superior and inferior mesenteric arterial vasculature, especially in patients with increased body mass index or when the fetus and uterus obscure imaging windows [84]. In these cases, it may serve as a screening tool

before transitioning to more advanced modalities, such as nonenhanced MRA or invasive angiography if active extravasation is expected requiring concomitant endovascular intervention.

It should be noted that the European Federation of Societies for Ultrasound in Medicine and Biology guidelines and recommendations for the clinical practice of CEUS do not recommend routine use of US contrast agents in obstetrics because of potential adverse effects of CEUS on the fetus [85]. However, due to their size it seems unlikely that US microbubbles can pass through the capillary bed of the placenta. Small studies have shown that the CEUS contrast agent could be safely administered in pregnant women without fetal complications [86].

US Duplex Doppler Aorta Abdomen. Conventional US uses high-frequency sound waves to generate real-time images of abdominal structures, providing valuable information about aneurysm size, shape, and vascular flow patterns. Doppler US further enhances the technique by assessing blood flow dynamics and identifying turbulent or abnormal flow patterns within aneurysms [39,40]. US remains one of the first-line imaging modalities, especially in hemodynamically stable patients. However, the use of sonography in renal or splanchnic aneurysm is limited by unfavorable patient body habitus and operator dependency of the modality. Larger patients and overshadowing bowel gas may preclude sonographic assessment. Furthermore, there has been no direct comparison study between US and other imaging modalities in the setting of splanchnic artery aneurysm evaluation. To date, only small case series have been reported in the literature, which have generally shown that US (including CEUS) could be used successfully for the detection of renal or splanchnic artery aneurysms [39,40,43,44].

MRA Abdomen and Pelvis Without IV Contrast. MRA abdomen and pelvis without IV contrast may be a suitable imaging modality for initial evaluation of renal or splanchnic artery aneurysm during pregnancy. It avoids administration of gadolinium-based contrast agents and the modality is not associated with radiation exposure. Some studies have demonstrated the feasibility of noncontrast MRA sequences for imaging visceral or renal aneurysms in smaller nonpregnant patient populations [45-47].

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visceral or renal aneurysms in smaller nonpregnant patient populations [45-47].

CTA Abdomen With IV Contrast. Given the ionized radiation exposure, CTA should be avoided in pregnant patients if at all possible. In an emergent situation, CTA may be performed given its rapid acquisition time.

CTA Abdomen and Pelvis With IV Contrast. Given the ionized radiation exposure, CTA should be avoided in pregnant patients if at all possible. In an emergent situation, CTA may be performed given its rapid acquisition time.

Arteriography Abdomen. There is currently no indication for arteriography for nonemergent assessment of renal or splanchnic artery aneurysm. In an emergent situation such as aneurysmal rupture and active arterial extravasation, the benefits and risks of endovascular therapy should be weighed against an open surgical repair approach and is beyond the scope of this document.

Arteriography Abdomen and Pelvis. There is no current indication for arteriography for nonemergent assessment of renal or splanchnic artery aneurysm. In an emergent situation such as aneurysmal rupture and active arterial extravasation, the benefits and risks of endovascular therapy should be weighed against an open surgical repair approach and is beyond the scope of this document.

MRA Abdomen and Pelvis With IV Contrast. MRA with IV contrast should be avoided in pregnant patients given the uncertain risk profile of gadolinium in pregnancy [87]. Newer MRA with IV contrast approaches include the administration of ferumoxytol as contrast agent and pulmonary MRA imaging with ferumoxytol as gadolinium alternative for the detection of pulmonary embolism has been described in a pregnant patient population reference [88].

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MRI Abdomen and Pelvis Without and With IV Contrast. MRI with IV contrast should be avoided in pregnant patients given the uncertain risk profile of gadolinium in pregnancy [87]. Further, without a dedicated angiographic vascular imaging component, MRI is likely less sensitive in detecting pathology in the arterial vasculature. Newer MRA with IV contrast approaches include the administration of ferumoxytol as contrast agent and pulmonary MRA imaging with ferumoxytol as gadolinium alternative for the detection of pulmonary embolism has been described in a pregnant patient population reference [88].

MRI Abdomen and Pelvis Without IV Contrast. Without a dedicated angiographic vascular imaging component, MRI is likely less sensitive in detecting pathology in the arterial vasculature.

Noncontrast MRA is a safe and effective imaging modality for evaluating renal or splanchnic artery aneurysms during pregnancy. It avoids the administration of contrast agents, eliminating concerns about potential risks to the fetus associated with gadolinium-based contrast agents [87]. This makes it particularly suitable for pregnant patients, in whom the priority is to ensure both maternal and fetal safety while obtaining accurate diagnostic information. Noncontrast MRA techniques, such as ToF and phase-contrast imaging, have the ability to provide detailed visualization of vascular structures and blood flow, thereby enabling the assessment of aneurysm size, morphology, and hemodynamics [20,21,45].

These techniques are valuable for deeply located aneurysms in the celiac axis, superior or inferior mesenteric arterial system, or renal arteries, which may not be well visualized using US. Noncontrast MRA also excels in evaluating adjacent vascular and soft tissue structures, thereby allowing comprehensive assessment without the risks of ionizing radiation exposure or nephrotoxic contrast agent administration, which are associated with CT-based modalities, such as CTA. Although noncontrast MRA may have slightly lower spatial resolution compared to contrast-

enhanced MRA, recent advancements in imaging protocols have improved its reliability [89].

MRI Abdomen Without and With IV Contrast. MRI with IV contrast should be avoided in pregnant patients given the uncertain risk profile of gadolinium in pregnancy. Further, without a dedicated angiographic vascular imaging component, MRI is likely less sensitive in detecting pathology in the arterial vasculature.

In pregnancy, MRA is preferred compared to CTA. Newer MRA with IV contrast approaches include the administration of ferumoxytol as contrast agent and pulmonary MRA imaging with ferumoxytol as gadolinium alternative for the detection of pulmonary embolism has been described in a pregnant patient population reference [88].

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CT Abdomen and Pelvis With IV Contrast. Given the ionized radiation exposure, CT should be avoided in pregnant patients if at all possible. In an emergent situation, CTA may be performed given its rapid acquisition time.

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Variant 4: Pregnant. Known splanchnic or renal artery aneurysm. Active surveillance.

More commonly, renal or splanchnic artery aneurysms are known in pregnant patients since they have been discovered during prior imaging. Surveillance of known renal or splanchnic artery aneurysms during pregnancy is crucial due to the heightened risk of complications secondary to potential accelerated growth and accelerated induction of vessel wall abnormalities during pregnancy, including risk of rupture carrying significant maternal and fetal mortality rates [80,90-93]. Pregnancy induces physiological changes such as increased blood volume, cardiac output, and hormonal effects on vascular walls, all of which can accelerate aneurysm growth and/or compromise wall integrity [91,94]. Timely surveillance allows for early detection of aneurysm progression, enabling appropriate management strategies to prevent rupture and other complications, thereby improving outcomes.

Despite the potential threatening consequences of existing renal or splanchnic artery aneurysms in the pregnant population, no consensus guidelines have been developed regarding the frequency and duration of surveillance imaging during pregnancy.

US Aorta Abdomen With IV Contrast. US is the preferred first-line imaging modality for assessing renal or splanchnic artery aneurysms in pregnancy due to its safety profile, noninvasive nature, and lack of ionizing radiation exposure. Pregnancy poses unique challenges in imaging, as

the physiological changes, including increased blood volume and vessel wall stress may exacerbate the risk of aneurysm growth and rupture [79-81]. US provides a practical and dynamic tool for evaluating these vascular abnormalities without exposing the fetus to potential harm. Based on The Society of Vascular Surgery and the European Society of Vascular Surgery recommendations, US remains the first-line diagnostic modality in assessing renal or splanchnic artery aneurysms [82,83].

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CTA Abdomen and Pelvis With IV Contrast. Given the ionizing radiation exposure, CTA should be avoided in pregnant patients if at all possible. In an emergent situation, CTA may be performed given its rapid acquisition time.

Arteriography Abdomen. There is no current indication for arteriography for nonemergent surveillance of known renal or splanchnic artery aneurysm in the pregnant

population. In an emergent situation such as aneurysmal rupture and arterial extravasation indicating active arterial bleeding, the benefits and risks of endovascular therapy should be weighed against an open surgical repair approach and is beyond the scope of this document.

Arteriography Abdomen and Pelvis. There is no current indication for arteriography for nonemergent surveillance of known renal or splanchnic artery aneurysm in the pregnant population. In an emergent situation such as aneurysmal rupture and active arterial extravasation, the risks of benefits of endovascular therapy should be weighed against an open surgical repair approach and is beyond the scope of this document.

MRA Abdomen and Pelvis With IV Contrast. MRA with contrast should be avoided in pregnant patients given the uncertain risk profile of gadolinium in pregnancy [87]. Newer MRA with IV contrast approaches include the administration of ferumoxytol as contrast agent and pulmonary MRA imaging with ferumoxytol as gadolinium alternative for the detection of pulmonary embolism has been described in a pregnant patient population reference [88].

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MRI Abdomen and Pelvis Without and With IV Contrast. MRI with IV contrast should be avoided in pregnant patients given the uncertain risk profile of gadolinium in pregnancy. Further, without a dedicated angiographic vascular imaging component, MRI is likely less sensitive in detecting interval changes in comparison to MRA. There is currently no direct comparison studies between the two modalities.

In pregnancy, MRA is preferred compared to CTA. Newer MRA with IV contrast approaches include the administration of ferumoxytol as contrast agent and pulmonary MRA imaging with ferumoxytol as gadolinium alternative for the detection of pulmonary embolism has been described in a pregnant patient population reference [88].

MRI Abdomen and Pelvis Without IV Contrast. Without a dedicated angiographic vascular imaging component, MRI is likely less sensitive in detecting interval changes in comparison to MRA.

Noncontrast MRA is a safe and effective imaging modality for evaluating renal or splanchnic artery aneurysms during pregnancy. It avoids the administration of contrast agents, eliminating concerns about potential risks to the fetus associated with gadolinium-based contrast agents [87]. This makes it particularly suitable for pregnant patients, in whom the priority is to ensure both maternal and fetal safety while obtaining accurate diagnostic information. Noncontrast MRA techniques, such as ToF and phase-contrast imaging have the ability to provide detailed visualization of vascular structures and blood flow, thereby enabling the assessment of aneurysm size, morphology, and hemodynamics [20,21,45].

These techniques are valuable for deeply located aneurysms in the celiac axis, superior or inferior mesenteric arterial system, or renal arteries, which may not be well visualized using US. Noncontrast MRA also excels in evaluating adjacent vascular and soft tissue structures, thereby allowing comprehensive assessment without the risks of ionizing radiation exposure or nephrotoxic contrast agent administration, which are associated with CT-based modalities, such as CTA. Although noncontrast MRA may have slightly lower spatial resolution compared to contrast-enhanced MRA, recent advancements in imaging protocols have improved its reliability [89].

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CT Abdomen and Pelvis With IV Contrast. Given the ionizing radiation exposure, CT should be avoided in pregnant patients if at all possible. In an emergent situation, CTA may be performed given its rapid acquisition time.

CT Abdomen and Pelvis Without IV Contrast. Given the ionizing radiation exposure, CT should be avoided in pregnant patients if at all possible. In an emergent situation, CTA may be performed given its rapid acquisition time.

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CT Abdomen and Pelvis Without and With IV Contrast. Given the ionizing radiation exposure, CT should be avoided in pregnant patients if at all possible. In an emergent situation, CTA may be performed given its rapid acquisition time.

CT Abdomen Without and With IV Contrast. Given the ionizing radiation exposure, CT should be avoided in pregnant patients if at all possible. In an emergent situation, CTA may be performed given its rapid acquisition time.

SUMMARY OF HIGHLIGHTS

This is a summary of the key recommendations from the variant tables. Refer to the complete narrative document for more information.

- **Variants 1 and 2:** CTA of the abdomen or abdomen and pelvis with IV contrast or MRA of the abdomen or abdomen and pelvis with IV contrast is usually appropriate for both initial evaluation and surveillance. CTA and MRA are the alternative examinations of choice since these provide high diagnostic accuracy for aneurysm detection, characterization, and treatment planning. CTA offers superior spatial resolution and rapid acquisition. US of the abdomen, including duplex Doppler or CEUS, may be appropriate in selected patients, particularly for surveillance when the aneurysm is well visualized. Diagnostic catheter angiography is usually not appropriate for routine diagnosis or surveillance and is reserved for cases with diagnostic uncertainty or when concurrent endovascular intervention is planned.
- **Variants 3 and 4:** US of the abdomen, including duplex Doppler as an alternative, is usually appropriate as the initial imaging modality given the absence of ionizing radiation and favorable safety profile. Noncontrast MRA of the abdomen or abdomen and pelvis can be pursued as a complementary procedure when US is nondiagnostic or when deeper vascular structures require further evaluation. CTA and other CT-based examinations are usually not appropriate due to ionizing radiation exposure and should be reserved for emergent situations, particularly when benefits outweigh risks. Catheter angiography is usually not appropriate except in emergent settings when concurrent endovascular treatment is anticipated.

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>.

GENDER EQUALITY AND INCLUSIVITY CLAUSE

The ACR acknowledges the limitations in applying inclusive language when citing research studies that predates the use of the current understanding of language inclusive of diversity in sex, intersex, gender, and gender-diverse people. The data variables regarding sex and gender used in the cited literature will not be changed. However, this guideline will use the terminology and definitions as proposed by the National Institutes of Health [96].

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) [97]
- ACR–SPR Practice Parameter for Imaging Pregnant or Potentially Pregnant Patients with Ionizing Radiation [98]
- ACR–ACOG–AIUM–SMFM–SRU Practice Parameter for the Performance of Standard Diagnostic Obstetrical Ultrasound [99]
- ACR Manual on Contrast Media [100]
- ACR Manual on MR Safety [101]

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 2). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document [102].

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