American College of Radiology
ACR Appropriateness Criteria®
Suspected and Known Renal or Splanchnic Artery Aneurysm

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	O
MRA abdomen and pelvis without and with IV contrast	Usually Appropriate	O
MRA abdomen with IV contrast	Usually Appropriate	O
MRA abdomen without and with IV contrast	Usually Appropriate	O
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	O
US duplex Doppler aorta abdomen	May Be Appropriate	O
MRA abdomen and pelvis without IV contrast	May Be Appropriate	O
MRA abdomen without IV contrast	May Be Appropriate	O
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	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 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	O
MRA abdomen and pelvis without and with IV contrast	Usually Appropriate	O
MRA abdomen with IV contrast	Usually Appropriate	O
MRA abdomen without and with IV contrast	Usually Appropriate	O
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	O
US duplex Doppler aorta abdomen	May Be Appropriate	O
MRA abdomen and pelvis without IV contrast	May Be Appropriate	O
MRA abdomen without IV contrast	May Be Appropriate	O
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	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 and pelvis without IV contrast	Usually Not Appropriate	☢☢☢
CT abdomen without IV contrast	Usually Not Appropriate	☢☢☢

<u>Variant: 3</u> Pregnant. Suspected splanchnic or renal artery aneurysm. Initial imaging.

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

<u>Variant: 4</u> Pregnant. Known splanchnic or renal artery aneurysm. Active surveillance.

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

Panel Members

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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 intraabdominal 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.

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

Variant 1:Adult. Suspected splanchnic or renal artery aneurysm. Initial imaging.
B. Arteriography abdomen and pelvis

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Variant 1:Adult. Suspected splanchnic or renal artery aneurysm. Initial imaging.
C. 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 intraabdominal pathologies; please refer to the ACR Appropriateness Criteria® topic on "Acute Nonlocalized Abdominal Pain" for further details [15].

Variant 1:Adult. Suspected splanchnic or renal artery aneurysm. Initial imaging.
D. CT abdomen and pelvis without and with IV contrast

CT abdomen and pelvis without and with 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 enabling 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 [15].

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

Variant 1:Adult. Suspected splanchnic or renal artery aneurysm. Initial imaging.
F. CT abdomen with IV contrast

CT abdomen with 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 enabling 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 [15].

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Variant 1:Adult. Suspected splanchnic or renal artery aneurysm. Initial imaging.
G. CT abdomen without and with IV contrast

CT abdomen without and with 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 enabling precise localization and characterization of the renal or splanchnic aneurysms. These modalities provide critical information regarding the size, shape, wall characteristics, and associated thrombus or calcification within the aneurysm, as well as its relationship with adjacent organs [15].

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Variant 1:Adult. Suspected splanchnic or renal artery aneurysm. Initial imaging.
H. 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 1:Adult. Suspected splanchnic or renal artery aneurysm. Initial imaging.
I. CTA abdomen and pelvis 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 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. 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 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 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].

Variant 1:Adult. Suspected splanchnic or renal artery aneurysm. Initial imaging.
J. CTA abdomen and pelvis without and 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 aneurysms.

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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].

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

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

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

Variant 1:Adult. Suspected splanchnic or renal artery aneurysm. Initial imaging.
M. MRA abdomen and pelvis without and 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 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; however, 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 manuscript 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.

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

Variant 1:Adult. Suspected splanchnic or renal artery aneurysm. Initial imaging.
O. MRA abdomen 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 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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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.

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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.

Variant 1:Adult. Suspected splanchnic or renal artery aneurysm. Initial imaging.
P. MRA abdomen without and 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 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; however, 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 manuscript from 2000 compared contrast-enhanced MRA to catheter angiography in the evaluation of the mesenteric circulation revealing a moderate agreement between the two modalities (κ = 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 (κ = 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.

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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 without and with IV contrast is sufficient for imaging as opposed to an MRA abdomen and pelvis without and with IV contrast.

Variant 1:Adult. Suspected splanchnic or renal artery aneurysm. Initial imaging.
Q. MRA abdomen without IV contrast

No currently available literature supports the use of MRA abdomen 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]. 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.

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

Variant 1:Adult. Suspected splanchnic or renal artery aneurysm. Initial imaging.
S. MRI abdomen and pelvis without IV contrast

No currently available literature supports the use of MRI abdomen and pelvis without 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.

Variant 1:Adult. Suspected splanchnic or renal artery aneurysm. Initial imaging.
T. MRI abdomen without and with IV contrast

No currently available literature supports the use of MRI abdomen 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.

Variant 1:Adult. Suspected splanchnic or renal artery aneurysm. Initial imaging.
U. MRI abdomen without IV contrast

No currently available literature supports the use of MRI abdomen without 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.

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

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

W. 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].

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.

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

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

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

C. 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.

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

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

Variant 2:Adult. Known splanchnic or renal artery aneurysm. Active surveillance.
F. CT abdomen 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] .

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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.

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

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.

Variant 2:Adult. Known splanchnic or renal artery aneurysm. Active surveillance.
H. 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 2:Adult. Known splanchnic or renal artery aneurysm. Active surveillance.
I. 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 [70, 71, 73] [66, 72]. 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.

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].

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

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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.

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

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

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Variant 2:Adult. Known splanchnic or renal artery aneurysm. Active surveillance.
M. 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 5 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].

Variant 2:Adult. Known splanchnic or renal artery aneurysm. Active surveillance.
N. MRA abdomen 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 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].

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.

Variant 2:Adult. Known splanchnic or renal artery aneurysm. Active surveillance.
O. MRA abdomen 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].

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 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].

The location of the known 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 with IV contrast.

Variant 2:Adult. Known splanchnic or renal artery aneurysm. Active surveillance.
P. MRA abdomen without IV contrast

No currently available literature supports the use of MRA abdomen 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 5 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].

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

Variant 2:Adult. Known splanchnic or renal artery aneurysm. Active surveillance.
R. MRI abdomen and pelvis without 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.

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

Variant 2:Adult. Known splanchnic or renal artery aneurysm. Active surveillance.
T. MRI abdomen without 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.

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

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

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 intraabdominal 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.

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

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

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

Variant 3:Pregnant. Suspected splanchnic or renal artery aneurysm. Initial imaging.
D. CT abdomen and pelvis without and 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.

Variant 3:Pregnant. Suspected splanchnic or renal artery aneurysm. Initial imaging.
E. CT abdomen and pelvis without 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.

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

Variant 3:Pregnant. Suspected splanchnic or renal artery aneurysm. Initial imaging.
G. CT abdomen without and 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.

Variant 3:Pregnant. Suspected splanchnic or renal artery aneurysm. Initial imaging.
H. CT abdomen without 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.

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

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

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

Variant 3:Pregnant. Suspected splanchnic or renal artery aneurysm. Initial imaging.
L. MRA abdomen and pelvis without and 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].

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

M. 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 pregnangypregnancy. It avoids administration of Gadolinium gadolinium-based contrast agents and the modality is not associated with radiation exposure. Some studies have demonstrated the feasibility of non-contrastnoncontrast MRA sequences for imaging visceral or renal aneurysms in smaller nonpregnant patient populations [45-47].

Variant 3:Pregnant. Suspected splanchnic or renal artery aneurysm. Initial imaging.
N. MRA abdomen 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].

Variant 3:Pregnant. Suspected splanchnic or renal artery aneurysm. Initial imaging.
O. MRA abdomen without and 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].

Variant 3:Pregnant. Suspected splanchnic or renal artery aneurysm. Initial imaging.
P. MRA abdomen without IV contrast

MRA abdomen 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 gadolinium-based contrast agents and the modality is not associated with radiation exposure. Some studies have demonstrated the feasibility of non-contrastnoncontrast MRA sequences for imaging visceral or renal aneurysms in smaller nonpregnant patient populations [45-47].

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

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

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

Variant 3:Pregnant. Suspected splanchnic or renal artery aneurysm. Initial imaging.
T. MRI abdomen 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 is 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 diagnostic reliability[89] .

Variant 3:Pregnant. Suspected splanchnic or renal artery aneurysm. Initial imaging.
U. 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 (EFSUMB) Guidelines guidelines and Recommendations recommendations for the Clinical clinical Practice 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 ultrasound 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].

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

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.

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

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

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

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

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

E. 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.

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

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

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

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

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

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

Variant 4:Pregnant. Known splanchnic or renal artery aneurysm. Active surveillance.
L. MRA abdomen and pelvis without and 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].

Variant 4:Pregnant. Known splanchnic or renal artery aneurysm. Active surveillance.
M. MRA abdomen and pelvis without IV contrast

MRA abdomen and pelvis without IV contrast may be a suitable imaging modality for surveillance of renal or splanchnic artery aneurysm during pregnancy. It avoids administration of Gadolinium

gadolinium-based contrast agents and the modality is not associated with radiation exposure. Small studies in non pregnant patients have demonstrated the feasibility of noncontrast MRA sequences for surveillance after endovascular coiling of splanchnic or renal aneurysm [45, 77, 95].

Variant 4:Pregnant. Known splanchnic or renal artery aneurysm. Active surveillance.
N. MRA abdomen 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].

Variant 4:Pregnant. Known splanchnic or renal artery aneurysm. Active surveillance.
O. MRA abdomen without and 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 [88].

Variant 4:Pregnant. Known splanchnic or renal artery aneurysm. Active surveillance.
P. MRA abdomen without IV contrast

MRA abdomen without IV contrast may be a suitable imaging modality for surveillance of renal or splanchnic artery aneurysm during pregnancy. It avoids administration of Gadolinium gadolinium-based contrast agents and the modality is not associated with radiation exposure. Small studies in non pregnant patients have demonstrated the feasibility of noncontrast MRA sequences for surveillance after endovascular coiling of splanchnic or renal aneurysm [45, 77, 95].

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

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

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

Variant 4:Pregnant. Known splanchnic or renal artery aneurysm. Active surveillance.
T. MRI abdomen 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 is 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 diagnostic reliability [89].

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

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 its usefulness by providing functional information about blood flow patterns and velocities within the aneurysm, which may enable assessment of aneurysm 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 challenging to evaluate splanchnic and renal aneurysms as the gravid uterus may obscure evaluation of the central and mesenteric arterial 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 (EFSUMB) Guidelines guidelines and Recommendations recommendations for the Clinical clinical Practice 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 ultrasound 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].

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

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.

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."

References

1. Brownstein AJ, Erben Y, Rajaee S, et al. Natural history and management of renal artery aneurysms in a single tertiary referral center. Journal of Vascular Surgery. 68(1):137-144, 2018 07.J Vasc Surg. 68(1):137-144, 2018 07.
2. Sellier J, Karam C, Beauchet A, et al. Higher prevalence of splenic artery aneurysms in hereditary hemorrhagic telangiectasia: Vascular implications and risk factors. PLoS ONE [Electronic Resource]. 15(1):e0226681, 2020.PLoS ONE. 15(1):e0226681, 2020.
3. Batagini NC, Constantin BD, Kirksey L, et al. Natural History of Splanchnic Artery Aneurysms. Annals of Vascular Surgery. 73:290-295, 2021 May.Ann Vasc Surg. 73:290-295, 2021 May.
4. Zhang J, Harish K, Speranza G, et al. Natural history of renal artery aneurysms. Journal of Vascular Surgery. 77(4):1199-1205.e1, 2023 04.J Vasc Surg. 77(4):1199-1205.e1, 2023 04.
5. Pasha SS, Gloviczki PP, Stanson AA, Kamath PP. Splanchnic artery aneurysms. Mayo Clin Proc 82:472-9, .
6. Leelaudomlipi S, Bramhall SR, Gunson BK, et al. Hepatic-artery aneurysm in adult liver transplantation. Transpl Int 16:257-61, 2003 Apr.
7. Heestand G, Sher L, Lightfoote J, et al. Characteristics and management of splenic artery aneurysm in liver transplant candidates and recipients. [Review] [19 refs]. American Surgeon. 69(11):933-40, 2003 Nov.Am Surg. 69(11):933-40, 2003 Nov.
8. Wayne EJ, Edwards MS, Stafford JM, Hansen KJ, Corriere MA. Anatomic characteristics and natural history of renal artery aneurysms during longitudinal imaging surveillance. J Vasc Surg 60:448-52, 2014 Aug.
9. Mattar SG, Lumsden AB. The management of splenic artery aneurysms: experience with 23 cases. American Journal of Surgery. 169(6):580-4, 1995 Jun.Am J Surg. 169(6):580-4, 1995 Jun.
10. Tulsyan N, Kashyap VS, Greenberg RK, et al. The endovascular management of visceral artery aneurysms and pseudoaneurysms. J Vasc Surg. 45(2):276-83; discussion 283, 2007 Feb.
11. Chaer RA, Abularrage CJ, Coleman DM, et al. The Society for Vascular Surgery clinical

practice guidelines on the management of visceral aneurysms. [Review]. Journal of Vascular Surgery. 72(1S):3S-39S, 2020 07.J Vasc Surg. 72(1S):3S-39S, 2020 07.

12. Rossi M, Krokidis M, Kashef E, Peynircioglu B, Tipaldi MA. CIRSE Standards of Practice for the Endovascular Treatment of Visceral and Renal Artery Aneurysms and Pseudoaneurysms. Cardiovascular & Interventional Radiology. 47(1):26-35, 2024 Jan.Cardiovasc Intervent Radiol. 47(1):26-35, 2024 Jan.

13. Pratesi C, Esposito D, Martini R, et al. Guidelines on the diagnosis, treatment and management of visceral and renal arteries aneurysms: a joint assessment by the Italian Societies of Vascular and Endovascular Surgery (SICVE) and Medical and Interventional Radiology (SIRM). Journal of Cardiovascular Surgery. 65(1):49-63, 2024 Feb.J Cardiovasc Surg (Torino). 65(1):49-63, 2024 Feb.

14. Abbas MM, Stone WW, Fowl RR, et al. Splenic artery aneurysms: two decades experience at Mayo clinic. Ann Vasc Surg 16:442-9, .

15. Scheirey CD, Fowler KJ, Therrien JA, et al. ACR Appropriateness Criteria® Acute Nonlocalized Abdominal Pain. J Am Coll Radiol 2018;15:S217-S31.

16. Schieda N, Blaichman JI, Costa AF, et al. Gadolinium-Based Contrast Agents in Kidney Disease: A Comprehensive Review and Clinical Practice Guideline Issued by the Canadian Association of Radiologists. Can J Kidney Health Dis. 2018;5():2054358118778573.

17. Liu Q, Lu JP, Wang F, et al. Visceral artery aneurysms: evaluation using 3D contrast-enhanced MR angiography. AJR Am J Roentgenol. 191(3):826-33, 2008 Sep.

18. Pilleul F, Beuf O. Diagnosis of splanchnic artery aneurysms and pseudoaneurysms, with special reference to contrast enhanced 3D magnetic resonance angiography: a review. Acta Radiol. 2004 Nov;45(7):702-8.

19. Hagspiel KD, Flors L, Hanley M, Norton PT. Computed tomography angiography and magnetic resonance angiography imaging of the mesenteric vasculature. [Review]. Tech Vasc Interv Radiol. 18(1):2-13, 2015 Mar.

20. Meaney JF. Non-invasive evaluation of the visceral arteries with magnetic resonance angiography. [Review] [32 refs]. Eur Radiol. 9(7):1267-76, 1999.

21. Leiner T. Magnetic resonance angiography of abdominal and lower extremity vasculature. [Review] [237 refs]. Top Magn Reson Imaging. 16(1):21-66, 2005 Feb.

22. Laissy JP, Trillaud H, Douek P. MR angiography: noninvasive vascular imaging of the abdomen. [Review] [74 refs]. Abdom Imaging. 27(5):488-506, 2002 Sep-Oct.

23. Barger AV, Block WF, Toropov Y, Grist TM, Mistretta CA. Time-resolved contrast-enhanced imaging with isotropic resolution and broad coverage using an undersampled 3D projection trajectory. Magn Reson Med. 2002 Aug;48(2):297-305.

24. Ernst O, Asnar V, Sergent G, et al. Comparing contrast-enhanced breath-hold MR angiography and conventional angiography in the evaluation of mesenteric circulation. AJR Am J Roentgenol. 174(2):433-9, 2000 Feb.

25. Carlos RC, Stanley JC, Stafford-Johnson D, Prince MR. Interobserver variability in the evaluation of chronic mesenteric ischemia with gadolinium-enhanced MR angiography. Acad Radiol. 8(9):879-87, 2001 Sep.

26. Meaney JF, Prince MR, Nostrant TT, Stanley JC. Gadolinium-enhanced MR angiography of

visceral arteries in patients with suspected chronic mesenteric ischemia. J Magn Reson Imaging. 7(1):171-6, 1997 Jan-Feb.

27. Wasser MN, Geelkerken RH, Kouwenhoven M, et al. Systolically gated 3D phase contrast MRA of mesenteric arteries in suspected mesenteric ischemia. J Comput Assist Tomogr. 20(2):262-8, 1996 Mar-Apr.

28. Horton KM, Smith C, Fishman EK. MDCT and 3D CT angiography of splanchnic artery aneurysms. [Review] [31 refs]. AJR Am J Roentgenol. 189(3):641-7, 2007 Sep.

29. Horton KM, Fishman EK. CT angiography of the mesenteric circulation. [Review] [53 refs]. Radiol Clin North Am. 48(2):331-45, viii, 2010 Mar.

30. Cikrit DF, Harris VJ, Hemmer CG, et al. Comparison of spiral CT scan and arteriography for evaluation of renal and visceral arteries. Ann Vasc Surg. 10(2):109-16, 1996 Mar.

31. Chappell ET, Moure FC, Good MC. Comparison of computed tomographic angiography with digital subtraction angiography in the diagnosis of cerebral aneurysms: a meta-analysis. Neurosurgery. 2003 Mar;52(3):624-31; discussion 630-1.

32. McKinney AM, Palmer CS, Truwit CL, Karagulle A, Teksam M. Detection of aneurysms by 64-section multidetector CT angiography in patients acutely suspected of having an intracranial aneurysm and comparison with digital subtraction and 3D rotational angiography. AJNR Am J Neuroradiol. 2008;29(3):594-602.

33. Jia Z, Huang Y, Shi H, et al. Comparison of CTA and DSA in the diagnosis of superior mesenteric artery dissecting aneurysm. Vascular. 26(4):346-351, 2018 Aug.

34. Chiesa R, Astore D, Guzzo G, et al. Visceral artery aneurysms. Ann Vasc Surg. 2005 Jan;19(1):42-8.

35. Chadha M, Ahuja C. Visceral artery aneurysms: diagnosis and percutaneous management. Semin Intervent Radiol. 2009 Sep;26(3):196-206.

36. Frauenfelder T, Wildermuth S, Marincek B, Boehm T. Nontraumatic emergent abdominal vascular conditions: advantages of multi-detector row CT and three-dimensional imaging. Radiographics. 24(2):481-96, 2004 Mar-Apr.

37. Zhang LJ, Wu SY, Niu JB, et al. Dual-energy CT angiography in the evaluation of intracranial aneurysms: image quality, radiation dose, and comparison with 3D rotational digital subtraction angiography. AJR Am J Roentgenol. 2010 Jan;194(1):23-30.

38. Saba L, Anzidei M, Lucatelli P, Mallarini G. The multidetector computed tomography angiography (MDCTA) in the diagnosis of splenic artery aneurysm and pseudoaneurysm. [Review]. Acta Radiol. 52(5):488-98, 2011 Jun 01.

39. Badea R. Splanchnic artery aneurysms: the diagnostic contribution of ultrasonography in correlation with other imaging methods. J Gastrointestin Liver Dis. 2008 Mar;17(1):101-5.

40. Ishida H, Konno K, Hamashima Y, et al. Splenic artery aneurysm: value of color Doppler and the limitation of gray-scale ultrasonography. Abdom Imaging. 23(6):627-32, 1998 Nov-Dec.

41. Li X, Staub D, Rafailidis V, Al-Natour M, Kalva S, Partovi S. Contrast-enhanced ultrasound of the abdominal aorta - current status and future perspectives. Vasa. 48(2):115-125, 2019 Mar.

42. Li X, Cokkinos D, Gadani S, et al. Advanced ultrasound techniques in arterial diseases. [Review]. Int J Cardiovasc Imaging. 38(8):1711-1721, 2022 Aug.

43. Pfister K, Kasprzak P, Oikonomou K, et al. [Management of Visceral Artery Aneurysms with Preservation of Organ Perfusion: More Than Twenty Years Experience]. Zentralbl Chir. 2018 Oct;143(5):516-525.

44. Gunabushanam G, Chaubal R, Scoutt LM. Doppler Ultrasound of the Renal Vasculature. [Review]. J Ultrasound Med. 43(8):1543-1562, 2024 Aug.

45. Maruno M, Kiyosue H, Tanoue S, Hongo N, Kashiwagi J, Mori H. Unenhanced magnetic resonance angiography with time-spatial labeling inversion pulse for evaluating visceral artery aneurysms after endosaccular packing with detachable coils: preliminary results. J Vasc Interv Radiol. 24(2):289-93, 2013 Feb.

46. Bultman EM, Klaers J, Johnson KM, et al. Non-contrast enhanced 3D SSFP MRA of the renal allograft vasculature: a comparison between radial linear combination and Cartesian inflow-weighted acquisitions. Magn Reson Imaging. 32(2):190-5, 2014 Feb.

47. Mori R, Kassai Y, Masuda A, et al. Ultrashort echo time time-spatial labeling inversion pulse magnetic resonance angiography with denoising deep learning reconstruction for the assessment of abdominal visceral arteries. J Magn Reson Imaging. 53(6):1926-1937, 2021 06.

48. Gietzen C, Janssen JP, Görtz L, et al. Non-contrast-enhanced MR-angiography of the abdominal arteries: intraindividual comparison between relaxation-enhanced angiography without contrast and triggering (REACT) and 4D contrast-enhanced MR-angiography. Abdom Radiol (NY). 2025 Apr;50(4):1887-1898.

49. Barrionuevo P, Malas MB, Nejim B, et al. A systematic review and meta-analysis of the management of visceral artery aneurysms. J Vasc Surg. 70(5):1694-1699, 2019 11.

50. Loffroy R, Favelier S, Pottecher P, et al. Endovascular management of visceral artery aneurysms: When to watch, when to intervene?. World J Radiol. 7(7):143-8, 2015 Jul 28.

51. Hong Z, Chen F, Yang J, Wu Z, Yan Z. Diagnosis and treatment of splanchnic artery aneurysms: a report of 57 cases. Chin Med J. 112(1):29-33, 1999 Jan.

52. Etezadi V, Gandhi RT, Benenati JF, et al. Endovascular treatment of visceral and renal artery aneurysms. J Vasc Interv Radiol. 22(9):1246-53, 2011 Sep.

53. Kok HK, Asadi H, Sheehan M, Given MF, Lee MJ. Systematic Review and Single-Center Experience for Endovascular Management of Visceral and Renal Artery Aneurysms. [Review]. J Vasc Interv Radiol. 27(11):1630-1641, 2016 Nov.

54. Ruhnke H, Kroncke TJ. Visceral Artery Aneurysms and Pseudoaneurysms: Retrospective Analysis of Interventional Endovascular Therapy of 43 Aneurysms. ROFO Fortschr Geb Rontgenstr Nuklearmed. 189(7):632-639, 2017 Jul.

55. Venturini M, Marra P, Colombo M, et al. Endovascular Repair of 40 Visceral Artery Aneurysms and Pseudoaneurysms with the Viabahn Stent-Graft: Technical Aspects, Clinical Outcome and Mid-Term Patency. Cardiovasc Intervent Radiol. 41(3):385-397, 2018 Mar.

56. Sheahan KP, Alam I, Pehlivan T, et al. A Qualitative Systematic Review of Endovascular Management of Renal Artery Aneurysms. [Review]. .J Vasc Interv Radiol. 35(8):1127-1138, 2024 Aug.

57. Shu K, Shao J, Lai Z, et al. Treatment strategy for splenic artery aneurysms and novel classification based on imaging. J Vasc Surg. 80(3):838-846.e1, 2024 Sep.

58. Hirsch AT, Haskal ZJ, Hertzer NR, et al. ACC/AHA 2005 Practice Guidelines for the management of patients with peripheral arterial disease (lower extremity, renal, mesenteric, and abdominal aortic): a collaborative report from the American Association for Vascular Surgery/Society for Vascular Surgery, Society for Cardiovascular Angiography and Interventions, Society for Vascular Medicine and Biology, Society of Interventional Radiology, and the ACC/AHA Task Force on Practice Guidelines (Writing Committee to Develop Guidelines for the Management of Patients With Peripheral Arterial Disease): endorsed by the American Association of Cardiovascular and Pulmonary Rehabilitation; National Heart, Lung, and Blood Institute; Society for Vascular Nursing; TransAtlantic Inter-Society Consensus; and Vascular Disease Foundation. [Review] [1308 refs]. Circulation. 113(11):e463-654, 2006 Mar 21.Circulation. 113(11):e463-654, 2006 Mar 21.

59. Tétreau RR, Beji HH, Henry LL, Valette PP, Pilleul FF. Arterial splanchnic aneurysms: Presentation, treatment and outcome in 112 patients. Diagn Interv Imaging 97:81-90, .

60. Erben YY, Brownstein AA, Rajaee SS, et al. Natural history and management of splanchnic artery aneurysms in a single tertiary referral center. J Vasc Surg 68:1079-1087, .

61. Gong C, Sun MS, Leng R, et al. Endovascular embolization of visceral artery aneurysm: a retrospective study. Sci Rep. 2023 Apr 28;13(1):6936.

62. Koganemaru M, Abe T, Uchiyama D, et al. Detection of neck recanalization with follow-up contrast-enhanced MR angiography after renal artery aneurysm coil embolization. J Vasc Interv Radiol. 2010 Feb;21(2):298-300.

63. Yamada N, Hayashi K, Murao K, Higashi M, Iihara K. Time-of-flight MR angiography targeted to coiled intracranial aneurysms is more sensitive to residual flow than is digital subtraction angiography. AJNR Am J Neuroradiol. 25(7):1154-7, 2004 Aug.

64. Ferré JC, Carsin-Nicol B, Morandi X, et al. Time-of-flight MR angiography at 3T versus digital subtraction angiography in the imaging follow-up of 51 intracranial aneurysms treated with coils. Eur J Radiol. 2009 Dec;72(3):365-9.

65. Kaufmann TJ, Huston J 3rd, Cloft HJ, et al. A prospective trial of 3T and 1.5T time-of-flight and contrast-enhanced MR angiography in the follow-up of coiled intracranial aneurysms. AJNR Am J Neuroradiol. 31(5):912-8, 2010 May.

66. Saltzberg SS, Maldonado TS, Lamparello PJ, et al. Is endovascular therapy the preferred treatment for all visceral artery aneurysms? Ann Vasc Surg. 2005 Jul;19(4):507-15.

67. Al-Habbal Y, Christophi C, Muralidharan V. Aneurysms of the splenic artery - a review. [Review]. Surgeon Journal of the Royal Colleges of Surgeons of Edinburgh & Ireland. 8(4):223-31, 2010 Aug.Surg.. 8(4):223-31, 2010 Aug.

68. Corey MR, Ergul EA, Cambria RP, et al. The natural history of splanchnic artery aneurysms and outcomes after operative intervention. J Vasc Surg. 63(4):949-57, 2016 Apr.

69. Schanzer H, Papa MC, Miller CM. Rupture of surgically thrombosed abdominal aortic aneurysm. J Vasc Surg. 1985 Mar;2(2):278-80.

70. Guillon R, Garcier JM, Abergel A, et al. Management of splenic artery aneurysms and false aneurysms with endovascular treatment in 12 patients. Cardiovasc Intervent Radiol. 26(3):256-60, 2003 May-Jun.

71. Berceli SA. Hepatic and splenic artery aneurysms. [Review] [23 refs]. Semin Vasc Surg.

18(4):196-201, 2005 Dec.

72. Dorigo W, Pulli R, Azas L, et al. Early and Intermediate Results of Elective Endovascular Treatment of True Visceral Artery Aneurysms. Ann Vasc Surg. 2016 Jan;30():S0890-5096(15)00668-8.

73. Carr SC, Pearce WH, Vogelzang RL, McCarthy WJ, Nemcek AA Jr, Yao JS. Current management of visceral artery aneurysms. Surgery. 120(4):627-33; discussion 633-4, 1996 Oct.

74. Lakin RO, Bena JF, Sarac TP, et al. The contemporary management of splenic artery aneurysms. J Vasc Surg. 53(4):958-64; discussion 965, 2011 Apr.

75. Pitton MB, Dappa E, Jungmann F, et al. Visceral artery aneurysms: Incidence, management, and outcome analysis in a tertiary care center over one decade. Eur Radiol. 25(7):2004-14, 2015 Jul.

76. Sessa C, Tinelli G, Porcu P, Aubert A, Thony F, Magne JL. Treatment of visceral artery aneurysms: description of a retrospective series of 42 aneurysms in 34 patients. Ann Vasc Surg. 18(6):695-703, 2004 Nov.

77. Hamamoto K, Chiba E, Oyama-Manabe N, et al. Ultra-short Echo-time MR Angiography Combined with a Modified Signal Targeting Alternating Radio Frequency with Asymmetric Inversion Slabs Technique to Assess Visceral Artery Aneurysm after Coil Embolization. Magn Reson Med Sci. 2024 Jan 01;23(1):110-121.

78. Henke PK, Stanley JC. Renal artery aneurysms: diagnosis, management and outcomes. [Review] [29 refs]. Minerva Chir. 58(3):305-11, 2003 Jun.

79. Hellmund A, Meyer C, Fingerhut D, Müller SC, Merz WM, Gembruch U. Rupture of renal artery aneurysm during late pregnancy: clinical features and diagnosis. Arch Gynecol Obstet. 2016 Mar;293(3):505-8.

80. Cohen JR, Shamash FS. Ruptured renal artery aneurysms during pregnancy. J Vasc Surg. 1987 Jul;6(1):51-9.

81. Suzuki K, Kashimura H, Sato M, et al. Pancreaticoduodenal artery aneurysms associated with celiac axis stenosis due to compression by median arcuate ligament and celiac plexus. J Gastroenterol. 1998 Jun;33(3):434-8.

82. Chaikof EL, Brewster DC, Dalman RL, et al. The care of patients with an abdominal aortic aneurysm: the Society for Vascular Surgery practice guidelines. [Review] [506 refs]. J Vasc Surg. 50(4 Suppl):S2-49, 2009 Oct.

83. Bjorck M, Koelemay M, Acosta S, et al. Editor's Choice - Management of the Diseases of Mesenteric Arteries and Veins: Clinical Practice Guidelines of the European Society of Vascular Surgery (ESVS). [Review]. Eur J Vasc Endovasc Surg. 53(4):460-510, 2017 04.

84. Pinto F, Miele V, Scaglione M, Pinto A. The use of contrast-enhanced ultrasound in blunt abdominal trauma: advantages and limitations. Acta Radiol. 2014 Sep;55(7):776-84.

85. Sidhu PS, Cantisani V, Dietrich CF, et al. The EFSUMB Guidelines and Recommendations for the Clinical Practice of Contrast-Enhanced Ultrasound (CEUS) in Non-Hepatic Applications: Update 2017 (Long Version). Ultraschall Med. 2018 Apr;39(2):e2-e44.

86. Schwarze V, Marschner C, Negrao de Figueiredo G, Rubenthaler J, Clevert DA. Single-Center Study: Evaluating the Diagnostic Performance and Safety of Contrast-Enhanced Ultrasound

(CEUS) in Pregnant Women to Assess Hepatic Lesions. Ultraschall in der Medizin. 41(1):29-35, 2020 Feb.Ultraschall Med. 41(1):29-35, 2020 Feb.

87. Alghamdi SA. Gadolinium-Based Contrast Agents in Pregnant Women: A Literature Review of MRI Safety. Cureus. 2023 May;15(5):e38493.

88. Starekova J, Nagle SK, Schiebler ML, Reeder SB, Meduri VN. Pulmonary MRA During Pregnancy: Early Experience With Ferumoxytol. J Magn Reson Imaging. 57(6):1815-1818, 2023 06.

89. Nael K, Villablanca JP, Mossaz L, et al. 3-T contrast-enhanced MR angiography in evaluation of suspected intracranial aneurysm: comparison with MDCT angiography. AJR Am J Roentgenol. 2008 Feb;190(2):389-95.

90. Lacroix HH, Bernaerts PP, Nevelsteen AA, Hanssens MM. Ruptured renal artery aneurysm during pregnancy: successful ex situ repair and autotransplantation. J Vasc Surg 33:188-90, .

91. Henke PP, Cardneau JJ, Welling TT, et al. Renal artery aneurysms: a 35-year clinical experience with 252 aneurysms in 168 patients. Ann Surg 234:454-62; discussion 462-3, .

92. Holdsworth RR, Gunn AA. Ruptured splenic artery aneurysm in pregnancy. A review. Br J Obstet Gynaecol 99:595-7, .

93. Barrett JJ, Van Hooydonk JJ, Boehm FF. Pregnancy-related rupture of arterial aneurysms. Obstet Gynecol Surv 37:557-66, .

94. Aung YY, Berry CC, Jayaram PP, Woon EE. Splenic artery aneurysm in pregnancy: A systematic review. Int J Gynaecol Obstet 160:1-11, .

95. Hamamoto K, Chiba E, Oyama-Manabe N, Shinmoto H. Ultra-short echo time magnetic resonance angiography using a modified signal targeting with alternative radio frequency spin labeling technique for detecting recanalized pulmonary arteriovenous malformation after coil embolization. Acta Radiol Open. 2021 Oct;10(10):20584601211057671.

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