New 2025

American College of Radiology
ACR Appropriateness Criteria®

Preprocedural Chest or Cardiac Imaging for Cardiothoracic Surgery

Variant: 1 Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.

Procedure	Appropriateness Category	Relative Radiation Level
US echocardiography transesophageal	Usually Appropriate	O
US echocardiography transthoracic resting	Usually Appropriate	O
Radiography chest	Usually Appropriate	☢
Arteriography coronary	Usually Appropriate	☢☢☢
MRA coronary arteries without and with IV contrast	May Be Appropriate	O
MRA coronary arteries without IV contrast	May Be Appropriate	O
MRI heart function and morphology without and with IV contrast	May Be Appropriate	O
MRI heart function and morphology without IV contrast	May Be Appropriate	O
CT chest with IV contrast	May Be Appropriate	☢☢☢
CT chest without IV contrast	May Be Appropriate	☢☢☢
CTA chest with IV contrast	May Be Appropriate	☢☢☢
CTA chest without and with IV contrast	May Be Appropriate	☢☢☢
CTA coronary arteries with IV contrast	May Be Appropriate	☢☢☢
MRA chest with IV contrast	Usually Not Appropriate	O
MRA chest without and with IV contrast	Usually Not Appropriate	O
MRA chest without IV contrast	Usually Not Appropriate	O
MRI chest with IV contrast	Usually Not Appropriate	O
MRI chest without and with IV contrast	Usually Not Appropriate	O
MRI chest without IV contrast	Usually Not Appropriate	O
CT chest without and with IV contrast	Usually Not Appropriate	☢☢☢
CT heart function and morphology with IV contrast	Usually Not Appropriate	☢☢☢☢

Variant: 2 Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.

Procedure	Appropriateness Category	Relative Radiation Level
US echocardiography transesophageal	Usually Appropriate	O
US echocardiography transthoracic resting	Usually Appropriate	O
Radiography chest	Usually Appropriate	☢
Arteriography coronary	Usually Appropriate	☢☢☢
CT chest with IV contrast	Usually Appropriate	☢☢☢
CT chest without IV contrast	Usually Appropriate	☢☢☢
CTA chest with IV contrast	Usually Appropriate	☢☢☢
CTA chest without and with IV contrast	Usually Appropriate	☢☢☢
MRA chest with IV contrast	May Be Appropriate	O
MRA chest without and with IV contrast	May Be Appropriate	O
MRA chest without IV contrast	May Be Appropriate	O

MRA coronary arteries without and with IV contrast	May Be Appropriate	O
MRA coronary arteries without IV contrast	May Be Appropriate	O
MRI chest with IV contrast	May Be Appropriate	O
MRI chest without and with IV contrast	May Be Appropriate	O
MRI chest without IV contrast	May Be Appropriate	O
MRI heart function and morphology without and with IV contrast	May Be Appropriate	O
MRI heart function and morphology without IV contrast	May Be Appropriate	O
CTA coronary arteries with IV contrast	May Be Appropriate	☢☢☢
CT heart function and morphology with IV contrast	May Be Appropriate	☢☢☢☢
CT chest without and with IV contrast	Usually Not Appropriate	☢☢☢

Variant: 3 Adult. Preprocedural chest or cardiac imaging prior to noncoronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.

Procedure	Appropriateness Category	Relative Radiation Level
US echocardiography transesophageal	Usually Appropriate	O
US echocardiography transthoracic resting	Usually Appropriate	O
Radiography chest	Usually Appropriate	☢
Arteriography coronary	Usually Appropriate	☢☢☢
MRA chest with IV contrast	May Be Appropriate	O
MRA chest without and with IV contrast	May Be Appropriate	O
MRA chest without IV contrast	May Be Appropriate	O
MRA coronary arteries without and with IV contrast	May Be Appropriate	O
MRA coronary arteries without IV contrast	May Be Appropriate	O
MRI heart function and morphology without and with IV contrast	May Be Appropriate	O
MRI heart function and morphology without IV contrast	May Be Appropriate	O
CT chest with IV contrast	May Be Appropriate	☢☢☢
CT chest without IV contrast	May Be Appropriate	☢☢☢
CTA chest with IV contrast	May Be Appropriate	☢☢☢
CTA chest without and with IV contrast	May Be Appropriate	☢☢☢
CTA coronary arteries with IV contrast	May Be Appropriate	☢☢☢
MRI chest with IV contrast	Usually Not Appropriate	O
MRI chest without and with IV contrast	Usually Not Appropriate	O
MRI chest without IV contrast	Usually Not Appropriate	O
CT chest without and with IV contrast	Usually Not Appropriate	☢☢☢
CT heart function and morphology with IV contrast	Usually Not Appropriate	☢☢☢☢

Variant: 4 Adult. Preprocedural chest or cardiac imaging for noncoronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.

Procedure	Appropriateness Category	Relative Radiation Level
US echocardiography transesophageal	Usually Appropriate	O
US echocardiography transthoracic resting	Usually Appropriate	O
Radiography chest	Usually Appropriate	☢
CT chest with IV contrast	Usually Appropriate	☢☢☢
CT chest without IV contrast	Usually Appropriate	☢☢☢

Arteriography coronary	May Be Appropriate	☢☢☢
MRA chest with IV contrast	May Be Appropriate	O
MRA chest without and with IV contrast	May Be Appropriate	O
MRA chest without IV contrast	May Be Appropriate	O
MRI chest with IV contrast	May Be Appropriate	O
MRI chest without and with IV contrast	May Be Appropriate	O
MRI chest without IV contrast	May Be Appropriate	O
MRI heart function and morphology without and with IV contrast	May Be Appropriate	O
MRI heart function and morphology without IV contrast	May Be Appropriate	O
CTA chest with IV contrast	May Be Appropriate	☢☢☢
CTA chest without and with IV contrast	May Be Appropriate (Disagreement)	☢☢☢
CTA coronary arteries with IV contrast	May Be Appropriate	☢☢☢
CT heart function and morphology with IV contrast	May Be Appropriate	☢☢☢☢
MRA coronary arteries without and with IV contrast	Usually Not Appropriate	O
MRA coronary arteries without IV contrast	Usually Not Appropriate	O
CT chest without and with IV contrast	Usually Not Appropriate	☢☢☢

<u>Variant: 5</u> Adult. Preprocedural chest or cardiac imaging for thoracic surgery. No history of cardiothoracic surgery. Preprocedure planning.

Procedure	Appropriateness Category	Relative Radiation Level
Radiography chest	Usually Appropriate	☢
CT chest with IV contrast	Usually Appropriate	☢☢☢
CT chest without IV contrast	Usually Appropriate	☢☢☢
US echocardiography transesophageal	May Be Appropriate	O
US echocardiography transthoracic resting	May Be Appropriate	O
MRA chest with IV contrast	May Be Appropriate	O
MRA chest without and with IV contrast	May Be Appropriate	O
MRA chest without IV contrast	May Be Appropriate	O
MRI chest with IV contrast	May Be Appropriate	O
MRI chest without and with IV contrast	May Be Appropriate	O
MRI chest without IV contrast	May Be Appropriate	O
MRI heart function and morphology without and with IV contrast	May Be Appropriate	O
MRI heart function and morphology without IV contrast	May Be Appropriate	O
CTA chest with IV contrast	May Be Appropriate	☢☢☢
CTA chest without and with IV contrast	May Be Appropriate	☢☢☢
Arteriography coronary	Usually Not Appropriate	☢☢☢
MRA coronary arteries without and with IV contrast	Usually Not Appropriate	O
MRA coronary arteries without IV contrast	Usually Not Appropriate	O
CT chest without and with IV contrast	Usually Not Appropriate	☢☢☢
CTA coronary arteries with IV contrast	Usually Not Appropriate	☢☢☢
CT heart function and morphology with IV contrast	Usually Not Appropriate	☢☢☢☢

<u>Variant: 6</u> Adult. Preprocedural chest or cardiac imaging for thoracic surgery. History of cardiothoracic surgery. Preprocedure planning.

Procedure	Appropriateness Category	Relative Radiation Level
Radiography chest	Usually Appropriate	☢
CT chest with IV contrast	Usually Appropriate	☢☢☢
CT chest without IV contrast	Usually Appropriate	☢☢☢
US chest	May Be Appropriate	O
US echocardiography transesophageal	May Be Appropriate	O
US echocardiography transthoracic resting	May Be Appropriate	O
MRA chest with IV contrast	May Be Appropriate	O
MRA chest without and with IV contrast	May Be Appropriate	O
MRA chest without IV contrast	May Be Appropriate	O
MRI chest with IV contrast	May Be Appropriate	O
MRI chest without and with IV contrast	May Be Appropriate	O
MRI chest without IV contrast	May Be Appropriate	O
MRI heart function and morphology without and with IV contrast	May Be Appropriate	O
MRI heart function and morphology without IV contrast	May Be Appropriate	O
CTA chest with IV contrast	May Be Appropriate	☢☢☢
CTA chest without and with IV contrast	May Be Appropriate	☢☢☢
CT heart function and morphology with IV contrast	May Be Appropriate	☢☢☢☢
Arteriography coronary	Usually Not Appropriate	☢☢☢
MRA coronary arteries without and with IV contrast	Usually Not Appropriate	O
MRA coronary arteries without IV contrast	Usually Not Appropriate	O
CT chest without and with IV contrast	Usually Not Appropriate	☢☢☢
CTA coronary arteries with IV contrast	Usually Not Appropriate	☢☢☢

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Summary of Literature Review

Introduction/Background

Preprocedural chest or cardiac imaging for cardiothoracic surgery refers to imaging performed after the initial diagnosis and decision to proceed with cardiothoracic surgery has been determined. The purpose of preprocedural imaging is to identify anatomy, physiology, or pathology that could inform the surgical approach or technique in patients already deemed appropriate for cardiothoracic surgery. Cardiothoracic surgery encompasses a diverse range of procedures, which can be categorized into noncoronary cardiac surgery, coronary cardiac surgery, and thoracic surgery. Examples of noncoronary cardiac surgery include valve repair or replacement, aortic root repair or replacement, ascending and aortic arch replacement, cardiac mass resection, cardiac transplant, and pericardiectomy. Examples of coronary cardiac surgery include coronary artery bypass grafting, coronary artery reimplantation, and coronary artery unroofing. Examples of thoracic surgery include esophagectomy, lung lobectomy or wedge resection, pleurectomy, decortication, and mediastinal mass resection. Each of these have their own unique surgical techniques, risks, and complications. These can further vary between patients undergoing first-time or repeat cardiothoracic surgery, with the latter having a higher rate of complications [1]. The Society of Thoracic Surgeons Adult Cardiac Surgery Database shows that redo cardiothoracic surgeries account for 8.6% to 10.3% of surgeries annually [2].

This document reviews the literature for preprocedural chest or cardiac imaging in patients undergoing noncoronary cardiac surgery, coronary cardiac surgery, and thoracic surgery with and without a history of prior cardiothoracic surgery. The scope of this document does not include imaging performed in making a specific clinical diagnosis or determining the potential benefit to the patient of performance of a surgical procedure, for identifying the etiology of a disease process, or for routine preoperative chest imaging performed for noncardiothoracic surgery, for which the reader is referred to the ACR Appropriateness Criteria® topic on "Routine Chest Imaging" [3]. The focus of this document is primarily on the imaging necessary to inform performance of a surgical procedure after the decision to operate has been made. Because the decision to perform a surgical procedure is complex, there may be overlap in the decision to operate, the choice of procedure, and the manner in which the procedure is performed, especially in situations in which there is equipoise in the efficacy of various surgical options.

This document does not address patient-specific comorbidities and risk for anesthesia. For the specific diagnosis and workup of coronary artery disease or other diseases that might be considered for assessment of surgical risk and possible concomitant treatment, the reader is referred to the ACR Appropriateness Criteria® topics on "Acute Nonspecific Chest Pain-Low Probability of Coronary Artery Disease" [4], "Chronic Chest Pain-High Probability of Coronary Artery Disease" [5], "Chronic Chest Pain-Noncardiac Etiology Unlikely: Low to Intermediate Probability of Coronary Artery Disease" [6], "Blunt Chest Trauma-Suspected Cardiac Injury" [7], "Congenital or Acquired Heart Disease" [8], "Dyspnea-Suspected Cardiac Origin (Ischemia Already Excluded)" [9], "Infective Endocarditis" [10], "Suspected Acute Aortic Syndrome" [11], "Workup of Noncerebral Systemic Arterial Embolic Source" [12], "Noninvasive Clinical Staging of Primary Lung Cancer" [13], "Imaging of Mediastinal Masses" [14], and "Staging and Follow-up of Esophageal Cancer" [15] and the 2024 AHA/ACC/ACS/ASNC/HRS/SCA/SCCT/SCMR/SVM Guideline for Perioperative Cardiovascular Management for Noncardiac Surgery [16].

Special Imaging Considerations

For the purposes of distinguishing between CT and CT angiography (CTA), ACR Appropriateness Criteria topics use the definition in the ACR–NASCI–SIR–SPR Practice Parameter for the Performance and Interpretation of Body Computed Tomography Angiography (CTA) [17]:

"CTA uses a thin-section CT acquisition that is timed to coincide with peak arterial or venous enhancement. The resultant volumetric dataset is interpreted using primary transverse reconstructions as well as multiplanar reformations and 3-D renderings."

All elements are essential: 1) timing, 2) reconstructions/reformats, and 3) 3-D renderings. Standard CTs with also include timing issues and recons/reformats. Only in CTA, however, is 3-D rendering a **required** element. This corresponds to the definitions that the CMS has applied to the Current

Procedural Terminology codes.

Discussion of Procedures by Variant

Variant 1: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.

The goal of preprocedural imaging for planned coronary cardiac surgery in a patient without a history of cardiothoracic surgery is to inform the surgical approach and technique and reduce the risk of intraoperative complications. Preprocedural imaging can identify aortic calcifications influencing the aortic cannulation site and site for proximal bypass graft anastomoses; identify adequacy of alternative arterial cannulation sites; identify aortic aneurysmal disease, which may alter the surgical approach or the decision for off- or on-pump bypass grafting; identify normal and variant anatomy of vascular and nonvascular structures, which can aid in choosing and guiding an open or minimally invasive approach; identify optimal distal targets for coronary artery bypass grafting; and identify disease in the left subclavian artery, which may inform the use of a left internal mammary artery graft. Several imaging modalities (including those not discussed in this document) can assess myocardial viability, which may play a role in the initial clinical decision-making pathway when determining suitability for coronary revascularization in patients with ischemic heart disease; this imaging is considered a step that in general would have been performed before this document is invoked [18].

Variant 1: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
A. Arteriography coronary

Invasive coronary angiography (ICA) can identify the location, degree, and hemodynamic significance of coronary stenoses, helping determine the need for coronary artery bypass grafting, and identify coronary anomalies. ICA is performed during the initial assessment for coronary artery disease or to confirm coronary artery disease suspected from another examination.

Variant 1: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
B. CT chest with IV contrast

CT chest with intravenous (IV) contrast can evaluate systemic vascular calcifications including within the aortic valve, aorta, and proximal aortic arch vessels, identify the location of vessels relative to the chest wall, assess chest wall anatomic abnormalities such as pectus excavatum, and assess pericardial or pleural calcifications and thickening, which may impact the surgical approach.

Several studies have shown that the use of preprocedural CT chest prior to cardiac surgery can identify aortic calcifications, which result in modification of the planned aortic cannulation site [19-21]. One study showed a reduced stroke rate in patients undergoing cardiac surgery who underwent a preprocedural CT chest compared with those without a preprocedural CT chest, postulated to be related to modification of the aortic cannulation site based on calcification identified on CT [21]. One meta-analysis including 18 studies and 4,057 patients suggests that the use of preprocedural CT may reduce the risk of perioperative stroke and mortality in first-time cardiac surgery patients [19]. This was attributed to choosing a different cannulation site based on location and degree of aortic calcifications, changing to off-pump cardiac surgery, or cancellation of the surgery.

A retrospective case-control study looked at the incidence of postoperative stroke in 405 patients undergoing primary coronary artery bypass grafting who had preprocedural CT chest looking for aortic calcifications [22]. They showed a higher percentage of aortic root, ascending aortic, and descending aortic calcifications in patients who developed postoperative stroke compared with those who did not. However, none of these achieved statistical significance. The authors conclude that although CT chest is helpful in identifying aortic calcifications, its role in reducing postoperative stroke is not clearly established and warrants further prospective investigation.

Variant 1: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
C. CT chest without and with IV contrast

CT chest without and with IV contrast has limited added value compared with a CT chest without IV contrast or a CT chest with IV contrast. Most vascular calcifications can typically be identified on examinations either without or with IV contrast examinations. There is no relevant literature to support the routine use of CT chest without and with IV contrast prior to coronary cardiac surgery in patients without a history of cardiothoracic surgery. The individual components of this procedure are covered in the relevant “without and with IV contrast” sections.

Variant 1: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
D. CT chest without IV contrast

CT chest without IV contrast can evaluate systemic vascular calcifications including within the aortic valve, aorta, and proximal aortic arch vessels, identify the location of vessels relative to the chest wall, assess chest wall anatomic abnormalities such as pectus excavatum, and assess pericardial or pleural calcifications and thickening, which may impact the surgical approach.

Several studies have shown that the use of preprocedural CT chest prior to cardiac surgery can identify aortic calcifications, which result in modification of the planned aortic cannulation site [19-21]. One study showed a reduced stroke rate in patients undergoing cardiac surgery who underwent a preprocedural CT chest compared with those without a preprocedural CT chest, postulated to be related to modification of the aortic cannulation site based on calcification identified on CT [21]. One meta-analysis including 18 studies and 4,057 patients suggests that the use of preprocedural CT may reduce the risk of perioperative stroke and mortality in first-time cardiac surgery patients [19]. This was attributed to choosing a different cannulation site based on location and degree of aortic calcifications, changing to off-pump cardiac surgery, or cancellation of the surgery.

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Variant 1: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
E. CT heart function and morphology with IV contrast

CT heart function and morphology with IV contrast provides information on cardiac function, chamber size and morphology, some valvular disease, cardiac masses, pericardial effusions, and aortic root size. There is no relevant literature to support the routine use of CT heart function and morphology with IV contrast prior to coronary cardiac surgery in patients without a history of cardiothoracic surgery.

Variant 1: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
F. CTA chest with IV contrast

In addition to findings seen on CT chest with IV contrast and CT chest without IV contrast, CTA chest with IV contrast provides detailed assessment of the thoracic arteries, including size, course, degree of atherosclerosis, and degree of luminal narrowing.

Several studies have shown that the use of preprocedural CT chest prior to cardiac surgery can identify aortic calcifications, which result in modification of the planned aortic cannulation site [19-21]. One study showed a reduced stroke rate in patients undergoing cardiac surgery who underwent a preprocedural CT chest compared with those without a preprocedural CT chest, postulated to be related to modification of the aortic cannulation site based on calcification identified on CT [21]. One meta-analysis including 18 studies and 4,057 patients suggests that the use of preprocedural CT may reduce the risk of perioperative stroke and mortality in first-time cardiac surgery patients [19]. This was attributed to choosing a different cannulation site based on location and degree of aortic calcifications, changing to off-pump cardiac surgery, or cancellation of the surgery.

A retrospective case-control study looked at the incidence of postoperative stroke in 405 patients undergoing primary coronary artery bypass grafting who had preprocedural CT chest looking for aortic calcifications [22]. They showed a higher percentage of aortic root, ascending aortic, and descending aortic calcifications in patients who developed postoperative stroke compared with those who did not. However, none of these achieved statistical significance. The authors conclude that although CT chest is helpful in identifying aortic calcifications, its role in reducing postoperative stroke is not clearly established and needs further prospective investigation.

Variant 1: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
G. CTA chest without and with IV contrast

In addition to findings seen on CT chest with IV contrast and CT chest without IV contrast, CTA chest without and with IV contrast provides detailed assessment of the thoracic arteries, including size, course, degree of atherosclerosis, and degree of luminal narrowing.

Several studies have shown that the use of preprocedural CT chest prior to cardiac surgery can identify aortic calcifications, which result in modification of the planned aortic cannulation site [19-21]. One study showed a reduced stroke rate in patients undergoing cardiac surgery who underwent a preprocedural CT chest compared with those without a preprocedural CT chest, postulated to be related to modification of the aortic cannulation site based on calcification identified on CT [21]. One meta-analysis including 18 studies and 4,057 patients suggests that the use of preprocedural CT may reduce the risk of perioperative stroke and mortality in first-time cardiac surgery patients [19]. This was attributed to choosing a different cannulation site based on location and degree of aortic calcifications, changing to off-pump cardiac surgery, or cancellation of the surgery.

A retrospective case-control study looked at the incidence of postoperative stroke in 405 patients undergoing primary coronary artery bypass grafting who had preprocedural CT chest looking for aortic calcifications [22]. They showed a higher percentage of aortic root, ascending aortic, and descending aortic calcifications in patients who developed postoperative stroke compared with those who did not. However, none of these achieved statistical significance. The authors conclude that although CT chest is helpful in identifying aortic calcifications, its role in reducing postoperative stroke is not clearly established and needs further prospective investigation.

Variant 1: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
H. CTA coronary arteries with IV contrast

CTA coronary arteries with IV contrast can provide detailed information regarding the origin, course, and termination of the coronary arteries, including the presence of a myocardial bridge for planning of a minimally invasive direct coronary artery bypass, the location and degree of coronary stenoses, and the presence and features of coronary plaque. The hemodynamic significance of a coronary stenosis can also be assessed by adding CT fractional flow reserve (FFR) analysis. In most cases of planned coronary surgery, an ICA will have established the presence or absence of coronary stenosis or obstruction, and in some cases, CTA coronary arteries may have been performed prior to the ICA. Thus, the role of CTA coronary arteries in the setting of planned coronary cardiac surgery may be limited to cases in which information complementary to ICA is expected and or relationship of variant anatomy to other mediastinal structures is warranted.

The 2018 American College of Cardiology/American Heart Association (AHA/ACC) guidelines for the management of adults with congenital heart disease gives the highest recommendation score of 1 for the use of preoperative coronary CTA in patients with anomalous origin of the coronary arteries [23]. Due to its high spatial resolution, CTA excels at identifying high-risk features of anomalous coronary arteries, which can impact the approach for surgery, including angle of origin, proximal narrowing and elliptical shape suggestive of an intramural course, and concomitant presence of coronary artery disease. See also the ACR Appropriateness Criteria® topics on "Congenital or Acquired Heart Disease" [8] and "Evaluation of Coronary Artery Anomalies" [24].

In patients with known left main or 3 vessel coronary artery disease, a randomized controlled trial evaluating 223 patients showed that heart team treatment decision making based on coronary CTA showed high agreement with the decision derived from ICA [25]. Notable strengths of coronary CTA prior to bypass grafting include identification of hemodynamic significance of a lesion using CT-FFR, visualization of coronary calcifications to help identify bypass graft targets, and assessment of runoff distal to the graft target location [26].

Variant 1: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
I. MRA chest with IV contrast

MR angiography (MRA) chest with IV contrast can provide similar information to CTA, including a detailed assessment of the thoracic vasculature. However, as it pertains to preprocedural planning, a major limitation of MRA is its reduced ability to accurately identify calcifications. There is no relevant literature to support the routine use of MRA chest with IV contrast prior to coronary cardiac surgery in patients without a history of cardiothoracic surgery.

Variant 1: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
J. MRA chest without and with IV contrast

MRA chest without and with IV contrast can provide similar information to CTA, including a detailed assessment of the thoracic vasculature. However, as it pertains to preprocedural planning, a major limitation of MRA is its reduced ability to accurately identify calcifications. There is no relevant literature to support the routine use of MRA chest without and with IV contrast prior to coronary cardiac surgery in patients without a history of cardiothoracic surgery.

Variant 1: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
K. MRA chest without IV contrast

MRA chest without IV contrast can provide similar information to CTA, including a detailed assessment of the thoracic vasculature. However, as it pertains to preprocedural planning, a major limitation of MRA is its reduced ability to accurately identify calcifications. There is no relevant literature to support the routine use of MRA chest without IV contrast prior to coronary cardiac surgery in patients without a history of cardiothoracic surgery.

Variant 1: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
L. MRA coronary arteries without and with IV contrast

MRA coronary arteries without and with IV contrast can provide detailed information regarding the origin, course, and termination of the coronary arteries. MRA coronary arteries may be useful in the evaluation of anomalous coronary arteries and can potentially provide similar information to CTA coronary arteries.

The 2018 AHA/ACC guidelines for the management of adults with congenital heart disease gives the highest recommendation score of 1 for the use of preoperative coronary MRA in patients with anomalous origin of the coronary arteries [23]. MRA can identify high-risk features of anomalous coronary arteries, which can impact the approach for surgery, including angle of takeoff and proximal narrowing and elliptical shape suggestive of intramural course. See also the ACR Appropriateness Criteria® topics on “Congenital or Acquired Heart Disease” [8] and "Evaluation of Coronary Artery Anomalies" [24].

Variant 1: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
M. MRA coronary arteries without IV contrast

MRA coronary arteries without IV contrast can provide detailed information regarding the origin, course, and termination of the coronary arteries. MRA coronary arteries may be useful in the evaluation of anomalous coronary arteries and can potentially provide similar information to CTA coronary arteries.

The 2018 AHA/ACC guidelines for the management of adults with congenital heart disease gives the highest recommendation score of 1 for the use of preoperative coronary MRA in patients with anomalous origin of the coronary arteries [23]. MRA can identify high-risk features of anomalous coronary arteries, which can impact the approach for surgery, including angle of takeoff and proximal narrowing and elliptical shape suggestive of intramural course. See also the ACR Appropriateness Criteria® topics on “Congenital or Acquired Heart Disease” [8] and "Evaluation of

Coronary Artery Anomalies" [24].

Variant 1: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
N. MRI chest with IV contrast

MRI chest with IV contrast can provide similar information to CT and is typically focused on nonvascular assessment. As it pertains to preprocedural planning, a major limitation of MRI is its reduced ability to accurately identify aortic calcifications. There is no relevant literature to support the routine use of MRI chest with IV contrast prior to coronary cardiac surgery in patients without a history of cardiothoracic surgery.

Variant 1: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
O. MRI chest without and with IV contrast

MRI chest without and with IV contrast can provide similar information to CT and is typically focused on nonvascular assessment. As it pertains to preprocedural planning, a major limitation of MRI is its reduced ability to accurately identify aortic calcifications. There is no relevant literature to support the routine use of MRI chest without and with IV contrast prior to coronary cardiac surgery in patients without a history of cardiothoracic surgery.

Variant 1: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
P. MRI chest without IV contrast

MRI chest without IV contrast can provide similar information to CT and is typically focused on nonvascular assessment. As it pertains to preprocedural planning, a major limitation of MRI is its reduced ability to accurately identify aortic calcifications. There is no relevant literature to support the routine use of MRI chest without IV contrast prior to coronary cardiac surgery in patients without a history of cardiothoracic surgery.

Variant 1: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
Q. MRI heart function and morphology without and with IV contrast

MRI heart function and morphology without and with IV contrast can provide an assessment of cardiac function, chamber size, and morphology. MRI can quantify valvular disease and shunts, assess for myocardial scar, characterize the pericardium, and characterize cardiac masses, including thrombus. There is no relevant literature to support the routine use of MRI heart function and morphology without and with IV contrast prior to coronary cardiac surgery in patients without a history of cardiothoracic surgery.

Variant 1: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
R. MRI heart function and morphology without IV contrast

MRI heart function and morphology without IV contrast can provide an assessment of cardiac function, chamber size, and morphology. MRI can quantify valvular disease and shunts, perform myocardial tissue characterization using parametric mapping techniques, characterize the pericardium, and characterize cardiac masses, although the latter 3 would typically be performed with IV contrast. There is no relevant literature to support the routine use of MRI heart function and morphology without IV contrast prior to coronary cardiac surgery in patients without a history of cardiothoracic surgery.

Variant 1: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
S. Radiography chest

Chest radiography can assess musculoskeletal anatomy and size of the cardiac silhouette and screen for pulmonary or pleural disease and extensive pericardial calcifications and vascular calcifications. Although many patients will have undergone chest radiography prior to surgery for various clinical reasons, preprocedural planning is not typically its primary use. One study showed preprocedural chest radiography to be insensitive to the detection of aortic atheromatous plaque, which has been associated with adverse neurologic outcome after cardiac surgery [20].

A retrospective study with 1,136 patients undergoing cardiac surgery showed that preprocedural chest radiography frequently found abnormalities (50% of patients) but rarely changed clinical management (0.3% of patients) [27].

Variant 1: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
T. US echocardiography transesophageal

Transesophageal echocardiography (TEE) can provide information on cardiac function, cardiac morphology, and valvular heart disease, detect intracardiac shunts, detect cardiac masses, and assess pericardial effusions. Compared with transthoracic echocardiography (TTE), a notable benefit is better visualization of some heart structures due to better special resolution and the probe’s closer proximity to the heart. TEE demonstrated aortic arch atheroma in 55% of patients without evidence of aortic arch plaque by chest radiography [28].

Some preprocedural imaging may be reserved for the day of surgery. A 2010 practice guidelines for perioperative TEE, which includes the performance of TEE immediately prior to surgery, recommends the use of perioperative TEE in all adult patients without a contraindication to TEE who are undergoing cardiac surgery and that it should be considered in patients undergoing coronary artery bypass grafting, particularly in patients with abnormal ventricular function [29]. TEE can confirm and refine the preprocedural diagnosis, detect new or unsuspected pathology, and adjust the surgical plan.

Variant 1: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
U. US echocardiography transthoracic resting

TTE can provide information on cardiac function, cardiac morphology, and valvular heart disease, detect intracardiac shunts, detect cardiac masses, and assess pericardial effusions.

Variant 2: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.

The goal of preprocedural imaging for planned coronary cardiac surgery in a patient with a history of cardiothoracic surgery is to inform the surgical approach and technique and reduce the risk of intraoperative complications. Preprocedural imaging can identify aortic calcifications influencing the aortic cannulation site and site for proximal bypass graft anastomoses; identify adequacy of alternative arterial cannulation sites; identify aortic aneurysmal disease, which may alter the surgical approach or the decision for off- or on-pump bypass grafting; identify normal and variant anatomy of vascular and nonvascular structures, which can aid in choosing and guiding an open or minimally invasive approach; identify optimal distal targets for coronary artery bypass grafting; and identify disease in the left subclavian artery, which may inform the use of a left internal mammary artery graft. In patients with a history of cardiothoracic surgery, a unique consideration is to identify the proximity of any prior bypass grafts to the posterior sternum or evidence of mediastinal adhesions in order to appropriately plan the surgical approach. Several imaging modalities (including those not discussed in this document) can assess myocardial viability, which may play a role in the initial clinical decision-making pathway when determining suitability for coronary revascularization in patients with ischemic heart disease; this imaging is considered a step that in general would have been performed before this document is invoked [18].

Variant 2: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
A. Arteriography coronary

ICA can identify the location, degree, and hemodynamic significance of coronary stenoses in the native coronary arteries or any coronary artery bypass grafts and identify coronary anomalies. ICA can assess coronary stenosis and most likely would have been performed during the initial assessment for coronary artery disease or commonly to confirm coronary artery disease suspected from another examination (ie, prior to this document being invoked).

Variant 2: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
B. CT chest with IV contrast

CT chest with IV contrast can evaluate systemic vascular calcifications including within the aortic valve, aorta, and proximal aortic arch vessels, identify the location of vessels relative to the chest wall, assess chest wall anatomic abnormalities such as pectus excavatum, assess pericardial or pleural calcifications and thickening, and evaluate for evidence of mediastinal adhesions, which may impact the surgical approach.

Multiple studies evaluating the use of preprocedural CT prior to redo sternotomy have shown a statistical trend toward reducing complications including sternal re-entry injury, shorter perfusion and cross clamp times, shorter intensive care unit stays, less frequent perioperative myocardial infarcts, and reduced risk of perioperative stroke. This was attributed to identifying high-risk features, such as extensive aortic calcifications and <10-mm distance of the right ventricle, aorta, or any coronary artery bypass grafts to the sternum, which may have resulted in a different surgical approach, different cannulation site, changing to off-pump cardiac surgery, or cancellation of the surgery [2,19,30-37].

One meta-analysis showed that the presence of high-risk features on preprocedural CT (right ventricle, aorta, or graft <10 mm from the sternum) resulted in cancellation of surgery in 4% to 13% of cases and a change in surgical strategy in up to 80% of cases [34].

Variant 2: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
C. CT chest without and with IV contrast

CT chest without and with IV contrast has limited added value compared with a CT chest without IV contrast or a CT chest with IV contrast. Most vascular calcifications can typically be identified on examinations either without or with IV contrast examinations. There is no relevant literature to support the routine use of CT chest without and with IV contrast prior to coronary cardiac surgery in patients with a history of cardiothoracic surgery. The individual components of this procedure are covered in the relevant “without and with IV contrast” sections.

Variant 2: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
D. CT chest without IV contrast

CT chest without IV contrast can evaluate systemic vascular calcifications including within the aortic valve, aorta, and proximal aortic arch vessels, identify the location of vessels relative to the chest wall, assess chest wall anatomic abnormalities such as pectus excavatum, assess pericardial or pleural calcifications and thickening, and evaluate for evidence of mediastinal adhesions, which may impact the surgical approach. In patients with a history of prior cardiothoracic surgery, CT chest without IV contrast may better visualize any surgical material.

Multiple studies evaluating the use of preprocedural CT prior to redo sternotomy have shown a statistical trend toward reducing complications including sternal re-entry injury, shorter perfusion and cross clamp times, shorter intensive care unit stays, less frequent perioperative myocardial infarcts, and reduced risk of perioperative stroke. This was attributed to identifying high-risk features, such as extensive aortic calcifications and <10-mm distance of the right ventricle, aorta, or any coronary artery bypass grafts to the sternum, which may have resulted in a different surgical approach, different cannulation site, changing to off-pump cardiac surgery, or cancellation of the surgery [2,19,30-37].

One meta-analysis showed that the presence of high-risk features on preprocedural CT (right ventricle, aorta, or graft <10 mm from the sternum) resulted in cancellation of surgery in 4% to 13% of cases and a change in surgical strategy in up to 80% of cases [34].

In their initial experience using a specialized dynamic free breathing noncontrast CT scan of the chest to look for dynamic tethering of mediastinal structures to the sternum, Narayan et al [38] demonstrated reliable exclusion of sternal adhesions in 14 of 19 patients undergoing redo cardiac surgery. The authors noted no false-negative results from the preprocedural CT, suggesting this technique may be useful in preprocedural planning to reduce the risk of sternal re-entry injury.

Variant 2: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
E. CT heart function and morphology with IV contrast

CT heart function and morphology with IV contrast provides information on cardiac function, chamber size and morphology, some valvular disease, cardiac masses, pericardial effusions, and aortic root size. Choi et al [39] looked at 80 consecutive patients scheduled for redo cardiac surgery who underwent a retrospectively gated cardiac CT and found that by using the cine reconstructions from the CT, they had a 95% accuracy in identifying retrosternal adhesions compared with those identified intraoperatively. The surgical approach changed in 62% of patients with adhesions detected by CT.

Variant 2: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
F. CTA chest with IV contrast

In addition to findings seen on CT chest with IV contrast and CT chest without IV contrast, CTA chest with IV contrast provides detailed assessment of the thoracic arteries, including size, course, degree of atherosclerosis, and degree of luminal narrowing. In patients with a history of cardiothoracic surgery, CTA chest with IV contrast can both evaluate patency of any prior bypass grafts and identify the proximity of any prior bypass grafts to the posterior sternum to inform the surgical approach.

Multiple studies evaluating the use of preprocedural CT prior to redo sternotomy have shown a statistical trend toward reducing complications including sternal re-entry injury, shorter perfusion and cross clamp times, shorter intensive care unit stays, less frequent perioperative myocardial infarcts, and reduced risk of perioperative stroke. This was attributed to identifying high-risk features, such as extensive aortic calcifications and <10-mm distance of the right ventricle, aorta, or any coronary artery bypass grafts to the sternum, which may have resulted in a different surgical approach, different cannulation site, changing to off-pump cardiac surgery, or cancellation of the surgery [2,19,30-37].

One meta-analysis showed that the presence of high-risk features on preprocedural CT (right ventricle, aorta, or graft <10 mm from the sternum) resulted in cancellation of surgery in 4% to 13% of cases and a change in surgical strategy in up to 80% of cases [34].

Variant 2: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
G. CTA chest without and with IV contrast

In addition to findings seen on CT chest with IV contrast and CT chest without IV contrast, CTA chest without and with IV contrast provides detailed assessment of the thoracic arteries, including size, course, degree of atherosclerosis, and degree of luminal narrowing. In patients with a history of cardiothoracic surgery, CTA chest without and with IV contrast can both evaluate patency of any prior bypass grafts and identify the proximity of any prior bypass grafts to the posterior sternum to inform the surgical approach. The portion of the examination without IV contrast may better visualize any surgical material.

Multiple studies evaluating the use of preprocedural CT prior to redo sternotomy have shown a statistical trend toward reducing complications including sternal re-entry injury, shorter perfusion and cross clamp times, shorter intensive care unit stays, less frequent perioperative myocardial infarcts, and reduced risk of perioperative stroke. This was attributed to identifying high-risk features, such as extensive aortic calcifications and <10-mm distance of the right ventricle, aorta, or any coronary artery bypass grafts to the sternum, which may have resulted in a different surgical approach, different cannulation site, changing to off-pump cardiac surgery, or cancellation of the surgery [2,19,30-37].

One meta-analysis showed that the presence of high-risk features on preprocedural CT (right ventricle, aorta, or graft <10 mm from the sternum) resulted in cancellation of surgery in 4% to 13% of cases and a change in surgical strategy in up to 80% of cases [34].

Variant 2: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
H. CTA coronary arteries with IV contrast

CTA coronary arteries with IV contrast can provide detailed information regarding the origin, course, and termination of the native coronary arteries and any coronary artery bypass grafts, the location and degree of native or bypass graft coronary stenoses, and the presence and features of coronary plaque. The hemodynamic significance of a native coronary stenosis can also be assessed with CT-FFR. In most cases of planned coronary surgery, an ICA will have established the presence or absence of coronary stenosis or obstruction, and in some cases, CTA coronary arteries may have been performed prior to the ICA. Thus, the role of CTA coronary arteries in the setting of planned coronary cardiac surgery may be limited to cases in which information complementary to ICA is expected and or relationship of variant anatomy to other mediastinal structures is warranted.

One randomized controlled trial evaluating 688 patients with a history of prior coronary artery bypass grafting referred for ICA showed that in patients who underwent coronary CTA prior to ICA compared with patients who underwent ICA alone, there was a reduction in ICA procedure time, reduction in contrast associated nephropathy, improved patient satisfaction scores, reduction in ICA procedural complications, and reduction in 1-year major adverse cardiac events [40].

The 2018 AHA/ACC guidelines for the management of adults with congenital heart disease gives the highest recommendation score of 1 for the use of preoperative coronary CTA in patients with anomalous origin of the coronary arteries [23]. Due to its high spatial resolution, CTA excels at identifying high-risk features of anomalous coronary arteries, which can impact the approach for surgery, including angle of origin, proximal narrowing and elliptical shape suggestive of an intramural course, and concomitant presence of coronary artery disease. See also the ACR Appropriateness Criteria® topics on "Congenital or Acquired Heart Disease" [8] and "Evaluation of Coronary Artery Anomalies" [24].

In patients with known left main or 3 vessel coronary artery disease, a randomized controlled trial evaluating 223 patients showed that heart team treatment decision making based on coronary CTA showed high agreement with the decision derived from ICA [25]. Notable strengths of coronary CTA prior to bypass grafting include identification of hemodynamic significance of a lesion using CT-FFR, visualization of coronary calcifications to help identify bypass graft targets, and assessment of runoff distal to the graft target location [26].

Variant 2: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
I. MRA chest with IV contrast

MRA chest with IV contrast can provide similar information to CTA, including a detailed assessment of the thoracic vasculature, evidence of mediastinal adhesions, and proximity of any prior bypass grafts to the posterior sternum. However, as it pertains to preprocedural planning, a major limitation of MRA is its reduced ability to accurately identify calcifications. There is no relevant literature to support the routine use of MRA chest with IV contrast prior to coronary cardiac surgery in patients with a history of cardiothoracic surgery.

Variant 2: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
J. MRA chest without and with IV contrast

MRA chest without and with IV contrast can provide similar information to CTA, including a detailed assessment of the thoracic vasculature, evidence of mediastinal adhesions, and proximity of any prior bypass grafts to the posterior sternum. However, as it pertains to preprocedural planning, a major limitation of MRA is its reduced ability to accurately identify calcifications. There is no relevant literature to support the routine use of MRA chest without and with IV contrast prior to coronary cardiac surgery in patients with a history of cardiothoracic surgery.

Variant 2: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery.

History of cardiothoracic surgery. Preprocedure planning.
K. MRA chest without IV contrast

MRA chest without IV contrast can provide similar information to CTA, including a detailed assessment of the thoracic vasculature, evidence of mediastinal adhesions, and proximity of any prior bypass grafts to the posterior sternum. However, as it pertains to preprocedural planning, a major limitation of MRA is its reduced ability to accurately identify calcifications. There is no relevant literature to support the routine use of MRA chest without IV contrast prior to coronary cardiac surgery in patients with a history of cardiothoracic surgery.

Variant 2: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
L. MRA coronary arteries without and with IV contrast

MRA coronary arteries without and with IV contrast can provide information regarding the origin, course, and termination of the native coronary arteries and any coronary artery bypass grafts. MRA coronary arteries may be useful in the evaluation of anomalous coronary arteries and identifying coronary bypass grafts and can potentially provide similar information to CTA coronary arteries.

The 2018 AHA/ACC guidelines for the management of adults with congenital heart disease gives the highest recommendation score of 1 for the use of preoperative coronary MRA in patients with anomalous origin of the coronary arteries [23]. MRA can identify high-risk features of anomalous coronary arteries, which can impact the approach for surgery, including angle of takeoff and proximal narrowing and elliptical shape suggestive of intramural course. See also the ACR Appropriateness Criteria® topics on “Congenital or Acquired Heart Disease” [8] and "Evaluation of Coronary Artery Anomalies" [24].

Variant 2: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
M. MRA coronary arteries without IV contrast

MRA coronary arteries without IV contrast can provide information regarding the origin, course, and termination of the native coronary arteries and any coronary artery bypass grafts. MRA coronary arteries may be useful in the evaluation of anomalous coronary arteries and identifying coronary bypass grafts and can potentially provide similar information to CTA coronary arteries.

The 2018 AHA/ACC guidelines for the management of adults with congenital heart disease gives the highest recommendation score of 1 for the use of preoperative coronary MRA in patients with anomalous origin of the coronary arteries [23]. MRA can identify high-risk features of anomalous coronary arteries, which can impact the approach for surgery, including angle of takeoff and proximal narrowing and elliptical shape suggestive of intramural course. See also the ACR Appropriateness Criteria® topics on “Congenital or Acquired Heart Disease” [8] and "Evaluation of Coronary Artery Anomalies" [24].

Variant 2: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
N. MRI chest with IV contrast

MRI chest with IV contrast can provide similar information to CT and may allow for the assessment of thoracic vasculature, evidence of mediastinal adhesions, and proximity of any prior bypass grafts to the posterior sternum and is typically focused on nonvascular assessment. As it pertains to preprocedural planning, a major limitation of MRI is its reduced ability to accurately identify calcifications. There is no relevant literature to support the routine use of MRI chest with IV contrast prior to coronary cardiac surgery in patients with a history of cardiothoracic surgery.

Variant 2: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
O. MRI chest without and with IV contrast

MRI chest without and with IV contrast can provide similar information to CT and may allow for the assessment of thoracic vasculature, evidence of mediastinal adhesions, and proximity of any prior bypass grafts to the posterior sternum and is typically focused on nonvascular assessment. As it pertains to preprocedural planning, a major limitation of MRI is its reduced ability to accurately identify calcifications. There is no relevant literature to support the routine use of MRI chest without and with IV contrast prior to coronary cardiac surgery in patients with a history of cardiothoracic surgery.

Variant 2: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
P. MRI chest without IV contrast

MRI chest without IV contrast can provide similar information to CT and may allow for the assessment of thoracic vasculature, evidence of mediastinal adhesions, and proximity of any prior bypass grafts to the posterior sternum and is typically focused on nonvascular assessment. As it pertains to preprocedural planning, a major limitation of MRI is its reduced ability to accurately identify calcifications. There is no relevant literature to support the routine use of MRI chest without IV contrast prior to coronary cardiac surgery in patients with a history of cardiothoracic surgery.

Variant 2: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
Q. MRI heart function and morphology without and with IV contrast

MRI heart function and morphology without and with IV contrast can assess cardiac function, chamber size, and morphology. MRI can quantify valvular disease and shunts, assess for myocardial scar, characterize the pericardium, and characterize cardiac masses, including thrombus.

Yoshioka et al [41] showed in 13 patients that preprocedural tagged cine MRI could provide an accurate assessment of retrosternal cardiac adhesions prior to sternal re-entry in redo cardiac surgery. A preprocedural adhesion score determined by visual assessment of the malformation of the tags between the sternum and myocardium correlated well ($r = .76$, $P < .01$) with the intraoperative adhesion score determined by the surgeon at the time of redo surgery.

Variant 2: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
R. MRI heart function and morphology without IV contrast

MRI heart function and morphology without IV contrast can assess cardiac function, chamber size, and morphology. MRI can quantify valvular disease and shunts, perform myocardial tissue characterization using parametric mapping techniques, characterize the pericardium, and characterize cardiac masses, although the latter 3 would typically be performed with IV contrast.

Yoshioka et al [41] showed in 13 patients that preprocedural tagged cine MRI could provide an accurate assessment of retrosternal cardiac adhesions prior to sternal re-entry in redo cardiac surgery. A preprocedural adhesion score determined by visual assessment of the malformation of the tags between the sternum and myocardium correlated well (r = .76, P < .01) with the intraoperative adhesion score determined by the surgeon at the time of redo surgery.

Variant 2: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
S. Radiography chest

Chest radiography can assess musculoskeletal anatomy and size of the cardiac silhouette and screen for pulmonary or pleural disease and extensive pericardial calcifications and vascular calcifications. Although many patients will have undergone chest radiography prior to surgery for various clinical reasons, preprocedural planning is not typically its primary use. One study showed preprocedural chest radiography to be insensitive to the detection of aortic atheromatous plaque, which has been associated with adverse neurologic outcome after cardiac surgery [20].

A retrospective study with 1,136 patients undergoing cardiac surgery showed that preprocedural chest radiography frequently found abnormalities (50% of patients) but rarely changed clinical management (0.3% of patients) [27].

Variant 2: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
T. US echocardiography transesophageal

TEE can provide information on cardiac function, cardiac morphology, and valvular heart disease, detect intracardiac shunts, detect cardiac masses, and assess pericardial effusions. Compared with TTE, a notable benefit is better visualization of some heart structures due to better special resolution and the probe’s closer proximity to the heart.

Some preprocedural imaging may be reserved for the day of surgery. A 2010 practice guidelines for perioperative TEE, which includes the performance of TEE immediately prior to surgery, recommends the use of perioperative TEE in all adult patients without a contraindication to TEE who are undergoing cardiac surgery and that it should be considered in patients undergoing coronary artery bypass grafting, particularly in patients with abnormal ventricular function [29]. TEE can confirm and refine the preprocedural diagnosis, detect new or unsuspected pathology, and adjust the surgical plan.

Variant 2: Adult. Preprocedural chest or cardiac imaging for coronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
U. US echocardiography transthoracic resting

TTE can provide information on cardiac function, cardiac morphology, valvular heart disease, detect intracardiac shunts, detect cardiac masses, and assess pericardial effusions.

Variant 3: Adult. Preprocedural chest or cardiac imaging prior to noncoronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.

The goal of preprocedural imaging for planned noncoronary cardiac surgery in a patient without a history of cardiothoracic surgery is to inform the surgical approach and technique and reduce the risk of intraoperative complications. Preprocedural imaging can identify aortic calcifications influencing the aortic cannulation site selection, valvular calcifications, and pericardial calcifications and identify normal and variant anatomy of vascular and nonvascular structures, which can aid in choosing and guiding an open or minimally invasive approach. For preprocedural imaging for transcatheter valve replacement or occlusion device, dedicated endovascular planning considerations should be addressed for sizing and vascular access; please refer to the ACR Appropriateness Criteria® topic on "Preprocedural Planning for Transcatheter Aortic Valve Replacement" [42] and other articles on transcatheter mitral and tricuspid valve replacement [43-45]. For dedicated imaging to delineate congenital and structural heart disease, please see ACR Appropriateness Criteria® topics on "Congenital or Acquired Heart Disease" [8] and "Evaluation of Coronary Artery Anomalies" [24].

Variant 3: Adult. Preprocedural chest or cardiac imaging prior to noncoronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
A. Arteriography coronary

ICA can identify the location, degree, and hemodynamic significance of coronary stenoses and identify coronary anomalies that may impact the surgical approach particularly for aortic root surgery.

Variant 3: Adult. Preprocedural chest or cardiac imaging prior to noncoronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
B. CT chest with IV contrast

CT chest with IV contrast can evaluate systemic vascular calcifications including within the aortic valve, aorta, and proximal aortic arch vessels, identify the location of vessels relative to the chest wall, assess chest wall anatomic abnormalities such as pectus excavatum, assess pericardial or pleural calcifications and thickening, and evaluate for evidence of mediastinal adhesions, which may impact the surgical approach.

Several studies have shown that the use of preprocedural CT chest prior to cardiac surgery can identify aortic calcifications, which result in modification of the planned aortic cannulation site [19-21]. One study showed a reduced stroke rate in patients undergoing cardiac surgery who underwent a preprocedural CT chest compared with those without a preprocedural CT chest, postulated to be related to modification of the aortic cannulation site based on calcification identified on CT [21]. One meta-analysis including 18 studies and 4,057 patients suggests that the use of preprocedural CT may reduce the risk of perioperative stroke and mortality in first-time cardiac surgery patients [19]. This was attributed to choosing a different cannulation site based on location and degree of aortic calcifications, changing to off-pump cardiac surgery, or cancellation of the surgery.

A retrospective case-control study looked at the incidence of postoperative stroke in 405 patients undergoing primary coronary artery bypass grafting who had preprocedural CT chest looking for aortic calcifications [22]. They showed a higher percentage of aortic root, ascending aortic, and descending aortic calcifications in patients who developed postoperative stroke compared with those who did not. However, none of these achieved statistical significance. The authors conclude that although CT chest is helpful in identifying aortic calcifications, its role in reducing postoperative stroke is not clearly established and warrants further prospective investigation.

Variant 3: Adult. Preprocedural chest or cardiac imaging prior to noncoronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
C. CT chest without and with IV contrast

CT chest without and with IV contrast has limited added value compared with a CT chest without

IV contrast or a CT chest with IV contrast. Most vascular calcifications can typically be identified on examinations either without or with IV contrast examinations. There is no relevant literature to support the routine use of CT chest without and with IV contrast prior to noncoronary cardiac surgery in patients without a history of cardiothoracic surgery. The individual components of this procedure are covered in the relevant "without and with IV contrast" sections.

Variant 3: Adult. Preprocedural chest or cardiac imaging prior to noncoronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
D. CT chest without IV contrast

CT chest without IV contrast can evaluate systemic vascular calcifications including in the aortic valve, aorta, and proximal aortic arch vessels, identify the location of systemic vessels in relationship to the chest wall, assess for chest wall anatomic abnormalities such as pectus excavatum, and assess for pericardial or pleural calcifications and thickening, which may impact the surgical approach.

Several studies have shown that the use of preprocedural CT chest prior to cardiac surgery can identify aortic calcifications, which result in modification of the planned aortic cannulation site [19-21]. One study showed a reduced stroke rate in patients undergoing cardiac surgery who underwent a preprocedural CT chest compared with those without a preprocedural CT chest, postulated to be related to modification of the aortic cannulation site based on calcification identified on CT [21]. One meta-analysis including 18 studies and 4,057 patients suggests that the use of preprocedural CT may reduce the risk of perioperative stroke and mortality in first-time cardiac surgery patients [19]. This was attributed to choosing a different cannulation site based on location and degree of aortic calcifications, changing to off-pump cardiac surgery, or cancellation of the surgery.

Variant 3: Adult. Preprocedural chest or cardiac imaging prior to noncoronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
E. CT heart function and morphology with IV contrast

CT heart function and morphology with IV contrast provides information on cardiac function, chamber size and morphology, some valvular disease, cardiac masses, pericardial effusions, and aortic root size. There is no relevant literature to support the routine use of CT heart function and morphology with IV contrast prior to noncoronary cardiac surgery in patients without a history of cardiothoracic surgery.

Variant 3: Adult. Preprocedural chest or cardiac imaging prior to noncoronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
F. CTA chest with IV contrast

In addition to findings seen on CT chest with IV contrast and CT chest without IV contrast, CTA chest with IV contrast provides detailed assessment of the thoracic arteries, including size, course, degree of atherosclerosis, and degree of luminal narrowing.

Several studies have shown that the use of preprocedural CT chest prior to cardiac surgery can identify aortic calcifications, which result in modification of the planned aortic cannulation site [19-21]. One study showed a reduced stroke rate in patients undergoing cardiac surgery who underwent a preprocedural CT chest compared with those without a preprocedural CT chest, postulated to be related to modification of the aortic cannulation site based on calcification identified on CT [21]. One meta-analysis including 18 studies and 4,057 patients suggests that the use of preprocedural CT may reduce the risk of perioperative stroke and mortality in first-time cardiac surgery patients [19]. This was attributed to choosing a different cannulation site based on location and degree of aortic calcifications, changing to off-pump cardiac surgery, or cancellation of the surgery.

Variant 3: Adult. Preprocedural chest or cardiac imaging prior to noncoronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
G. CTA chest without and with IV contrast

In addition to findings seen on CT chest with IV contrast and CT chest without IV contrast, CTA chest without and with IV contrast provides detailed assessment of the thoracic arteries, including size, course, degree of atherosclerosis, and degree of luminal narrowing.

Several studies have shown that the use of preprocedural CT chest prior to cardiac surgery can identify aortic calcifications, which result in modification of the planned aortic cannulation site [19-21]. One study showed a reduced stroke rate in patients undergoing cardiac surgery who underwent a preprocedural CT chest compared with those without a preprocedural CT chest, postulated to be related to modification of the aortic cannulation site based on calcification identified on CT [21]. One meta-analysis including 18 studies and 4,057 patients suggests that the use of preprocedural CT may reduce the risk of perioperative stroke and mortality in first-time cardiac surgery patients [19]. This was attributed to choosing a different cannulation site based on location and degree of aortic calcifications, changing to off-pump cardiac surgery, or cancellation of the surgery.

Variant 3: Adult. Preprocedural chest or cardiac imaging prior to noncoronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
H. CTA coronary arteries with IV contrast

CTA coronary arteries with IV contrast can provide detailed information regarding the origin, course, and termination of the coronary arteries, which may impact the surgical approach particularly for aortic root surgery, the location and degree of coronary stenoses, and the presence and features of coronary plaque. The hemodynamic significance of a coronary stenosis can also be assessed with adjunctive analyses such as CT-FFR.

Variant 3: Adult. Preprocedural chest or cardiac imaging prior to noncoronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
I. MRA chest with IV contrast

MRA chest with IV contrast can provide similar information to CTA, including a detailed assessment of the thoracic vasculature. However, as it pertains to preprocedural planning, a major limitation of MRA is its reduced ability to accurately identify calcifications compared with CTA. There is no relevant literature to support the routine use of MRA chest with IV contrast prior to noncoronary cardiac surgery in patients without a history of cardiothoracic surgery.

Variant 3: Adult. Preprocedural chest or cardiac imaging prior to noncoronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
J. MRA chest without and with IV contrast

MRA chest without and with IV contrast can provide similar information to CTA, including a detailed assessment of the thoracic vasculature. However, as it pertains to preprocedural planning, a major limitation of MRA is its reduced ability to accurately identify calcifications compared with CTA. There is no relevant literature to support the routine use of MRA chest without and with IV contrast prior to noncoronary cardiac surgery in patients without a history of cardiothoracic surgery.

Variant 3: Adult. Preprocedural chest or cardiac imaging prior to noncoronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
K. MRA chest without IV contrast

MRA chest without IV contrast can provide similar information to CTA, including a detailed assessment of the thoracic vasculature. However, as it pertains to preprocedural planning, a major limitation of MRA is its reduced ability to accurately identify calcifications. There is no relevant literature to support the routine use of MRA chest without IV contrast prior to noncoronary cardiac surgery in patients without a history of cardiothoracic surgery.

Variant 3: Adult. Preprocedural chest or cardiac imaging prior to noncoronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
L. MRA coronary arteries without and with IV contrast

MRA coronary arteries without and with IV contrast can provide detailed information regarding the origin, course, and termination of the coronary arteries. There is no relevant literature to support the routine use of MRA coronary arteries without and with IV contrast prior to noncoronary cardiac surgery in patients without a history of cardiothoracic surgery.

Variant 3: Adult. Preprocedural chest or cardiac imaging prior to noncoronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
M. MRA coronary arteries without IV contrast

MRA coronary arteries without IV contrast can provide detailed information regarding the origin, course, and termination of the coronary arteries. There is no relevant literature to support the routine use of MRA coronary arteries without IV contrast prior to noncoronary cardiac surgery in patients without a history of cardiothoracic surgery.

Variant 3: Adult. Preprocedural chest or cardiac imaging prior to noncoronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
N. MRI chest with IV contrast

MRA coronary arteries without IV contrast can provide detailed information regarding the origin, course, and termination of the coronary arteries. There is no relevant literature to support the routine use of MRA coronary arteries without IV contrast prior to noncoronary cardiac surgery in patients without a history of cardiothoracic surgery.

Variant 3: Adult. Preprocedural chest or cardiac imaging prior to noncoronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
O. MRI chest without and with IV contrast

MRI chest without and with IV contrast can provide similar information to CT and is typically focused on nonvascular assessment. As it pertains to preprocedural planning, a major limitation of MRI is its reduced ability to accurately identify calcifications. There is no relevant literature to support the routine use of MRI chest without and with IV contrast prior to noncoronary cardiac surgery in patients without a history of cardiothoracic surgery.

Variant 3: Adult. Preprocedural chest or cardiac imaging prior to noncoronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
P. MRI chest without IV contrast

MRI chest without IV contrast can provide similar information to CT and is typically focused on nonvascular assessment. As it pertains to preprocedural planning, a major limitation of MRI is its reduced ability to accurately identify calcifications. There is no relevant literature to support the routine use of MRI chest without IV contrast prior to noncoronary cardiac surgery in patients without a history of cardiothoracic surgery.

Variant 3: Adult. Preprocedural chest or cardiac imaging prior to noncoronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
Q. MRI heart function and morphology without and with IV contrast

MRI heart function and morphology without and with IV contrast can assess cardiac function, chamber size, and morphology. MRI has the added advantage of being able to quantify valvular disease and shunts, assess for myocardial scar, and potentially better characterize the pericardium. In cases of planned surgery for cardiac mass resection, MRI will commonly be performed during the initial workup to better characterize the mass, which may guide the decision for surgery. There is no relevant literature to support the routine use of MRI heart function and morphology without and with IV contrast prior to noncoronary cardiac surgery in patients without a history of cardiothoracic surgery.

Variant 3: Adult. Preprocedural chest or cardiac imaging prior to noncoronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
R. MRI heart function and morphology without IV contrast

MRI heart function and morphology without IV contrast can assess cardiac function, chamber size, and morphology. MRI can quantify valvular disease and shunts, perform myocardial tissue characterization using parametric mapping techniques, characterize the pericardium, and characterize cardiac masses, although the latter 3 would typically be performed with IV contrast. There is no relevant literature to support the routine use of MRI heart function and morphology without IV contrast prior to noncoronary cardiac surgery in patients without a history of cardiothoracic surgery.

Variant 3: Adult. Preprocedural chest or cardiac imaging prior to noncoronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
S. Radiography chest

Chest radiography can assess musculoskeletal anatomy and size of the cardiac silhouette and screen for pulmonary or pleural disease and extensive pericardial calcifications and vascular calcifications. Although many patients will have undergone chest radiography prior to surgery for various clinical reasons, preprocedural planning is not typically its primary use. One study showed preprocedural chest radiography to be insensitive to the detection of aortic atheromatous plaque, which has been associated with adverse neurologic outcome after cardiac surgery [20].

A retrospective study with 1,136 patients undergoing cardiac surgery showed that preprocedural chest radiography frequently found abnormalities (50% of patients) but rarely changed clinical management (0.3% of patients) [27].

Variant 3: Adult. Preprocedural chest or cardiac imaging prior to noncoronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
T. US echocardiography transesophageal

TEE can provide information on cardiac function, cardiac morphology, and valvular heart disease, detect intracardiac shunts, detect cardiac masses, and assess pericardial effusions. Compared with TTE, a notable benefit is better visualization of some heart structures due to better special resolution and the probe's closer proximity to the heart. TEE demonstrated aortic arch atheroma in 55% of patients without evidence of aortic arch plaque by chest radiography [28].

Some preprocedural imaging may be reserved for the day of surgery. A 2010 practice guidelines for perioperative TEE, which includes the performance of TEE immediately prior to surgery, recommends the use of perioperative TEE in all adult patients without a contraindication to TEE who are undergoing cardiac surgery and that it should be considered in patients undergoing coronary artery bypass grafting, particularly in patients with abnormal ventricular function [29]. TEE can confirm and refine the preprocedural diagnosis, detect new or unsuspected pathology, and adjust the surgical plan.

Variant 3: Adult. Preprocedural chest or cardiac imaging prior to noncoronary cardiac surgery. No history of cardiothoracic surgery. Preprocedure planning.
U. US echocardiography transthoracic resting

TTE can provide information on cardiac function, cardiac morphology, valvular heart disease, detect intracardiac shunts, detect cardiac masses, and assess pericardial effusions.

Variant 4: Adult. Preprocedural chest or cardiac imaging for noncoronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.

Preprocedural imaging for planned noncoronary cardiac surgery in a patient with a history of cardiothoracic surgery is to inform the surgical approach and technique and reduce the risk of intraoperative complications. Preprocedural imaging can identify aortic calcifications influencing the aortic cannulation site selection, valvular calcifications, and pericardial calcifications and identify normal and variant anatomy of vascular and nonvascular structures, which can aid in choosing and guiding an open or minimally invasive approach. In patients with a history of cardiothoracic surgery, a unique consideration is to identify the proximity of any prior bypass grafts to the posterior sternum or evidence of mediastinal adhesions in order to appropriately plan the surgical approach. For preprocedural imaging for transcatheter valve replacement or occlusion device, dedicated endovascular planning considerations should be addressed for sizing and vascular access; please refer to the ACR Appropriateness Criteria® topic on "Preprocedural Planning for Transcatheter Aortic Valve Replacement" [42] and other articles on transcatheter mitral and tricuspid valve replacement [43-45]. For dedicated imaging to delineate congenital and structural heart disease, please see ACR Appropriateness Criteria® topics on "Congenital or Acquired Heart Disease" [8] and "Evaluation of Coronary Artery Anomalies" [24].

Variant 4: Adult. Preprocedural chest or cardiac imaging for noncoronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
A. Arteriography coronary

ICA can identify the location, degree, and hemodynamic significance of coronary stenoses in the native coronary arteries or any coronary artery bypass grafts and identify coronary anomalies, which may impact the surgical approach particularly for aortic root surgery.

Variant 4: Adult. Preprocedural chest or cardiac imaging for noncoronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
B. CT chest with IV contrast

CT chest with IV contrast can evaluate systemic vascular calcifications including within the aortic valve, aorta, and proximal aortic arch vessels, identify the location of vessels relative to the chest wall, assess chest wall anatomic abnormalities such as pectus excavatum, assess pericardial or pleural calcifications and thickening, and evaluate for evidence of mediastinal adhesions, which may impact the surgical approach.

Multiple studies evaluating the use of preprocedural CT prior to redo sternotomy have shown a statistical trend toward reducing complications including sternal re-entry injury, shorter perfusion and cross clamp times, shorter intensive care unit stays, less frequent perioperative myocardial infarcts, and reduced risk of perioperative stroke. This was attributed to identifying high-risk features, such as extensive aortic calcifications and <10-mm distance of the right ventricle, aorta, or any coronary artery bypass grafts to the sternum, which may have resulted in a different surgical approach, different cannulation site, changing to off-pump cardiac surgery, or cancellation of the surgery [2,19,30-37].

One meta-analysis showed that the presence of high-risk features on preprocedural CT (right ventricle, aorta, or graft <10 mm from the sternum) resulted in cancellation of surgery in 4% to 13% of cases and a change in surgical strategy in up to 80% of cases [34].

Variant 4: Adult. Preprocedural chest or cardiac imaging for noncoronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
C. CT chest without and with IV contrast

CT chest without and with IV contrast has limited added value compared with a CT chest without IV contrast or a CT chest with IV contrast. Most vascular calcifications can typically be identified on examinations either without or with IV contrast examinations. There is no relevant literature to support the routine use of CT chest without and with IV contrast prior to noncoronary cardiac surgery in patients with a history of cardiothoracic surgery. The individual components of this procedure are covered in the relevant “without and with IV contrast” sections.

Variant 4: Adult. Preprocedural chest or cardiac imaging for noncoronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
D. CT chest without IV contrast

CT chest without IV contrast can evaluate systemic vascular calcifications including within the aortic valve, aorta, and proximal aortic arch vessels, identify the location of vessels relative to the chest wall, assess chest wall anatomic abnormalities such as pectus excavatum, assess pericardial or pleural calcifications and thickening, and evaluate for evidence of mediastinal adhesions, which may impact the surgical approach. In patients with a history of prior cardiothoracic surgery, CT chest without IV contrast may better visualize any surgical material.

Multiple studies evaluating the use of preprocedural CT prior to redo sternotomy have shown a statistical trend toward reducing complications including sternal re-entry injury, shorter perfusion and cross clamp times, shorter intensive care unit stays, less frequent perioperative myocardial infarcts, and reduced risk of perioperative stroke. This was attributed to identifying high-risk features, such as extensive aortic calcifications and <10-mm distance of the right ventricle, aorta, or any coronary artery bypass grafts to the sternum, which may have resulted in a different surgical approach, different cannulation site, changing to off-pump cardiac surgery, or cancellation of the surgery [2,19,30-37].

One meta-analysis showed that the presence of high-risk features on preprocedural CT (right ventricle, aorta, or graft <10 mm from the sternum) resulted in cancellation of surgery in 4% to 13% of cases and a change in surgical strategy in up to 80% of cases [34].

In their initial experience using a specialized dynamic free breathing noncontrast CT scan of the chest to look for dynamic tethering of mediastinal structures to the sternum, Narayan et al [38] demonstrated reliable exclusion of sternal adhesions in 14 of 19 patients undergoing redo cardiac surgery. The authors noted no false-negative results from the preprocedural CT, suggesting this technique may be useful in preprocedural planning to reduce the risk of sternal re-entry injury.

Variant 4: Adult. Preprocedural chest or cardiac imaging for noncoronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
E. CT heart function and morphology with IV contrast

CT heart function and morphology with IV contrast provides information on cardiac function, chamber size and morphology, some valvular disease, cardiac masses, pericardial effusions, and aortic root size. Choi et al [39] looked at 80 consecutive patients scheduled for redo cardiac surgery who underwent a retrospectively gated cardiac CT and found that by using the cine reconstructions from the CT, they had a 95% accuracy in identifying retrosternal adhesions compared with those identified intraoperatively. The surgical approach changed in 62% of patients with adhesions detected by CT.

Variant 4: Adult. Preprocedural chest or cardiac imaging for noncoronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
F. CTA chest with IV contrast

In addition to findings seen on CT chest with IV contrast and CT chest without IV contrast, CTA chest with IV contrast provides detailed assessment of the thoracic arteries, including size, course, degree of atherosclerosis, and degree of luminal narrowing. In patients with a history of cardiothoracic surgery, CTA chest with IV contrast can both evaluate patency of any prior bypass grafts and identify the proximity of any prior bypass grafts to the posterior sternum to inform the surgical approach.

Multiple studies evaluating the use of preprocedural CT prior to redo sternotomy have shown a statistical trend toward reducing complications including sternal re-entry injury, shorter perfusion and cross clamp times, shorter intensive care unit stays, less frequent perioperative myocardial infarcts, and reduced risk of perioperative stroke. This was attributed to identifying high-risk features, such as extensive aortic calcifications and <10-mm distance of the right ventricle, aorta, or any coronary artery bypass grafts to the sternum, which may have resulted in a different surgical approach, different cannulation site, changing to off-pump cardiac surgery, or cancellation of the surgery [2,19,30-37].

One meta-analysis showed that the presence of high-risk features on preprocedural CT (right ventricle, aorta, or graft <10 mm from the sternum) resulted in cancellation of surgery in 4% to 13% of cases and a change in surgical strategy in up to 80% of cases [34].

Variant 4: Adult. Preprocedural chest or cardiac imaging for noncoronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
G. CTA chest without and with IV contrast

In addition to findings seen on CT chest with IV contrast and CT chest without IV contrast, CTA chest without and with IV contrast provides detailed assessment of the thoracic arteries, including size, course, degree of atherosclerosis, and degree of luminal narrowing. In patients with a history of cardiothoracic surgery, CTA chest without and with IV contrast can both evaluate patency of any prior bypass grafts and identify the proximity of any prior bypass grafts to the posterior sternum to inform the surgical approach. The without IV contrast portion of the examination may better visualize any surgical material.

Multiple studies evaluating the use of preprocedural CT prior to redo sternotomy have shown a statistical trend toward reducing complications including sternal re-entry injury, shorter perfusion and cross clamp times, shorter intensive care unit stays, less frequent perioperative myocardial infarcts, and reduced risk of perioperative stroke. This was attributed to identifying high-risk features, such as extensive aortic calcifications and <10-mm distance of the right ventricle, aorta, or any coronary artery bypass grafts to the sternum, which may have resulted in a different surgical approach, different cannulation site, changing to off-pump cardiac surgery, or cancellation of the surgery [2,19,30-37].

One meta-analysis showed that the presence of high-risk features on preprocedural CT (right ventricle, aorta, or graft <10 mm from the sternum) resulted in cancellation of surgery in 4% to 13% of cases and a change in surgical strategy in up to 80% of cases [34].

The panel did not reach consensus on the appropriateness of CTA of the chest without and with IV contrast.

Variant 4: Adult. Preprocedural chest or cardiac imaging for noncoronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
H. CTA coronary arteries with IV contrast

CTA coronary arteries with IV contrast can provide detailed information regarding the origin, course, and termination of the native coronary arteries and any coronary artery bypass grafts, which may impact the surgical approach particularly for aortic root surgery, the location and degree of native or bypass graft coronary stenoses, and the presence and features of coronary plaque. The hemodynamic significance of a native coronary stenosis can also be assessed with adjunctive analyses such as CT-FFR.

Variant 4: Adult. Preprocedural chest or cardiac imaging for noncoronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
I. MRA chest with IV contrast

MRA chest with IV contrast can provide similar information to CTA, including a detailed assessment of the thoracic vasculature, evidence of mediastinal adhesions, and proximity of any prior bypass grafts to the posterior sternum. However, as it pertains to preprocedural planning, a major limitation of MRA is its reduced ability to accurately identify calcifications. There is no relevant literature to support the routine use of MRA chest with IV contrast prior to noncoronary cardiac surgery in patients with a history of cardiothoracic surgery.

Variant 4: Adult. Preprocedural chest or cardiac imaging for noncoronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
J. MRA chest without and with IV contrast

MRA chest without and with IV contrast can provide similar information to CT, including a detailed assessment of the thoracic vasculature, evidence of mediastinal adhesions, and proximity of any prior bypass grafts to the posterior sternum. However, as it pertains to preprocedural planning, a major limitation of MRA is its reduced ability to accurately identify calcifications. There is no relevant literature to support the routine use of MRA chest without and with IV contrast prior to noncoronary cardiac surgery in patients with a history of cardiothoracic surgery.

Variant 4: Adult. Preprocedural chest or cardiac imaging for noncoronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
K. MRA chest without IV contrast

MRA chest without IV contrast can provide similar information to CT, including a detailed assessment of the thoracic vasculature, evidence of mediastinal adhesions, and proximity of any prior bypass grafts to the posterior sternum. However, as it pertains to preprocedural planning, a major limitation of MRA is its reduced ability to accurately identify aortic calcifications compared with CT. There is no relevant literature to support the routine use of MRA chest without IV contrast prior to noncoronary cardiac surgery in patients with a history of cardiothoracic surgery.

Variant 4: Adult. Preprocedural chest or cardiac imaging for noncoronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
L. MRA coronary arteries without and with IV contrast

MRA coronary arteries without and with IV contrast can provide detailed information regarding the origin, course, and termination of the native coronary arteries and any coronary artery bypass grafts. There is no relevant literature to support the routine use of MRA coronary arteries without and with IV contrast prior to noncoronary cardiac surgery in patients with a history of cardiothoracic surgery. There is no relevant literature to support the routine use of MRA coronary arteries without and with IV contrast prior to noncoronary cardiac surgery in patients with a history of cardiothoracic surgery.

Variant 4: Adult. Preprocedural chest or cardiac imaging for noncoronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
M. MRA coronary arteries without IV contrast

MRA coronary arteries without IV contrast can provide detailed information regarding the origin, course, and termination of the native coronary arteries and any coronary artery bypass grafts. There is no relevant literature to support the routine use of MRA coronary arteries without IV contrast prior to noncoronary cardiac surgery in patients with a history of cardiothoracic surgery.

Variant 4: Adult. Preprocedural chest or cardiac imaging for noncoronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
N. MRI chest with IV contrast

MRI chest with IV contrast can provide similar information to CT and may allow for the assessment of thoracic vasculature, evidence of mediastinal adhesions, and proximity of any prior bypass grafts to the posterior sternum, and is typically focused on nonvascular assessment. As it pertains to preprocedural planning, a major limitation of MRI is its reduced ability to accurately identify calcifications. There is no relevant literature to support the routine use of MRI chest with IV contrast prior to noncoronary cardiac surgery in patients with a history of cardiothoracic surgery.

Variant 4: Adult. Preprocedural chest or cardiac imaging for noncoronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
O. MRI chest without and with IV contrast

MRI chest without and with IV contrast can provide similar information to CT and may allow for the assessment of thoracic vasculature, evidence of mediastinal adhesions, and proximity of any prior bypass grafts to the posterior sternum, and is typically focused on nonvascular assessment. As it pertains to preprocedural planning, a major limitation of MRI is its reduced ability to accurately identify calcifications. There is no relevant literature to support the routine use of MRI chest without and with IV contrast prior to noncoronary cardiac surgery in patients with a history of cardiothoracic surgery.

Variant 4: Adult. Preprocedural chest or cardiac imaging for noncoronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
P. MRI chest without IV contrast

MRI chest without IV contrast can provide similar information to CT and may allow for the assessment of thoracic vasculature, evidence of mediastinal adhesions, and proximity of any prior bypass grafts to the posterior sternum and is typically focused on nonvascular assessment. As it pertains to preprocedural planning, a major limitation of MRI is its reduced ability to accurately identify calcifications. There is no relevant literature to support the routine use of MRI chest without IV contrast prior to noncoronary cardiac surgery in patients with a history of cardiothoracic surgery.

Variant 4: Adult. Preprocedural chest or cardiac imaging for noncoronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
Q. MRI heart function and morphology without and with IV contrast

MRI heart function and morphology without and with IV contrast can assess of cardiac function, chamber size, and morphology. MRI can quantify valvular disease and shunts, assess for myocardial scar, and characterize the pericardium. In cases of planned surgery for cardiac mass resection, MRI will commonly be performed during the initial workup to better characterize the mass, which may guide the decision for surgery.

Yoshioka et al [41] showed in 13 patients that preprocedural tagged cine MRI could provide an accurate assessment of retrosternal cardiac adhesions prior to sternal re-entry in redo cardiac surgery. A preprocedural adhesion score determined by visual assessment of the malformation of the tags between the sternum and myocardium correlated well ($r = .76$, $P < .01$) with the intraoperative adhesion score determined by the surgeon at the time of redo surgery.

Variant 4: Adult. Preprocedural chest or cardiac imaging for noncoronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
R. MRI heart function and morphology without IV contrast

MRI heart function and morphology without IV contrast can assess cardiac function, chamber size, and morphology. MRI can quantify valvular disease and shunts, perform myocardial tissue characterization using parametric mapping techniques, characterize the pericardium, and characterize cardiac masses, although the latter 3 would typically be performed with IV contrast.

Yoshioka et al [41] showed in 13 patients that preprocedural tagged cine MRI could provide an accurate assessment of retrosternal cardiac adhesions prior to sternal re-entry in redo cardiac surgery. A preprocedural adhesion score determined by visual assessment of the malformation of the tags between the sternum and myocardium correlated well ($r = .76$, $P < .01$) with the intraoperative adhesion score determined by the surgeon at the time of redo surgery.

Variant 4: Adult. Preprocedural chest or cardiac imaging for noncoronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
S. Radiography chest

Chest radiography can assess musculoskeletal anatomy and size of the cardiac silhouette and screen for pulmonary or pleural disease and extensive pericardial calcifications and vascular calcifications. Although many patients will have undergone chest radiography prior to surgery for various clinical reasons, preprocedural planning is not typically its primary use. One study showed preprocedural chest radiography to be insensitive to the detection of aortic atheromatous plaque, which has been associated with adverse neurologic outcome after cardiac surgery [20].

A retrospective study with 1,136 patients undergoing cardiac surgery showed that preprocedural chest radiography frequently found abnormalities (50% of patients) but rarely changed clinical management (0.3% of patients) [27].

Variant 4: Adult. Preprocedural chest or cardiac imaging for noncoronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
T. US echocardiography transesophageal

TEE can provide information on cardiac function, cardiac morphology, and valvular heart disease, detect intracardiac shunts, detect cardiac masses, and assess pericardial effusions. Compared with TTE, a notable benefit is better visualization of some heart structures due to better special resolution and the probe’s closer proximity to the heart. TEE demonstrated aortic arch atheroma in 55% of patients without evidence of aortic arch plaque by chest radiography [28].

Some preprocedural imaging may be reserved for the day of surgery. A 2010 practice guidelines for perioperative TEE, which includes the performance of TEE immediately prior to surgery, recommends the use of perioperative TEE in all adult patients without a contraindication to TEE who are undergoing cardiac surgery and that it should be considered in patients undergoing coronary artery bypass grafting, particularly in patients with abnormal ventricular function [29]. TEE can confirm and refine the preprocedural diagnosis, detect new or unsuspected pathology, and adjust the surgical plan.

Variant 4: Adult. Preprocedural chest or cardiac imaging for noncoronary cardiac surgery. History of cardiothoracic surgery. Preprocedure planning.
U. US echocardiography transthoracic resting

TTE can provide information on cardiac function, cardiac morphology, valvular heart disease, detect intracardiac shunts, detect cardiac masses, and assess pericardial effusions.

Variant 5: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. No history of cardiothoracic surgery. Preprocedure planning.

The goal of preprocedural imaging for planned thoracic surgery in a patient without a history of cardiothoracic surgery is to inform the surgical approach and technique and reduce the risk of intraoperative complications. Preprocedural imaging can identify aortic calcifications influencing the aortic cannulation site selection for those thoracic surgeries requiring cardiopulmonary bypass and identify normal and variant anatomy of vascular and nonvascular structures, which can aid in choosing and guiding an open or minimally invasive approach. Imaging to assess invasion of a mass across tissue planes would typically be performed as part of the initial workup leading to the decision for surgery. For a more detailed discussion, please refer to the ACR Appropriateness Criteria® topic on “Imaging of Mediastinal Masses” [14].

Variant 5: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. No history of cardiothoracic surgery. Preprocedure planning.
A. Arteriography coronary

ICA can identify the location, degree, and hemodynamic significance of coronary stenoses and identify coronary anomalies. There is no relevant literature to support the routine use of arteriography coronary prior to thoracic surgery in patients without a history of cardiothoracic surgery.

Variant 5: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. No history of cardiothoracic surgery. Preprocedure planning.
B. CT chest with IV contrast

CT chest with IV contrast can evaluate systemic vascular calcifications; identify the location of vessels relative to the chest wall; assess chest wall anatomic abnormalities such as pectus excavatum; assess pericardial or pleural calcifications and thickening, which may impact the surgical approach; and assess for extension of a mass across tissue planes. Most patients undergoing thoracic surgery without a history of prior cardiothoracic surgery will have had CT chest with IV contrast and/or CT chest without IV contrast performed as part of their clinical workup.

Variant 5: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. No history of cardiothoracic surgery. Preprocedure planning.
C. CT chest without and with IV contrast

CT chest without and with IV contrast has limited added value compared with a CT chest without IV contrast or a CT chest with IV contrast. Most vascular calcifications can typically be identified on examinations either without or with IV contrast examinations. There is no relevant literature to support the routine use of CT chest without and with IV contrast prior to thoracic surgery in patients without a history of cardiothoracic surgery. The individual components of this procedure are covered in the relevant "without and with IV contrast" sections.

Variant 5: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. No history of cardiothoracic surgery. Preprocedure planning.
D. CT chest without IV contrast

CT chest without IV contrast can evaluate systemic vascular calcifications, identify the location of vessels relative to the chest wall, assess chest wall anatomic abnormalities such as pectus excavatum, and assess pericardial or pleural calcifications and thickening, which may impact the surgical approach, and assess for extension of a mass across tissue planes, although this would typically be done with IV contrast. Most patients undergoing thoracic surgery without a history of prior cardiothoracic surgery will have had CT chest with IV contrast and/or CT chest without IV contrast performed as part of their clinical workup.

Variant 5: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. No history of cardiothoracic surgery. Preprocedure planning.
E. CT heart function and morphology with IV contrast

CT heart function and morphology with IV contrast provides information on cardiac function, chamber size and morphology, some valvular disease, cardiac masses, pericardial effusions, aortic root size, and potentially assess for invasion of a soft tissue mass into pericardium, myocardium, and coronary arteries and veins. There is no relevant literature to support the routine use of CT heart function and morphology with IV contrast prior to thoracic surgery in patients without a history of cardiothoracic surgery.

Variant 5: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. No history of cardiothoracic surgery. Preprocedure planning.
F. CTA chest with IV contrast

In addition to findings seen on CT chest with IV contrast and CT chest without IV contrast, CTA chest with IV contrast provides detailed assessment of the thoracic arteries, including size, course, degree of atherosclerosis, degree of luminal narrowing, and the relationship of soft tissue masses with mediastinal vascular structures.

Variant 5: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. No history of cardiothoracic surgery. Preprocedure planning.
G. CTA chest without and with IV contrast

In addition to findings seen on CT chest with IV contrast and CT chest without IV contrast, CTA chest without and with IV contrast provides detailed assessment of the thoracic arteries, including size, course, degree of atherosclerosis, degree of luminal narrowing, and the relationship of soft tissue masses with mediastinal vascular structures.

Variant 5: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. No history of cardiothoracic surgery. Preprocedure planning.
H. CTA coronary arteries with IV contrast

CTA coronary arteries with IV contrast can provide detailed information regarding the origin, course, and termination of the coronary arteries, the location and degree of coronary stenoses, and the presence and features of coronary plaque. The hemodynamic significance of a coronary stenosis can also be assessed with CT-FFR. There is no relevant literature to support the routine use of CTA coronary arteries with IV contrast prior to thoracic surgery in patients without a history of cardiothoracic surgery.

Variant 5: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. No history of cardiothoracic surgery. Preprocedure planning.
I. MRA chest with IV contrast

MRA chest with IV contrast can provide similar information to CTA, including a detailed assessment of the thoracic vasculature, and assessment of the relationship of a soft tissue mass with mediastinal vascular structures [14]. As it pertains to preprocedural planning, a major limitation of MRA is its reduced ability to accurately identify a calcifications compared with CT.

Variant 5: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. No history of cardiothoracic surgery. Preprocedure planning.
J. MRA chest without and with IV contrast

MRA chest without and with IV contrast can provide similar information to CT, including a detailed assessment of the thoracic vasculature, and assessment of the relationship of a soft tissue mass with mediastinal vascular structures [14]. As it pertains to preprocedural planning, a major limitation of MRA is its reduced ability to accurately identify calcifications compared with CTA.

Variant 5: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. No history of cardiothoracic surgery. Preprocedure planning.
K. MRA chest without IV contrast

MRA chest without IV contrast can provide similar information to CT, including a detailed assessment of the thoracic vasculature, and assessment of the relationship of a soft tissue mass with mediastinal vascular structures [14]. As it pertains to preprocedural planning, a major limitation of MRA is its reduced ability to accurately identify calcifications compared with CTA.

Variant 5: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. No history of cardiothoracic surgery. Preprocedure planning.
L. MRA coronary arteries without and with IV contrast

MRA coronary arteries without and with IV contrast can provide detailed information regarding the origin, course, and termination of the coronary arteries. There is no relevant literature to support the routine use of MRA coronary arteries without and with IV contrast prior to thoracic surgery in patients without a history of cardiothoracic surgery.

Variant 5: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. No history of cardiothoracic surgery. Preprocedure planning.
M. MRA coronary arteries without IV contrast

MRA coronary arteries without IV contrast can provide detailed information regarding the origin, course, and termination of the coronary arteries. There is no relevant literature to support the routine use of MRA coronary arteries without IV contrast prior to thoracic surgery in patients without a history of cardiothoracic surgery.

Variant 5: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. No history of cardiothoracic surgery. Preprocedure planning.
N. MRI chest with IV contrast

MRI chest with IV contrast can provide similar information to CT, including a detailed assessment of the thoracic vasculature, and assessment of the relationship of a soft tissue mass with mediastinal vascular structures [14]. This examination is typically focused on nonvascular assessment. As it pertains to preprocedural planning, a major limitation of MRI is its reduced ability to accurately identify calcifications.

Variant 5: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. No history of cardiothoracic surgery. Preprocedure planning.
O. MRI chest without and with IV contrast

MRI chest without and with IV contrast can provide similar information to CT, including a detailed assessment of the thoracic vasculature, and assessment of the relationship of a soft tissue mass with mediastinal vascular structures [14]. This examination is typically focused on nonvascular assessment. As it pertains to preprocedural planning, a major limitation of MRI is its reduced ability to accurately identify calcifications.

Variant 5: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. No history of cardiothoracic surgery. Preprocedure planning.
P. MRI chest without IV contrast

MRI chest without IV contrast can provide similar information to CT, including a detailed assessment of the thoracic vasculature, and assessment of the relationship of a soft tissue mass with mediastinal vascular structures [14], though this would typically be performed with IV contrast. This examination is typically focused on nonvascular assessment. As it pertains to preprocedural planning, a major limitation of MRI is its reduced ability to accurately identify calcifications.

Variant 5: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. No history of cardiothoracic surgery. Preprocedure planning.
Q. MRI heart function and morphology without and with IV contrast

MRI heart function and morphology without and with IV contrast can provide an assessment of cardiac function, chamber size, and morphology. MRI can quantify valvular disease and shunts, assess for myocardial scar, characterize the pericardium, characterize cardiac masses, and assess for invasion of a soft tissue mass into the pericardium, myocardium, and coronary arteries and veins. There is no relevant literature to support the routine use of MRI heart function and morphology without and with IV contrast prior to thoracic surgery in patients without a history of cardiothoracic surgery.

Variant 5: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. No history of cardiothoracic surgery. Preprocedure planning.
R. MRI heart function and morphology without IV contrast

MRI heart function and morphology without and with IV contrast can provide an assessment of cardiac function, chamber size, and morphology. MRI can quantify valvular disease and shunts, assess for myocardial scar, characterize the pericardium, characterize cardiac masses, and assess for invasion of a soft tissue mass into the pericardium, myocardium, and coronary arteries and veins. The latter would typically be performed with IV contrast. There is no relevant literature to support the routine use of MRI heart function and morphology without IV contrast prior to thoracic surgery in patients without a history of cardiothoracic surgery.

Variant 5: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. No history of cardiothoracic surgery. Preprocedure planning.
S. Radiography chest

Chest radiography can assess musculoskeletal anatomy and size of the cardiac silhouette and screen for pulmonary or pleural disease and extensive pericardial calcifications and vascular calcifications. Many patients will have undergone chest radiography prior to surgery for various clinical reasons. One meta-analysis [46] including 11,598 patients who received preprocedural chest radiographs showed that only 0.1% of patients required modification of their management.

Variant 5: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. No history of cardiothoracic surgery. Preprocedure planning.
T. US echocardiography transesophageal

TEE can provide information on cardiac function, cardiac morphology, and valvular heart disease, detect intracardiac shunts, detect cardiac masses, and assess pericardial effusions. Compared with TTE, a notable benefit is better visualization of some heart structures due to better special resolution and the probe’s closer proximity to the heart. If performed, this examination would typically be done after a TTE. There is no relevant literature to support the routine use of TEE prior to thoracic surgery in patients without a history of cardiothoracic surgery.

Variant 5: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. No history of cardiothoracic surgery. Preprocedure planning.
U. US echocardiography transthoracic resting

TTE can provide information on cardiac function, cardiac morphology, and valvular heart disease, detect intracardiac shunts, detect cardiac masses, and assess pericardial effusions. There is no relevant literature to support the routine use of TTE prior to thoracic surgery in patients without a history of cardiothoracic surgery.

Variant 6: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. History of cardiothoracic surgery. Preprocedure planning.

The goal of preprocedural imaging for planned thoracic surgery in a patient with a history of cardiothoracic surgery is to inform the surgical approach and technique and reduce the risk of intraoperative complications. Preprocedural imaging can identify aortic calcifications influencing the aortic cannulation site selection for those thoracic surgeries requiring cardiopulmonary bypass and identify normal and variant anatomy of vascular and nonvascular structures, which can aid in choosing and guiding an open or minimally invasive approach. In patients with a history of cardiothoracic surgery, a unique consideration is to identify the proximity of any prior bypass grafts to the posterior sternum or evidence of mediastinal or pleural adhesions in order to appropriately plan the surgical approach. Imaging to assess invasion of a mass across tissue planes would typically be performed as part of the initial workup leading to the decision for surgery. For a more detailed discussion, please refer to the ACR Appropriateness Criteria® topic on "Imaging of Mediastinal Masses" [14].

Variant 6: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. History of cardiothoracic surgery. Preprocedure planning.
A. Arteriography coronary

ICA can identify the location, degree, and hemodynamic significance of coronary stenoses in the native coronary arteries or any coronary artery bypass grafts and identify coronary anomalies. There is no relevant literature to support the routine use of arteriography coronary prior to thoracic surgery in patients with a history of cardiothoracic surgery.

Variant 6: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. History of cardiothoracic surgery. Preprocedure planning.
B. CT chest with IV contrast

CT chest with IV contrast can evaluate systemic vascular calcifications including within the aortic valve, aorta, and proximal aortic arch vessels; identify the location of vessels relative to the chest wall; assess chest wall anatomic abnormalities such as pectus excavatum; assess pericardial or pleural calcifications and thickening; evaluate for evidence of mediastinal or pleural adhesions, which may impact the surgical approach; and assess for extension of a mass across tissue planes. Most patients undergoing thoracic surgery with a history of prior cardiothoracic surgery will have had CT chest with IV contrast and/or CT chest without IV contrast performed as part of their clinical workup.

Variant 6: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. History of cardiothoracic surgery. Preprocedure planning.
C. CT chest without and with IV contrast

CT chest without and with IV contrast has limited added value compared with a CT chest without IV contrast or a CT chest with IV contrast. Most vascular calcifications can typically be identified on examinations either without or with IV contrast examinations. There is no relevant literature to support the routine use of CT chest without and with IV contrast prior to thoracic surgery in patients with a history of cardiothoracic surgery. The individual components of this procedure are covered in the relevant "without and with IV contrast" sections.

Variant 6: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. History of cardiothoracic surgery. Preprocedure planning.
D. CT chest without IV contrast

CT chest without IV contrast can evaluate systemic vascular calcifications including within the aortic valve, aorta, and proximal aortic arch vessels; identify the location of vessels relative to the chest wall; assess chest wall anatomic abnormalities such as pectus excavatum; assess pericardial or pleural calcifications and thickening, which may impact the surgical approach; and assess for extension of a mass across tissue planes, although this would typically be done with IV contrast. Most patients undergoing thoracic surgery with a history of prior cardiothoracic surgery will have had CT chest with IV contrast and/or CT chest without IV contrast performed as part of their clinical workup.

Variant 6: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. History of cardiothoracic surgery. Preprocedure planning.
E. CT heart function and morphology with IV contrast

CT heart function and morphology with IV contrast provides information on cardiac function, chamber size and morphology, some valvular disease, cardiac masses, pericardial effusions, and aortic root size and assesses for invasion of a soft tissue mass into the pericardium, myocardium, and coronary arteries and veins. Choi et al [39] looked at 80 consecutive patients scheduled for redo cardiac surgery who underwent a retrospectively gated cardiac CT and found that by using the cine reconstructions from the CT, they had a 95% accuracy in identifying retrosternal adhesions compared with those identified intraoperatively. The surgical approach changed in 62% of patients with adhesions detected by CT. Although this study only looked at patients undergoing redo cardiac surgery, one could reasonably extrapolate the results to thoracic surgery in patients with a prior history of cardiothoracic surgery, specifically for those thoracic surgeries requiring a sternotomy.

Variant 6: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. History of cardiothoracic surgery. Preprocedure planning.
F. CTA chest with IV contrast

In addition to findings seen on CT chest with IV contrast and CT chest without IV contrast, CTA chest with IV contrast provides detailed assessment of the thoracic arteries, including size, course, degree of atherosclerosis, degree of luminal narrowing, and the relationship of soft tissue masses with mediastinal vascular structures. In patients with a history of cardiothoracic surgery, CTA chest with IV contrast can both evaluate patency of any prior bypass grafts and identify the proximity of any prior bypass grafts to the posterior sternum to inform the surgical approach.

Variant 6: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. History of cardiothoracic surgery. Preprocedure planning.
G. CTA chest without and with IV contrast

In addition to findings seen on CT chest with IV contrast and CT chest without IV contrast, CTA chest without and with IV contrast provides detailed assessment of the thoracic arteries, including size, course, degree of atherosclerosis, degree of luminal narrowing, and the relationship of soft tissue masses with mediastinal vascular structures. In patients with a history of cardiothoracic surgery, CTA chest without and with IV contrast can both evaluate patency of any prior bypass grafts and identify the proximity of any prior bypass grafts to the posterior sternum to inform the surgical approach. The without IV contrast portion of the examination may better visualize any surgical material.

Variant 6: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. History of cardiothoracic surgery. Preprocedure planning.
H. CTA coronary arteries with IV contrast

CTA coronary arteries with IV contrast can provide detailed information regarding the origin, course, and termination of the native coronary arteries and any coronary artery bypass grafts, the location and degree of native or bypass graft coronary stenoses, and the presence and features of coronary plaque. The hemodynamic significance of a native coronary stenosis can also be assessed with CT-FFR. There is no relevant literature to support the routine use of CTA coronary arteries with IV contrast prior to thoracic surgery in patients with a history of cardiothoracic surgery.

Variant 6: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. History of cardiothoracic surgery. Preprocedure planning.

I. MRA chest with IV contrast

MRA chest with IV contrast can provide similar information to CT, including a detailed assessment of the thoracic vasculature, evidence of mediastinal adhesions, proximity of any prior bypass grafts to the posterior sternum, and assessment of the relationship of a soft tissue mass with mediastinal vascular structures [14]. As it pertains to preprocedural planning, a major limitation of MRA is its reduced ability to accurately identify calcifications.

Variant 6: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. History of cardiothoracic surgery. Preprocedure planning.
J. MRA chest without and with IV contrast

MRA chest without and with IV contrast can provide similar information to CT, including a detailed assessment of the thoracic vasculature, evidence of mediastinal adhesions, proximity of any prior bypass grafts to the posterior sternum, and assessment of the relationship of a soft tissue mass with mediastinal vascular structures [14]. As it pertains to preprocedural planning, a major limitation of MRA is its reduced ability to accurately identify calcifications.

Variant 6: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. History of cardiothoracic surgery. Preprocedure planning.
K. MRA chest without IV contrast

MRA chest without IV contrast can provide similar information to CT, including a detailed assessment of the thoracic vasculature, evidence of mediastinal adhesions, proximity of any prior bypass grafts to the posterior sternum, and assessment of the relationship of a soft tissue mass with mediastinal vascular structures [14]. As it pertains to preprocedural planning, a major limitation of MRA is its reduced ability to accurately identify calcifications.

Variant 6: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. History of cardiothoracic surgery. Preprocedure planning.
L. MRA coronary arteries without and with IV contrast

MRA coronary arteries without and with IV contrast can provide detailed information regarding the origin, course, and termination of the native coronary arteries and any coronary artery bypass grafts. There is no relevant literature to support the routine use of MRA coronary arteries without and with IV contrast prior to thoracic surgery in patients with a history of cardiothoracic surgery.

Variant 6: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. History of cardiothoracic surgery. Preprocedure planning.
M. MRA coronary arteries without IV contrast

MRA coronary arteries without and with IV contrast can provide detailed information regarding the origin, course, and termination of the native coronary arteries and any coronary artery bypass grafts. There is no relevant literature to support the routine use of MRA coronary arteries without IV contrast prior to thoracic surgery in patients with a history of cardiothoracic surgery.

Variant 6: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. History of cardiothoracic surgery. Preprocedure planning.
N. MRI chest with IV contrast

MRI chest with IV contrast can provide similar information to CTA, including a detailed assessment of the thoracic vasculature, evidence of mediastinal adhesions, proximity of any prior bypass grafts to the posterior sternum, and assessment of the relationship of a soft tissue mass with mediastinal vascular structures [14]. This examination is typically focused on nonvascular assessment. As it pertains to preprocedural planning, a major limitation of MRI is its reduced ability to accurately identify calcifications.

Variant 6: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. History of cardiothoracic surgery. Preprocedure planning.
O. MRI chest without and with IV contrast

MRI chest without and with IV contrast can provide similar information to CTA, including a detailed assessment of the thoracic vasculature, evidence of mediastinal adhesions, proximity of any prior bypass grafts to the posterior sternum, and assessment of the relationship of a soft tissue mass with mediastinal vascular structures [14]. This examination is typically focused on nonvascular assessment. As it pertains to preprocedural planning, a major limitation of MRI is its reduced ability to accurately identify calcifications.

Variant 6: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. History of cardiothoracic surgery. Preprocedure planning.
P. MRI chest without IV contrast

MRI chest without IV contrast can provide similar information to CT, including a detailed assessment of the thoracic vasculature, evidence of mediastinal adhesions, proximity of any prior bypass grafts to the posterior sternum, and assessment of the relationship of a soft tissue mass with mediastinal vascular structures [14]. This examination is typically focused on nonvascular assessment. As it pertains to preprocedural planning, a major limitation of MRI is its reduced ability to accurately identify calcifications.

Variant 6: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. History of cardiothoracic surgery. Preprocedure planning.
Q. MRI heart function and morphology without and with IV contrast

MRI heart function and morphology without and with IV contrast can provide an assessment of cardiac function, chamber size, and morphology. MRI can quantify valvular disease and shunts, assess for myocardial scar, characterize the pericardium, characterize cardiac masses, and assess for invasion of a soft tissue mass into the pericardium, myocardium and coronary arteries and veins.

Yoshioka et al [41] showed in 13 patients that preprocedural tagged cine MRI could provide an accurate assessment of retrosternal cardiac adhesions prior to sternal re-entry in redo cardiac surgery. A preprocedural adhesion score determined by visual assessment of the malformation of the tags between the sternum and myocardium correlated well ($r = .76$, $P < .01$), with the intraoperative adhesion score determined by the surgeon at the time of redo surgery. Although this study only looked at patients undergoing redo cardiac surgery, one could reasonably extrapolate the results to thoracic surgery in patients with a prior history of cardiothoracic surgery, specifically for those thoracic surgeries requiring a sternotomy.

Variant 6: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. History of cardiothoracic surgery. Preprocedure planning.
R. MRI heart function and morphology without IV contrast

MRI heart function and morphology without IV contrast can provide similar information to CT related to cardiac function, chamber size and morphology, and aortic root size. MRI has the added advantage of being able to quantify valvular disease and shunts, perform myocardial tissue characterization using parametric mapping techniques, potentially better characterize the pericardium, have better soft tissue characterization of cardiac masses, and potentially better assess for invasion of a soft tissue mass into the pericardium, myocardium, and coronary arteries and veins, although the latter 4 would typically be performed with IV contrast.

Yoshioka et al [41] showed in 13 patients that preprocedural tagged cine MRI could provide an accurate assessment of retrosternal cardiac adhesions prior to sternal re-entry in redo cardiac surgery. A preprocedural adhesion score determined by visual assessment of the malformation of the tags between the sternum and myocardium correlated well ($r = .76$, $P < .01$) with the intraoperative adhesion score determined by the surgeon at the time of redo surgery. Although this study only looked at patients undergoing redo cardiac surgery, one could reasonably extrapolate the results to thoracic surgery in patients with a prior history of cardiothoracic surgery, specifically for those thoracic surgeries requiring a sternotomy.

Variant 6: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. History of cardiothoracic surgery. Preprocedure planning.
S. Radiography chest

Chest radiography can assess musculoskeletal anatomy and size of the cardiac silhouette and screen for pulmonary or pleural disease and extensive pericardial calcifications and vascular calcifications. Many patients will have undergone chest radiography prior to surgery for various clinical reasons. One meta-analysis [46] including 11,598 patients who received preprocedural chest radiographs showed that only 0.1% of patients required modification of their management.

Variant 6: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. History of cardiothoracic surgery. Preprocedure planning.
T. US chest

Ultrasound (US) of the chest can be used to identify pleural effusions and pleural adhesions, guide thoracenteses, and assess diaphragm movement.

In a study of 33 patients, Yasukawa et al [47] used US of the chest wall to evaluate for the presence or absence of pleural adhesions in patients with prior thoracic surgery to help guide initial port placement in redo video-assisted thoracoscopic surgery. In this small cohort, there were 0 false-positive cases, 26 true-negative cases, 5 true-positive cases, and 2 false-negative cases. The overall sensitivity was 71.4%, with a specificity of 100%. The group suggested that the use of preprocedural US of the chest wall to identify pleural adhesions could reduce the incidence of lung injury during initial port insertion in redo video-assisted thoracoscopic surgery. Similar findings were reported by Cassanelli et al [48] and Wei et al [49].

Variant 6: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. History of cardiothoracic surgery. Preprocedure planning.
U. US echocardiography transesophageal

TEE can provide information on cardiac function, cardiac morphology, and valvular heart disease, detect intracardiac shunts, detect cardiac masses, and assess pericardial effusions. Compared with TTE, a notable benefit is better visualization of some heart structures due to better special resolution and the probe’s closer proximity to the heart. If performed, this examination would typically be done after a TTE. There is no relevant literature to support the routine use of TEE prior to thoracic surgery in patients with a history of cardiothoracic surgery.

Variant 6: Adult. Preprocedural chest or cardiac imaging for thoracic surgery. History of cardiothoracic surgery. Preprocedure planning.
V. US echocardiography transthoracic resting

TTE can provide information on cardiac function, cardiac morphology, and valvular heart disease, detect intracardiac shunts, detect cardiac masses, and assess pericardial effusions. There is no relevant literature to support the routine use of TTE prior to thoracic surgery in patients with a history of cardiothoracic surgery.

Summary of Highlights

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

- **Variant 1**: For preprocedural chest or cardiac imaging for coronary cardiac surgery in patients without a history of cardiothoracic surgery, TEE, resting TTE, chest radiography, and coronary arteriography are usually appropriate. These procedures may be complementary or alternative examinations depending on the specific surgery being performed. MRA coronary arteries without and with IV contrast, MRA coronary arteries without IV contrast, MRI heart function and morphology without and with IV contrast, MRI heart function and morphology without IV contrast, CT chest with IV contrast, CT chest without IV contrast, CTA chest with IV contrast, CTA chest without and with IV contrast, and CTA coronary arteries with IV contrast may be appropriate.
- **Variant 2**: For preprocedural chest or cardiac imaging for coronary cardiac surgery in patients with a history of cardiothoracic surgery, TEE, resting TTE, chest radiography, coronary arteriography, CT chest with IV contrast, CT chest without IV contrast, CTA chest with IV contrast, and CTA chest without and with IV contrast are usually appropriate. These procedures may be complementary or alternative examinations depending on the specific surgery being performed. MRA chest with IV contrast, MRA chest without and with IV contrast, MRA chest without IV contrast, MRA coronary arteries without and with IV contrast, MRA coronary arteries without IV contrast, MRI chest with IV contrast, MRI chest without and with IV contrast, MRI chest without IV contrast, MRI heart function and morphology without and with IV contrast, MRI heart function and morphology without IV contrast, CTA coronary arteries with IV contrast, and CT heart function and morphology with IV contrast may be appropriate.
- **Variant 3**: For preprocedural chest or cardiac imaging for noncoronary cardiac surgery in patients without a history of cardiothoracic surgery, TEE, resting TTE, chest radiography, and coronary arteriography are usually appropriate. These procedures may be complementary or alternative examinations depending on the specific surgery being performed. MRA chest with IV contrast, MRA chest without and with IV contrast, MRA chest without IV contrast, MRA coronary arteries without and with IV contrast, MRA coronary arteries without IV contrast, MRI heart function and morphology without and with IV contrast, MRI heart function and morphology without IV contrast, CT chest with IV contrast, CT chest without IV contrast, CTA chest with IV contrast, CTA chest without and with IV contrast, and CTA coronary arteries with IV contrast may be appropriate.
- **Variant 4**: For preprocedural chest or cardiac imaging for noncoronary cardiac surgery in patients with a history of cardiothoracic surgery, TEE, resting TTE, chest radiography, CT chest with IV contrast, and CT chest without IV contrast are usually appropriate. These procedures may be complementary or alternative examinations depending on the specific surgery being performed. Coronary arteriography, MRA chest with IV contrast, MRA chest without and with IV contrast, MRA chest without IV contrast, MRI chest with IV contrast, MRI chest without and with IV contrast, MRI chest without IV contrast, MRI heart function and morphology without and with IV contrast, MRI heart function and morphology without IV contrast, CTA chest with IV contrast, CTA coronary

arteries with IV contrast, and CT heart function and morphology with IV contrast may be appropriate. CTA chest without and with IV contrast was considered for appropriateness, but consensus was not reached by the panel. The majority of the panel was primarily split between usually appropriate and may be appropriate.

- **Variant 5**: For preprocedural chest or cardiac imaging for thoracic surgery in patients without a history of cardiothoracic surgery, chest radiography, CT chest with IV contrast, and CT chest without IV contrast are usually appropriate. These procedures may be complementary or alternative examinations depending on the specific surgery being performed. TEE, resting TTE, MRA chest with IV contrast, MRA chest without and with IV contrast, MRA chest without IV contrast, MRI chest with IV contrast, MRI chest without and with IV contrast, MRI chest without IV contrast, MRI heart function and morphology without and with IV contrast, MRI heart function and morphology without IV contrast, CTA chest with IV contrast, and CTA chest without and with IV contrast may be appropriate.
- **Variant 6**: For preprocedural chest or cardiac imaging for thoracic surgery in patients with a history of cardiothoracic surgery, chest radiography, CT chest with IV contrast, and CT chest without IV contrast are usually appropriate. These procedures may be complementary or alternative examinations depending on the specific surgery being performed. US of the chest, TEE, resting TTE, MRA chest with IV contrast, MRA chest without and with IV contrast, MRA chest without IV contrast, MRI chest with IV contrast, MRI chest without and with IV contrast, MRI chest without IV contrast, MRI heart function and morphology without and with IV contrast, MRI heart function and morphology without IV contrast, CTA chest with IV contrast, CTA chest without and with IV contrast, and CT heart function and morphology with IV contrast may be appropriate.

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.

Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be

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

Relative Radiation Level Information

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

Relative Radiation Level Designations

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

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

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