

Practical Tips and Tricks

Practical tips and tricks in cardiovascular computed tomography: Patient preparation for optimization of cardiovascular CT data acquisition

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KEYWORDS:

Angiography;
Body mass index;
Breathhold;
Calcium scoring;
Cardiac motion;
Computed tomography;
Contrast agent;
Coronary artery disease;
ECG, electrocardiogram;
Heart rate

The acquisition of diagnostic cardiovascular computed tomography (CT) images requires careful preparation of the patient before scanning. Guidelines for patient preparation are largely dictated by scanner capabilities and the technical limits they impose on patient-specific characteristics. The objective of this paper is to highlight procedures for patient screening, premedication, instruction, positioning, and electrocardiographic (ECG) lead placement. Awareness of scanner limitations and adherence to patient preparation guidelines can significantly improve CT image quality and diagnostic yield.

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Introduction

Proper preparation of the cardiovascular patient for a computed tomography (CT) examination is essential for the reproducible acquisition of diagnostic images. The objective of this paper is to highlight procedures that should be followed before scanning. These procedures include patient screening, premedication, instruction, positioning, and electrocardiographic (ECG) lead placement.

Conflict of interest: Dr Halliburton reports that she is supported by a research grant from Siemens Medical Solutions. Dr Abbara reports that he has received a honorarium from Siemens and that he is on the medical advisory panels of EZEM and Partners Imaging.

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Submitted April 3, 2007. Accepted for publication April 16, 2007.

Patient screening

Although the referring physician may determine that a cardiovascular CT examination is clinically indicated for a given patient, the imaging physician must ensure that patient-specific barriers to maintaining patient safety and obtaining diagnostic images do not exist. First, patients scheduled for contrast-enhanced scans should be screened for contraindications to iodinated contrast media, including known allergies to iodine and compromised renal function (detected by screening serum creatinine levels or creatinine clearance).

In addition, for coronary CT angiography (CTA), patient heart rate, patient size, and the likelihood of significant coronary calcium should also be assessed. The diagnostic accuracy of coronary CTA for the evaluation of coronary

Table 1 Premedication of coronary patients with β -blockers

Screen for contraindications
Obtain baseline HR and BP
Administer β -blockers
Intravenous only
■ Inject 5 mg metoprolol
■ Assess HR during a breathhold and BP
■ Repeat dose up to five times over 30 minutes, not exceeding 30 mg until HR target is reached (≤ 65 bpm)
Oral only (not preferred)
■ Administer 50–100 mg metoprolol 1 h before scan
■ If target HR is not reached, consider intravenous dose
Scan patient
For intravenous administration of β -blockers, monitor patient HR and BP for 30 min

HR, heart rate; BP, blood pressure; bpm, beats per minute.

artery disease (CAD) depends on patient heart rate.^{1,2} Patients with CAD with high heart rates or sustained arrhythmia should not be imaged on most current CT scanners if a contraindication to heart rate–stabilizing or –lowering drugs such as β -blockers exist (the procedure for drug administration is later).

Some institutions have established a body mass index cutoff (eg, 40 kg/m²) for examination of the coronary arteries with CTA. Because submillimeter slices must be acquired for coronary artery evaluation, high x-ray tube current is necessary to reduce image noise at the expense of increased radiation exposure. For very large patients, particularly those men and women with wide skin-to-skin measurements of the upper chest, the limits of x-ray tube output are reached without achieving an adequate signal-to-noise ratio.³

The presence of large amounts of coronary artery calcium also negatively affects the accuracy of stenosis detection with CTA. Dense calcium appears larger on current CT systems than it is in reality because of partial volume averaging resulting from limited spatial resolution and blurring resulting from limited temporal resolution. Knowledge of a significant amount of coronary calcium from a prior or pre-CTA calcium scoring CT scan (eg, Agatston score ≥ 1000) should trigger consideration of alternative imaging tests because the likelihood of multiple nonevaluable coronary segments from CTA images is high.⁴

Patient premedication

Currently, because of the limited temporal resolution of CT scanners, most clinical practices administer heart rate–lowering drugs (eg, β -blockers) to patients before imaging of the coronary arteries to slow the heart rate and reduce RR interval variability.⁵ A typical procedure for the administration of β -blockers before scanning is described in Table 1. The target heart rate depends on the CT scanner model used and its temporal resolution. For most single-source systems, the target heart rate is typically 60–70 beats per minute.^{1,2}

Dual source systems (units with two orthogonally positioned x-ray source and detector systems) offer improved temporal resolution and the possibility of raising the target heart rate or eliminating the use of β -blockers. Research studies are still needed to identify appropriate target heart rates for patients scanned on these systems.

Patients should be screened for contraindications to β -blockers.⁵ Calcium channel blockers may offer an alternative to patients with hypersensitivity to β -blockers. Depending on the scanner type, patients who cannot receive either type of heart rate–lowering medication may need to be denied a CTA for indications such as CAD.

In addition to the use of heart rate–lowering drugs, the limits of spatial resolution with CT images of the coronary arteries motivate administration of a vasodilator (eg, nitroglycerine) before scanning (Table 2). The resulting increased diameter (typically approximately 20%)⁶ of the coronaries permits increased visualization distally.

Patient instruction

Specific patient instructions should be given even before the patient arrives for the cardiovascular CT scan. As with any imaging examination requiring the injection of iodine-

Table 2 Premedication with nitroglycerine for patients with coronary artery disease

Screen for contraindications
Obtain baseline HR and BP
Administer nitroglycerine
Sublingual, spray
■ Apply 800 μ g under or on the tongue immediately before CT scan (may limit to 400 μ g in the setting of reduced BP)
Scan patient
Monitor patient HR and BP for ~ 30 min

HR, heart rate; BP, blood pressure.

ated contrast, the patient should be contacted 1 day before an angiographic examination is scheduled and instructed to fast for at least 4 hours before the scan. Patients scheduled for a noncontrast examination (eg, calcium scoring) are allowed to eat but should be instructed to avoid caffeine because of the increased incidence of cardiac motion artifacts at higher heart rates with all CT scanners.

Once a patient arrives for a scheduled appointment, additional information and instruction can improve patient compliance during the cardiovascular CT examination and reduce patient anxiety that adversely increases heart rate. Significant artifacts can arise from patient and respiratory motion. Gross patient motion can often be avoided by explaining to the patient the importance of lying motionless during data acquisition. In addition, the patient should be informed that the patient table will move and the gantry will make noise during the examination.

Respiratory artifacts can be minimized or even eliminated by practicing a breathhold with the patient. This practice serves to prepare the patient for the breathing instructions and to inform the technologist or physician of the patient's breathhold capabilities. Some patients will perform breathholds without closing their glottis, which may result in slow exhalation. It is important to identify these patients and instruct them not to slowly exhale, because this generates a slow diaphragmatic motion during data acquisition that could result in motion artifact. Hyperventilation of the patient before breathholding may be considered to extend the breathhold period and should also be practiced with the patient.

Information gained from a practice breathhold may also be used to minimize artifacts arising from cardiac motion. Specifically, if the patient's heart rate is observed to change significantly after initiation of a breathhold (often it decreases), the technologist or physician may choose to initiate the breathhold four or five cardiac cycles before the start of the scan, giving the heart rate a chance to stabilize before data are acquired.⁷

Finally, preparing patients for possible side effects from injection of the contrast agent, including warmth, pain at the injection site, and allergic reactions such as nausea and itching, may reduce patient anxiety and heart rate in the event of occurrence.

Patient positioning and ECG lead placement

Images should be taken with the patient supine with arms raised above the head and out of the field of view to avoid artifact arising from the humeri. For angiographic examinations, the arm with intravenous access should be as straight as possible to facilitate injection of the contrast agent. To optimize the spatial and temporal resolution of current CT systems for cardiovascular imaging, the patient's heart should be centered in the gantry^{8,9} as shown in [Figure 1](#).

The proper placement of ECG leads is critical to obtaining a reliable ECG trace for scanner gating. Leads are

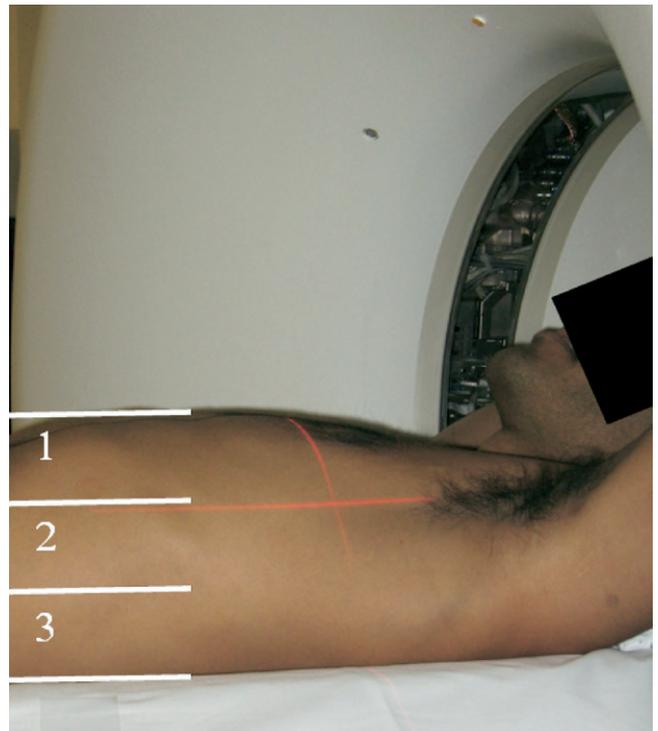


Figure 1 Patient positioning. For cardiovascular CT scanning, patients should be supine with arms raised above the head. The heart should be centered within the gantry by adjusting the table height until the horizontal laser light marker (which marks the gantry center in vertical dimensions) is at the junction of the anterior to middle one third of the thoracic anteroposterior diameter.

typically placed under the right clavicle, under the left clavicle, and on the left hip such that electrodes and lead wires are outside the imaging field of view. To ensure good electrode-to-skin contact the skin should be cleaned with alcohol and abraded and, for some men, shaved at the site of electrode placement. If initial attempts to obtain a clear, noise-free ECG signal fail, the electrodes should be repositioned or the lead configurations switched.

In summary, preparation of the patient for cardiovascular CT is essential for obtaining diagnostic images. Guidelines for patient preparation are dictated by scanner capabilities and the technical limits they impose on patient-specific characteristics such as heart rate. Awareness of these limits and consistent adherence to meticulous patient preparation will optimize CT image quality and diagnostic yield.

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