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# Scanning Technique for Cardiac CTA in Infants and Small Children

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To fully utilize the advantages of cardiac CTA, it is important to consider radiation exposure and to optimize scanning techniques. Recent advances in multidetector CT (MDCT) technology have revolutionized cardiovascular imaging in children with complex congenital heart disease. For infants with congenital heart disease, ECG-gated cardiac CTA is the modality of choice for imaging the coronary arteries, airway, and extracardiac vascular structures. Fast scanning times and high-quality evaluation of both complex cardiac and coronary anatomy have enabled CTA to aid in patient management and treatment planning. Currently, there are two accepted cardiac CTA scanning techniques for infants with congenital heart disease: retrospective and prospective ECG-gated scanning.

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## Technique

General anesthesia is administered routinely in infants less than 1 year of age to optimize the scans. All examinations are performed with multidetector

scanners. The following parameters are given for a GE 64-slice MDCT: 4 cm detector length. Iodinated contrast medium is used at 1 mL/lb of body weight, with an injection speed of 0.7 mL/s. A weight-based protocol is used, with 80-kVp tube voltage and tube current adjusted according to body weight for prospective scanning. Tube current adjustment to body weight varies from institution to institution and may range from 10 to 40 mA/kg [1, 2]. The gantry speed is set at a 0.35-s rotation with a helical thickness of 0.6 mm and detector coverage of 40 mm. The technologist begins the scan when contrast fills the ventricle. The patient is scanned in a craniocaudal direction starting at the level of the subclavian artery and ending at the level of the diaphragm. The anesthesiologist assists with the breath hold.  $\beta$ -Blockers typically are not used to decrease the heart rate in children with congenital heart disease.

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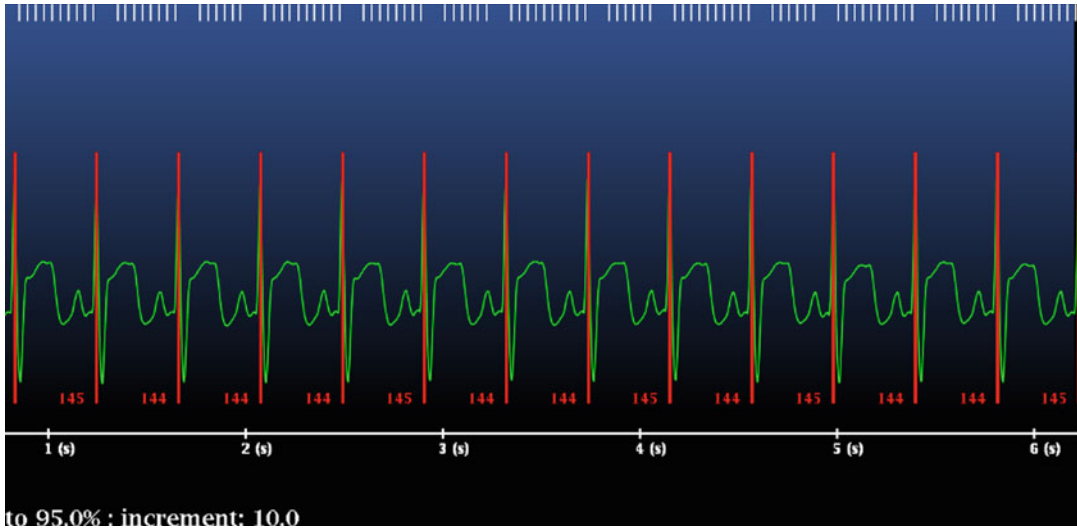
## Retrospective Scanning

During retrospective scanning, the x-ray beam is turned on during the entire cardiac cycle and spiral scanning continues during table motion (Fig. 2.1). Retrospective gating uses a low pitch (0.2) to obtain attenuation measurements at all spatial locations in the heart and to scan during all phases of the cardiac cycle, including the entire R-R interval. The pitch in retrospective scanning depends on the heart rate. Pitch normally falls in the range of 0.2–0.24 for infants with heart rates above 100 bpm. The current in retrospective scanning is set at 250–300 mA.

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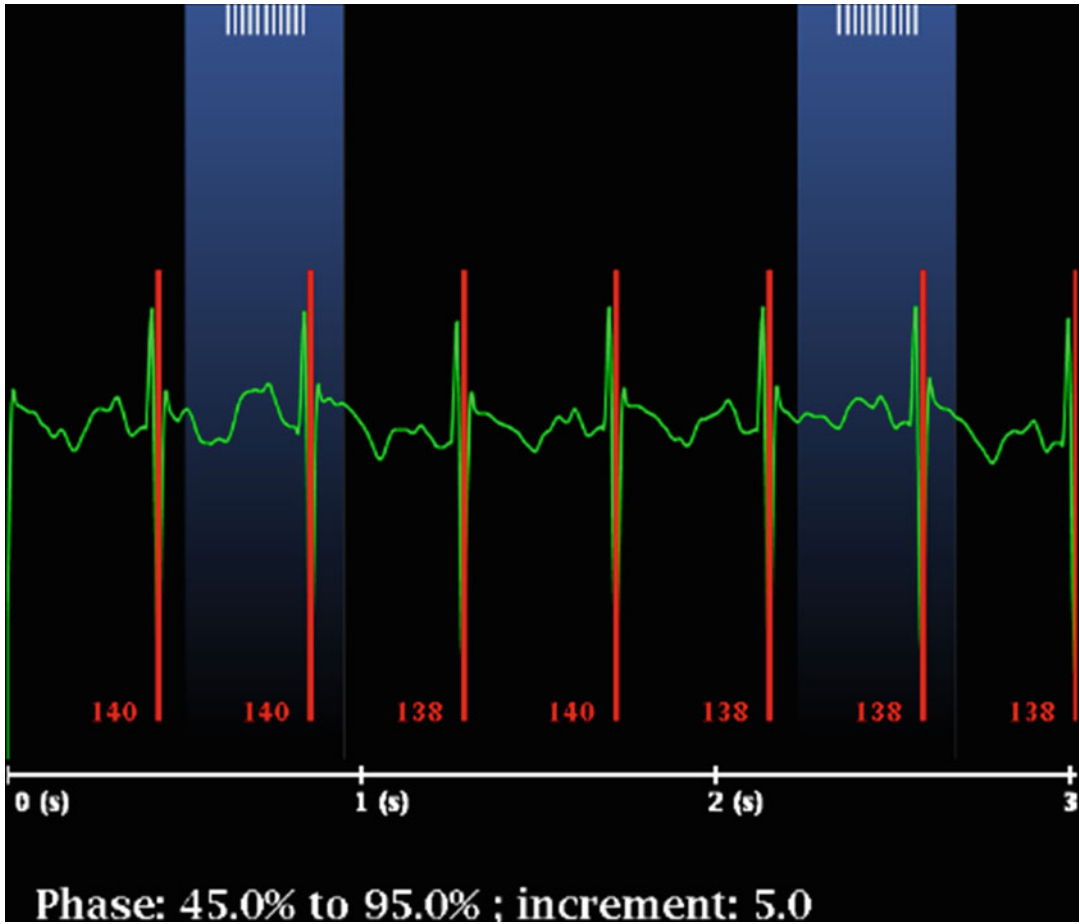


**Fig. 2.1** Retrospective ECG-gated scan. The x-ray beam (in blue) is on through the entire cardiac cycle

### Prospective Scanning

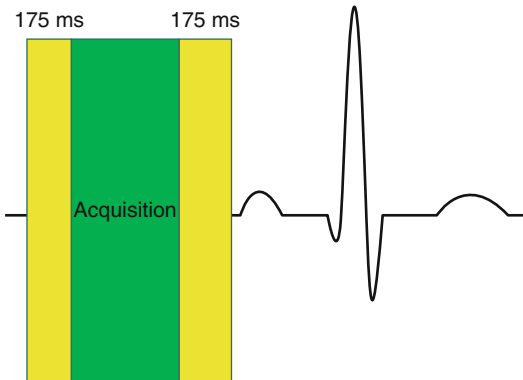
The vast majority of scanning can and should be done using the prospective ECG-triggered scanning technique, even in children and infants with very fast heart rates. This technique uses a nonspiral step-and-shoot axial scanning process in which the x-ray beam is on for a short time and is turned off as the table moves. The imaging window is approximately 50 % of the cardiac cycle. Because an infant's heart rate is relatively high, short acquisition times with padding may be used to capture up to 50 % of the cardiac cycle to evaluate function (Fig. 2.2);

when functional analysis is needed, 175 ms of padding should be used. The padding turns the tube on before the required acquisition time and leaves it on afterward, increasing the time the current is on to include more of the cardiac cycle (Fig. 2.3) for functional imaging. For prospective scanning, our tube current–body weight adjustment has three weight based settings. Typically, end systole is the time for imaging the coronary arteries in adults, with optimal visualization between 65 and 80 % of the cardiac cycle. In infants, the optimal time for imaging the coronary arteries typically is during systole, at 45–55 % of the cardiac cycle.



**Fig. 2.2** Prospective ECG-gated scan. The x-ray beam (in blue) is not on during the entire cardiac cycle. Notice the rapid heart rate of 140 bpm. The rapid heart rate is

advantage as the scan time covers enough of the cardiac cycle so that functional information can be obtained with provided with postprocessing



**Fig. 2.3** Padding. Padding of 175 ms (yellow) is used to flank the acquisition time (green) to include more cardiac phases

## Prospective Versus Retrospective Scanning (Table 2.1)

**Table 2.1** Retrospective versus prospective ECG-gated scanning

Retrospective	Prospective
Scans the entire cardiac cycle	Scans a variable portion of the cardiac cycle based on the padding time
X-ray beam is <i>on</i> the entire time	X-ray beam is <i>not</i> on the entire time
No padding is used	Padding may be used to cover parts of the cardiac cycle to obtain functional information
Higher radiation dose	Lower radiation dose

## Radiation Dose

Children are more sensitive than adults to the effects of ionizing radiation; therefore, it is essential to balance image quality with radiation dose delivered when performing CTA in children. It is important to apply the ALARA (As Low As Reasonably Achievable) principle for infants and neonates by using low peak kilovoltage and adapting the milliamperes to the patient's weight. Published studies comparing retrospective with prospective ECG-gated scanning techniques have reported radiation dose savings ranging from two

to four times with prospective ECG-gated techniques [1–4]. Radiation doses estimated for prospective ECG-gated protocols have been reported to be less than 1 mSv in studies using low peak kilovoltage and low milliamperes per kilogram. On the contrary, retrospective ECG-gated scanning yields higher radiation doses, estimated to be around 3–10 mSv, even with the low-dose technique [5–10]. Another technique that may be used to lower the radiation dose for the patient is adaptive statistical iterative reconstruction, a unique CT reconstruction algorithm with matrix algebra used to selectively identify and subtract noise from the image. The result is less noise or the same amount of noise with less radiation [8–11].

## CT Data Postprocessing and Analysis

At our institution, all images have a reconstruction section thickness of 0.625 mm and a section interval of 0.625 mm with use of a small cardiac field of view. The lung window is reconstructed at a 2.5-mm section. All images obtained are transferred to an external workstation, where they are reconstructed with multiplanar reformation, volume rendering, and maximum intensity projections. The protocol parameters used at our institution are described in detail in Table 2.2.

**Table 2.2** MDCT cardiac CTA protocols in infants for a 64-slice GE scanner

Parameter	ECG-gated scanning technique	
	Retrospective	Prospective
Contrast	Iodinated contrast medium (iopamidol, 300 mg/ml) is used at 1 ml/lb of body weight with injection speed of 0.7 ml/s	Iodinated contrast medium (iopamidol, 300 mg/ml) is used at 1 ml/lb of body weight with injection speed of 0.7 ml/s
Peak kilovoltage	80	80
Milliamperes	weight based protocol	weight based protocol
R-R interval	Entire interval	50–75 %
Pitch	0.2–0.24	No pitch
Padding	None	175 ms
Rotation, <i>sec</i>	0.35	0.35
Collimation, <i>mm</i>	0.6	0.6
Slice thickness, <i>mm</i>	0.625	0.625
Field of view	Small cardiac	Small cardiac

## References

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