Multi–detector Row CT:

Is Prospective Electrocardiographic Triggering Improving the Detection of Small Pulmonary Tumors?[1]

Sandra Pauls, MD, Andrik J. Aschoff, MD, Juliane Wahl, MS, Hans-Jürgen Brambs, MD, MBA, Thorsten R. Fleiter, MD

Rationale and Objectives. To compare prospectively ECG-triggered multi–detector row computed tomography (ECG-MDR-CT) and multi–detector row computed tomography (MDR-CT) without triggering for the detection of pulmonary tumors.

Materials and Methods. 100 patients with proven or suspected tumors were referred for CT of the lung for staging of lung metastases. First, a non-enhanced scan was performed using prospective ECG-triggering on a four-row multidetector helical CT scanner, followed by a contrast-enhanced scan without triggering. The diagnostic assessibility in detecting intrapulmonary nodules and mediastinal structures was graded using a 5-point scale (rated 1 = bad to 5 = very good image quality).

Results. ECG-MDR-CT images detected a total of 26% more pulmonary nodules than MDR-CT. For tumors <5 mm, the detection rate was 62% higher using ECG-triggered scans ($P = .024$). Subjective assessment found median demarcation ratings for all pulmonary findings of 4 (ECG-MDR-CT) versus 3 (MDR-CT). Mediastinal structures were delineated better using ECG triggering. The median ranking for demarcation of pulmonary findings <10 mm was 4 on ECG-MDR-CT and 3 on MDR-CT, respectively. For vessels and the left bronchus, the median of demarcation was 4 on triggered images and 2 on MDR-CT, respectively. The median values referring to the demarcation of mediastinal structures were not significantly different between ECG-MDR-CT and MDR-CT.

Conclusion. Our data indicate the superiority of prospectively triggered ECG-MDR-CT over MDR-CT for the diagnosis of small pulmonary tumors using a 4-row multidetector CT.

Key Words. Multi–detector row CT; ECG; pulmonary nodules.

The prognosis and therapy for patients with malignant carcinomas is dependent on the correct staging of local spread, lymph node metastasis, and distant metastasis of the malignancy, eg, as in lung metastasis.

Acad Radiol 2005; 12:614–619

[1] From the Department of Diagnostic Radiology, University of Ulm, Steinhoevelstr. 9, 89075 Ulm, Germany (S.P., A.J.A, J.W., H.-J.B.) and the Department of Diagnostic Imaging, University Hospitals of Maryland, Baltimore, USA (T.R.F.). Received November 15, 2004; revision received January 31, 2005; revision accepted February 4. **Address correspondence to** S.P. e-mail: sandra.pauls@medizin.uni-ulm.de

doi:10.1016/j.acra.2005.02.004

Helical computed tomography is widely available and used routinely for thoracic diagnostic procedures, in particular for staging and follow-up of pulmonary nodules (1–3). Using the multidetector technique, we acquired images of the thorax during a single breath hold and the respiratory artifacts were thus subsequently reduced. However, motion artifacts caused by the beating heart were unavoidable. This artifact especially impairs bronchopulmonary segments near the heart. Consequently it should be more difficult to detect small tumors and to differentiate between malignant nodules and benign lesions as the same motion artifact affects both lesions. There are numerous published studies regarding cardiac

Table 1
Indications and Diagnoses of All Patients

Diagnosis	N
Colorectal cancer	33
Gastrointestinal carcinoma	12
Primary pulmonary tumors	15
Bone tumors	11
Others	32

NOTE: There are a total of 103 tumors because three patients had two malignant tumors (colorectal + bronchial cancer, colorectal cancer + chronic lymphatic leukemia, pancreatic and breast cancer).

scans to assess coronary calcifications (4–6). However, the influence of ECG-triggering for the evaluation of pulmonary tumors remains unclear.

We conducted a prospective study to evaluate the diagnostic value of ECG-triggered multidetector-row CT (ECG-MDR-CT) scanning for detecting pulmonary nodules (7). In this pilot study, our results indicate the superiority of ECG-MDR-CT for the detection of pulmonary masses and nodules compared to MDR-CT. We therefore extended the study in order to acquire an exact statement for ECG-MDR-CT in a routine setting.

MATERIALS AND METHODS

Patients and CT

One hundred patients (57 men, 43 women; age: 21 to 82 years; average age: 57 years) with proven or suspected malignant or benign pulmonary tumor, ie, pulmonary metastases, bronchopulmonary carcinoma, or fibroma, were included in the prospective study (Table 1). Patients younger than 18 years of age, pregnant women, patients with absolute arrhythmia, or those with general contraindications for application of contrast media, eg, iodine allergy, hyperthyroidism, or renal insufficiency, were excluded from the study. The local ethics committee approved the study protocol, and written informed consent was obtained for all patients prior to inclusion in the study.

All CT scans were performed using a 4-row multidetector helical CT scanner (MX 8000, Philips Medical Systems, Cleveland, OH). ECG electrodes were attached to the patient outside of the scan field and connected to the CT triggering system. All scans were performed in 2 phases. In Phase 1, a non-enhanced, prospectively ECG-triggered examination was performed from the jugulum to the margin of the liver in the dorsal supine position. Images were acquired during a single breath hold. The rotation time was 0.5 second, and the cycle time was as low as 0.75 seconds for the axial images. A collimation of 4 $\times$ 2.5 mm with 120 KV and 120 mAs was used. The diastolic phase of the heart cycle was chosen for the prospective trigger to ensure acquisition during cardiac rest in order to minimize motion artifacts. Phase 2 was a contrast-enhanced scan. A bolus of 130 mL Iopamidol (Solutrast® 300; Altana, Konstanz, Germany) was injected intravenously with a flow of 2 mL/sec. Sixty seconds after the start of the contrast injection, images were acquired (jugulum to the liver margin) in the dorsal supine position using the following parameters: collimation 4 $\times$ 2.5 mm; reconstruction interval 1.6 mm; pitch 0.875; and 0.5 second gantry rotation. Amperage and voltage corresponded to the ECG-triggered phase. Identical reconstruction filters were used for both examinations.

Subjective Image Analysis

Two experienced radiologists (S.P., T.R.F.) analyzed the CT images on a dedicated workstation (MX View; Philips, Cleveland, OH). CT scans were analyzed for the presence and number of intrapulmonary nodules, their demarcation, and the demarcation of the following mediastinal structures: aorta, pulmonary arteries, vena cava inferior, trachea, right and left bronchus, and esophagus. The subjective evaluation of demarcation was carried out using a 5-point scale: 5 = excellent, exact demarcation of the pulmonary lesion; 4 = improved, good demarcation; 3 = moderate, blurred lesion margin; 2 = bad, very blurred lesion; and 1 = poor, very difficult to differentiate the lesion from the lung structures. Each reading was done in separate sessions for the ECG-triggered and the standard helical scans.

Statistical Analysis

The statistically significant differences for the detection rates of pulmonary nodules were determined using a two-tailed *t*-test on a 95% level of significance. The Wilcoxon matched-pairs signed-ranks test was used to analyze the differences in detecting lung and mediastinal structures between ECG-MDR-CT and MDR-CT.

RESULTS

Twenty patients had no pulmonary findings with either CT technique. In 80 patients, 364 pulmonary lesions were