Residents' Performance in the Interpretation of On-Call "Triple-Rule-Out" CT Studies in Patients with Acute Chest Pain

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Rationale and Objectives: To evaluate the performance of radiology residents in the interpretation of on-call, emergency "triple-rule-out" (TRO) computed tomographic (CT) studies in patients with acute chest pain.

Materials and Methods: The study was institutional review board–approved and Health Insurance Portability and Accountability Act compliant. Data from 617 on-call TRO studies were analyzed. Dedicated software enables subspecialty attendings to grade discrepancies in interpretation between preliminary trainee reports and their final interpretation as "unlikely to be significant" (minor discrepancies) or "likely to be significant" for patient management (major discrepancies). The frequency of minor, major and all discrepancies in resident's TRO interpretations was compared to 609 emergent non–electrocardiography (ECG)-synchronized chest CT studies using Pearson χ^2 test.

Results: Minor discrepancies occurred more often in the TRO group (9.1% vs. 3.9%, $P < .001$), but there was no difference in the frequency of major discrepancies (2.1% vs. 2.8%, $P = .55$). Minor discrepancies in the TRO group most commonly resulted from missed extrathoracic findings with missed liver lesions being the most frequent. Major discrepancies mostly encompassed cardiac and extracardiac vascular findings but did not result in unnecessary interventions, significant immediate changes in management, or adverse patient outcomes.

Conclusions: On-call resident interpretation of TRO CT studies in patients with acute chest pain is congruent with final subspecialty attending interpretation in the overwhelming majority of cases. The rate of discrepancies likely to affect patient management in this domain is not different from emergent non–ECG-synchronized chest CT.

Key Words: Triple-rule-out CT; cardiac CT; chest CT; training; residents; acute chest pain.

In patients presenting with acute, undifferentiated, or atypical chest pain, computed tomography (CT) offers the possibility of ruling out obstructive coronary artery disease, pulmonary embolism, acute aortic syndrome, and other pathologies in a single comprehensive evaluation (1–6). This approach is commonly referred to as "triple-rule-out" (TRO) CT and is performed as an electrocardiography (ECG)–synchronized CT angiography (CTA) study of the heart or the entire chest (1,7,8). Evidence on the clinical utility of this approach is rapidly accumulating (4,7,9–12).

At the majority of academic institutions throughout the United States, preliminary interpretation of emergent diagnostic imaging studies in the on-call setting is provided by radiology trainees. On-call imaging studies are typically reviewed and finalized by subspecialty attending radiologists during normal business hours. For a number of imaging modalities and indications, a small but significant discrepancy rate between preliminary residents' and final subspecialists' interpretation has been demonstrated (13–15).

It has been shown that there is a learning curve for the interpretation of cardiac CT studies and that a large number of cases are required for sufficient proficiency (16,17). It is therefore controversial whether subspecialty attending coverage is required to perform TRO CT in an emergency

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setting (18). It is not clear, whether trainees are sufficiently skilled in the interpretation of this examination type to allow for the safe use of this technique in the on-call setting. Therefore, the purpose of this study was to evaluate the performance of radiology residents in the interpretation of on-call, emergency TRO CT studies in patients with acute chest pain.

MATERIALS AND METHODS

Our institutional review board approved this retrospective analysis and waived individual informed consent. The study was performed in Health Insurance Portability and Accountability Act compliance.

Study Design and Selection of Studies

At our institution, TRO studies are clinically available on a 24/7/365 basis for the evaluation of patients presenting with acute, atypical chest pain, initially negative troponin I, absence of ECG signs of myocardial injury, no known history of coronary artery disease, body mass index ≤ 40 kg/m^2, and a Thrombolysis In Myocardial Infarction (TIMI) score (19) of ≤ 4.

We retrospectively analyzed 617 TRO CT studies that had been performed at our institution in the on-call setting between 05:00 PM and 07:00 AM on weekdays and on weekends during a 24-month sampling period from April 2011 through March 2013. The agreement between preliminary resident reports and the final subspecialty attending interpretations was evaluated. As a control group, we analyzed 609 consecutive non–ECG-synchronized noncontrast and contrast-enhanced chest CT scans performed in the on-call setting during the same period. This population included 465 CT pulmonary angiography studies, 75 standard contrast-enhanced chest CT examinations, and 69 noncontrast chest CT examinations.

All studies in both groups were initially interpreted by a third- or fourth-year upper-level radiology resident who had completed at least one cardiovascular imaging and chest CT rotation before starting call. During the cardiovascular imaging rotation, residents at our institution typically read 10 ECG-synchronized coronary CTAs per day amounting to approximately 200 studies over the 1-month rotation. All studies were subsequently reviewed and finalized during normal business hours by one of four attending cardiothoracic subspecialty radiologists.

CT Examination Protocols

All TRO CT examinations were performed using dual-source CT scanners (Somatom Definition or Somatom Definition Flash; Siemens Healthcare, Forchheim, Germany). CT TRO protocols included a noncontrast prospectively ECG-triggered acquisition from the level of the carina to the base of the heart for the purpose of coronary artery calcium scoring. Subsequently, CTA was acquired from the level of the lung apices through the diaphragm after administration of intravenous contrast. Depending on the patient's heart rate, rhythm, age, and the type of scanner used, prospectively ECG-triggered, retrospectively ECG-gated, or prospectively ECG-triggered high-pitch spiral acquisition was performed. Functional data sets were obtained whenever enabled by the acquisition method. In the absence of contraindications, β blockers are used in patients with heart rates >75 beats/min on the discretion of the on-call resident and/or emergency department physician.

Emergent non–ECG-synchronized contrast-enhanced chest CT examinations were performed on a variety of CT systems with at least 16 detector rows. For CT pulmonary angiographies, bolus tracking with a region of interest in the main pulmonary artery and a triggering threshold of 100 Hounsfield units were used.

A system-wide, server-based, image postprocessing platform (iNtuition; TeraRecon, San Mateo, CA) is available to on-call residents and provides modules for calcium scoring, three-dimensional rendering, multiplanar reformations, curved multiplanar reformations, and cardiac function analysis.

Grading of Discrepancies between Preliminary and Final Interpretation

The "PeerVue Over-Read" system (PeerVue, Sarasota, FL) was used to track agreement and discrepancies between on-call preliminary trainee and final subspecialty attending interpretation. This system enables attendings to mark discrepancies in interpretation between the preliminary resident reports and their final interpretation as either "unlikely to be significant" for patient management (minor discrepancy), or "likely to be significant" for patient management (major discrepancy).

Analysis of Sources of Discrepancies

To evaluate for the most frequently occurring sources of discrepancies, all discrepant cases were retrospectively reviewed for the point of disagreement. Minor discrepancy cases were further subcategorized for sources of discrepancies. The categories were retrospectively identified using a grounded theory approach (20). Rather than using a predefined theoretical framework, grounded theory generates categories from the qualitative data. As data are added, the generated categories are constantly modified and sharpened to optimally represent the data (20).

For the control group undergoing non–ECG-synchronized chest CT, the following categories were finally used: pulmonary parenchymal, extrathoracic, vascular, and other. For the TRO group, the following categories were used as sources of minor discrepancies: pulmonary parenchymal, extrathoracic, congenital cardiac, coronary, and cardiac noncoronary.

Analysis of Potential Impact on Patient Management and Outcome

For all cases assigned a "major discrepancy" status in the TRO group, retrospective review of the medical charts was additionally performed by an independent third party clinician board certified in emergency medicine. Based on the chart