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Reduction in Observation Unit Length of Stay with Coronary Computed Tomography Angiography Depends on Time of Emergency Department Presentation

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Abstract

Objectives—Prior studies demonstrating shorter length of stay (LOS) from coronary computed tomography angiography (CCTA) relative to stress testing in emergency department (ED) patients have not considered time of patient presentation. The objectives of this study were to determine whether low-risk chest pain patients receiving stress testing or CCTA have differences in ED plus observation unit (OU) LOS, and if there are disparities in testing modality use, based upon the time of patient presentation to the ED.

Methods—The authors examined a cohort of low-risk chest pain patients evaluated in an ED-based OU using prospective and retrospective OU registry data. During the study period, stress testing and CCTA were both available from 08:00 to 17:00 hrs. CCTA was not available on weekends, and therefore only subjects presenting on weekdays were included. Cox regression analysis was used to model the effect of testing modality (stress testing vs. CCTA) on OU LOS. Separate models were fit based on time of patient presentation to the ED using four hour blocks beginning at midnight. The primary independent variable was testing modality: stress testing or CCTA. Age, sex, and race were included as covariates. Logistic regression was used to model testing modality choice by time period adjusted for age, sex, and race.

Results—Over the study period, 841 subjects presented Monday through Friday. Median LOS was 18.0 hours (IQR 11.7 to 22.9 hours). Objective cardiac testing was completed in 788 of 841 (94%) patients, with 496 (63%) receiving stress testing and 292 (37%) receiving CCTA. After adjusting for age, race, and sex, patients presenting between 08:00 and 11:59 hrs not only had a shorter LOS associated with CCTA ($p < 0.0001$), but also had a greater likelihood of being tested by CCTA ($p = 0.001$). None of the other time periods had significant differences in LOS or testing modality choice for CCTA relative to stress testing.

Conclusions—In an OU setting with weekday and standard business hours CCTA availability, CCTA testing was associated with shorter LOS among low-risk chest pain patients only in patients presenting to the ED between 08:00 and 11:59 hrs. That time period was also associated with a

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greater likelihood of being tested by CCTA, suggesting that ED providers may have intuited the inability of CCTA to shorten LOS during other times.

INTRODUCTION

American College of Cardiology/American Heart Association (ACC/AHA) guidelines recommend that patients at risk for acute coronary syndrome (ACS) should receive serial cardiac markers followed by objective cardiac testing (stress testing or cardiac imaging).^{1–3} Several studies have demonstrated that coronary computed tomography angiography (CCTA) results can permit clinicians to safely and effectively identify emergency department (ED) patients at very low risk for the occurrence of ACS within 6 to 12 months.^{4–12} Compared to other objective cardiac testing modalities, CCTA has been shown to decrease costs and reduce length of stay (LOS).^{7,9,11–14}

With conventional stress testing, myocardial infarction (MI) needs to be excluded with cardiac biomarker assessments at least eight hours after symptom onset prior to myocardial stress.^{15–17} CCTA does not involve stress testing, and therefore imaging can be conducted in parallel with serial cardiac marker measurements, potentially shortening LOS.^{9,18} In this circumstance, changes in LOS would relate to whether the patient arrived during hours when CCTA was available. Alternatively, CCTA could reduce LOS due to changes in post-test decision making, an effect that should remain constant regardless of presentation time. CCTA, like other objective cardiac testing modalities, but unlike many other computed tomography (CT) examinations, often has limited hours of availability due to the specialized personnel required to obtain quality images and accurately interpret them. Two recent large multicenter randomized controlled trials comparing CCTA to stress testing modalities demonstrated significant LOS reductions for patients receiving CCTA. However, these and other investigations have not delineated whether this LOS benefit is constant or varies based on patient arrival time. As a result, it is not clear whether parallel processing or post-test decision making is responsible for the reduction in LOS. Studies also have yet to determine if disparities exist in testing modality choice based on time of patient presentation.

The objective of this study was to determine whether the relationship between LOS and testing modality (CCTA vs. stress testing) varies based on the time of ED patient presentation, and to establish if a disparity exists in testing modality choice based on time of patient presentation. Results from this analysis can assist EDs considering implementing CCTA testing, or optimize existing cardiac testing programs.

METHODS

Study Design

We performed a cohort study of patients included in the ED-based observation unit (OU) Chest Pain Registry at Wake Forest University School of Medicine from January 2008 through April 2012. Registry data elements included a combination of prospectively collected cross-sectional data and retrospective data consistent with standardized reporting guidelines.¹⁹ The registry and this analysis were approved with a waiver of informed consent by the institutional review board of Wake Forest University.

Study Setting and Population

The study institution is an urban, academic tertiary referral center with an adult ED volume of approximately 72,000 patients per year. Patients with acute chest pain suggestive of a cardiac etiology, but determined to be at low risk for ACS by a Thrombolysis in Myocardial Infarction (TIMI) risk score less than 2 and clinician assessment of low risk were admitted to the ED-based OU and were included in the registry.²⁰ Care providers were encouraged to

use the ACC/AHA framework for risk assessment.¹ Inclusion criteria for the registry included a normal or non-diagnostic electrocardiogram (ECG) and a first troponin I that was below the 99th percentile of normal. Patients with pre-existing significant coronary disease are not managed in the OU unless they are participating in a formal research protocol, and therefore were not included in this study. The OU provides care for approximately 500 chest pain patients annually, and is open seven days a week, with 24-hour nursing coverage. Physician extenders provide coverage in the OU from 8 am to midnight, seven days a week. An ED attending physician rounds on OU patients each morning, and an attending physician working in the ED provides 24-hour OU oversight. For admission to the OU, patients routinely have orders placed for serial ECGs, serial cardiac biomarkers, and objective cardiac testing. As a result, nearly all patients in this care pathway receive cardiac testing prior to discharge. The cardiac testing modality selected is at the discretion of the care provider, and can consist of exercise stress echocardiogram (ESE), dobutamine stress echocardiogram (DSE), coronary computed tomography angiography (CCTA), single photon emission computed tomography (SPECT), or adenosine stress cardiac magnetic resonance (CMR). ECG stress tests without imaging are not performed within the OU protocol. CCTA and stress testing modalities have similar hours of availability: business hours (08:00–17:00 hrs) from Monday through Friday. On weekends, stress echocardiography is available but CCTA is not. Due to lack of availability of CCTA on weekends, subjects presenting from 17:00 hrs Friday through Sunday were excluded from this analysis to provide a valid and balanced comparator group.

Study Protocol

CCTA Protocol—Patients undergoing CCTA with resting heart rates more than 65 beats per minute were administered oral and/or intravenous metoprolol. Imaging was performed with a 64-slice single-source scanner as previously described in detail.²¹ Study interpretation was conducted in real time as part of clinical care by radiologists meeting Level 2 or 3 training guidelines from the ACC/AHA for cardiac computed tomography.²² See the Appendix for additional CCTA information.

Cardiac Markers and Disposition—Patients with stress testing ordered did not receive stress testing until completion of cardiac markers at three and six hours after arrival. CCTA participants received testing at the first available time, which could be prior to the results of serial cardiac markers. The OU protocol allowed patients without evidence of coronary stenosis on CCTA to be discharged without serial cardiac markers. The decision to order additional testing was determined by the care providers. Typically patients with negative stress tests were discharged. During the study time period (January 2008 through April 2010), the OU protocol suggested that patients with CCTA exams revealing <25% maximal diameter coronary stenosis were discharged, 25% to 50% stenosis underwent stress testing, and those with >50% maximal stenosis were consulted to cardiology.²¹

Measures

Length of stay was defined as the time in hours from ED arrival to OU discharge or hospital admission. This was indicated by the charted time that the patient physically left the unit, including patients who left against medical advice, were discharged without objective testing by the clinician, or were admitted or discharged following objective cardiac testing. Patients were classified by the first objective testing modality received: stress testing or CCTA. Patients receiving ESE, DSE, or CMR were included in the stress testing group. Time of arrival (divided into four-hour blocks from 00:00–03:59 hrs, 04:00–07:59 hrs, 08:00–11:59 hrs, 12:00–15:59 hrs, 16:00–19:59 hrs, and 20:00–23:59 hrs) was determined for each patient. Secondary objective testing, defined as stress testing or CCTA following

the objective testing modality, was recorded. Additional data analyzed included patient age, sex, and race (dichotomized as white vs. non-white for this analysis).

The total cost and charges of the visit for each patient were calculated as the sum of hospital and provider cost and charges measured from the hospital perspective. For hospital cost, itemized patient charges were converted to cost with departmental-specific cost-to-charge ratios filed with the Centers for Medicare & Medicaid Services annually. Provider cost was determined by obtaining work-related relative value units associated with each charged procedure code and converting to dollars using the Medicare conversion factor in effect for the service date of each visit. This is consistent with cost methods used in recent clinical trials.^{23–25}

Data Analysis

Due to some patients being discharged without objective cardiac testing (or leaving against medical advice prior to the completion of their workup), Cox proportional hazard modeling with censoring was performed to evaluate the effect of objective cardiac testing modality on OU LOS. The full Cox proportional hazard model included all clinically relevant covariates and was reduced using stepwise backward elimination with a threshold for alpha of 0.05 to be retained in the model. Predictor variables included objective cardiac testing modality, patient age, sex, and race. Age, sex, and race were retained in the models because these variables have been shown to represent potential confounders for LOS.^{26–28} Age was treated as linear and continuous in the modeling process. The full Cox proportional hazard model resulted in a significant interaction term (time of patient arrival by testing modality); therefore, we proceeded with a stratified analysis. Separate Cox models were fit based on time of patient presentation to the ED, consisting of four-hour blocks beginning at midnight. The primary independent variable was first test modality: stress testing (ESE, DSE, SPECT, or CMR), or CCTA. The proportional hazards assumption was tested using scaled Schoenfeld residuals, and the models were graphically examined for outliers and overly influential covariate patterns. The proportional hazards assumption failed in the 8 am model. Test selection was a time dependent covariate in the 8am model, and therefore the interaction with ln (LOS) was included as a correction term. In order to correct for multiple comparisons due to separate models, we established an alpha of 0.01 as the threshold for statistical significance. Patients who did not receive objective testing, whether planned or due to the patient leaving against medical advice, were included in the Cox proportional hazards models. However, a sensitivity analysis was conducted in which patients who did not receive objective cardiac testing were excluded from the time models. The choice of test modality was modeled using logistic regression. Covariates included time-block, age, sex, and race. Statistical analysis was performed using STATA IC 11.2 (College Station, TX).

RESULTS

From January 2008 to April 2010, 1070 patients at low risk for ACS with normal or non-diagnostic ECGs and negative initial cardiac biomarkers were included in the OU Chest Pain Registry. Of the 1,070 patients, 841 presented Monday through Friday. The study cohort was 57% white, and 61% female; additional characteristics of the cohort are summarized in Table 1. The median LOS was 18.0 hours (interquartile range [IQR] 11.7 to 22.9 hours). Objective cardiac testing (stress testing or CCTA) was completed in 788 of 841 (94%) patients, with 496 (63%) receiving stress tests, and 292 (37%) receiving CCTA (Figure 1). The median LOS was 14 hours (IQR 9.5 to 20.5 hours) among patients selected for CCTA, and 20 hours (IQR 15.1 to 23.9 hours) among those selected for stress testing. The costs and charges for CCTA and stress testing are summarized in Table 2.

After adjusting all models for age, race, and sex, CCTA only reduced LOS relative to stress testing in patients presenting between 08:00 and 11:59 hrs ($p < 0.0001$). CCTA was not significantly associated with shorter LOS relative to stress testing over any of the other time periods. During the 08:00–11:59 time block, providers were significantly more likely to choose CCTA over stress testing ($p = 0.001$). No other time blocks were associated with significant differences in test modality choice. Kaplan Meier curves for each time model are presented in Figure 2. The numbers of patients, numbers tested, and the numbers undergoing stress testing vs. CCTA in each time strata, the odds ratio for testing modality choice by time block, adjusted for age, sex, and race, and the hazard ratios (HR) for objective cardiac testing modality adjusted for age, race, and sex, are summarized in Table 3. A sensitivity analysis, excluding patients discharged without objective testing, resulted in similar HRs for each time model, with LOS remaining significantly shorter for CCTA patients presenting between 08:00 and 11:59 hrs.

Secondary objective testing occurred in 45 of 292 (15%, 95% CI = 11.5% to 20%) with a first test of CCTA: 35 ESEs, 6 DSEs, and 4 CMRs. This testing was protocol driven, as patients with CCTA exams revealing 25% to 50% stenosis underwent stress testing, and patients with >50% maximal stenosis received cardiology consultation. Among patients with stress testing as their first testing modality, 15 of 492 (3%, 95% CI = 2% to 5%) received secondary testing. None of the patients with stress testing as their first test received CCTA as a secondary test.

DISCUSSION

The results of this study demonstrate that the ability of CCTA to decrease ED plus OU LOS compared to stress testing is dependent on the time of patient presentation. In our cohort, only patients presenting during the 08:00 to 11:59 time period had a significantly shorter LOS associated with CCTA testing. This time period, in which CCTA was readily available with adequate radiological staff to obtain and interpret the imaging, was also associated with a significant increase in provider use of CCTA compared to stress testing. These findings demonstrate that ED and OU providers consider time of patient arrival in their decision making regarding a patient's objective cardiac testing modality. Furthermore, it is unlikely to be a coincidence that the only time period associated with a LOS decrease with CCTA was also the only time period with a significant increase in CCTA utilization. This suggests that providers are likely to have intuited the inability of CCTA to decrease LOS during off-hours, based on their prior clinical experiences.

This study may help put the results of two recent high-profile multicenter randomized controlled trials by Litt et al. and Hoffman et al. into perspective. Both trials demonstrated the ability of CCTA to decrease LOS compared to stress testing.^{11,12} However, Hoffman et al. limited enrollment to daylight hours Monday through Friday, when CCTA was immediately available, and neither study analyzed the effect of ED arrival time. Our study confirms that CCTA is a useful tool to decrease LOS, but only when it is immediately available for same-day testing.

Operationally, these findings suggest that CCTA reduces LOS mostly due to parallel processing of cardiac biomarkers and cardiac testing, or the elimination of biomarker testing, rather than differences in post-test decision making. With stress testing, MI needs to be excluded by cardiac biomarker assessments at least eight hours after symptom onset prior to myocardial stress.^{15–17} CCTA does not produce a myocardial stress, so serial biomarkers can be conducted in parallel with serial biomarker measurements. Furthermore, a CCTA demonstrating no evidence of coronary disease eliminates the need for serial biomarker

testing.^{9,18} If post-test decision-making was the driver of decreased LOS, we would have expected the LOS to be decreased for patients with CCTA across all time periods.

Patients in the 08:00–11:59 time period had same-day CCTA, while patients selected for stress testing received serial cardiac markers with subsequent testing, often the next day, resulting in prolonged OU stays. Although CCTA was available during the 12:00–15:59 time period, it did not result in a significant decrease in LOS. For most patients in this time period, by the time they had been evaluated in the ED, transferred to the OU, and heart rate control was achieved, CCTA was no longer available. Patients waiting in the OU overnight for next-day CCTA had comparable LOS to patients scheduled for next-morning stress testing. Relatively few patients in our cohort arrived during the early morning time periods, from 00:00 to 03:59 hrs, and 04:00 to 07:59 hrs. During these time periods, the numerical average for the ED plus OU LOS was lower when CCTA was employed. However, the difference in LOS did not achieve statistical significance ($p = 0.15$ and 0.28 , respectively). It is possible that a larger cohort or a cohort with more patients presenting during these times would have yielded a significant reduction.

Although cost was not the focus of this study, our results demonstrate that costs and charges were similar for patients undergoing CCTA or stress testing. This result is consistent with those of Hoffman et al., who recently reported similar index cost for stress testing and CCTA, and suggested that reduction in LOS by CCTA is not associated with increased expense. However, Hoffman et al. also reported that CCTA was associated with increased downstream utilization and costs.¹⁰ Downstream costs were not evaluated in our study.

Considering the results of our study in context with the findings of Litt et al.¹⁴ and Hoffman et al.¹⁰ raises important questions regarding CCTA availability. Most centers are currently unable or unwilling to support 24-hour CCTA availability, due to the costly infrastructure necessary for image acquisition and interpretation. Unlike other forms of CT imaging, CCTA requires specialized technicians trained to provide medications such as beta-blockers and nitroglycerin to optimize image quality, and requires highly trained and experienced radiologists to interpret them. Given that CCTA can reduce LOS without increasing cost, it is worth considering whether the lack of availability represents a clinically relevant disparity determined solely on the basis of ED arrival time. It must be determined if the benefits associated with CCTA are of sufficient magnitude to justify eliminating this disparity. In addition, the potential draw-backs of this modality must also be considered.

Coronary CTA is unlikely to be a one-size-fits-all approach for improving ED/OU ACS risk stratification efficiency, given that it requires very careful patient selection. Prior studies have demonstrated that up to 25% of patients presenting with symptoms concerning for ACS may have relative or absolute contraindications to CCTA.⁷ CCTA should be avoided in patients with renal dysfunction and allergies to iodinated contrast agents. Patients with tachycardia, obesity, advanced age, known coronary artery disease (CAD), or multiple risk factors for CAD are also poor candidates for CCTA, as these findings are associated with an increased rate of non-diagnostic CCTAs due to poor imaging quality.^{29,30}

Another concern related to a potential increase in CCTA use is radiation exposure. The potential LOS benefits of CCTA must be weighed against the potential harm from radiation exposure. Radiation exposure is higher in patients receiving CCTA compared to those receiving other diagnostic imaging modalities. The mean radiation exposure for 64-slice CCTA in the ROMICAT II clinical trial was 12.3 mSv.¹² This is a significant dose of radiation, given that a 10 mSV dose has been projected to cause one cancer death per 2,000 exposed persons.³¹ However, advances in technology now permit CCTA at much lower radiation doses, which may mitigate these risks.

The findings of our study should assist EDs interested in implementing CCTA-based care pathways with setting realistic expectations regarding the effect on LOS. Further, the overall effect of CCTA on LOS is likely highly related to the hours of availability and efficiency of the CCTA process, variables that must be factored into the decision of whether a CCTA pathway should be implemented. However, further study is required to determine if expanded hours of CCTA availability would enhance ED efficiency, be cost-effective, and provide benefits that outweigh concerns over radiation exposure.

While not the focus of this study, further reduction in the total LOS for OU chest pain patients can be made through minimizing the time period with lab, radiographic, or provocation study turnaround. Established processes that place importance on the turnaround time for these tests, which allow for branch-point care determination, are essential for quality and efficiency. Improved processes in these areas will decrease LOS for both CCTA and stress testing, but the greatest gains will likely be in the areas with increased parallel processing. This should also be considered when creating or revising OU chest pain protocols.

LIMITATIONS

This study included patients determined to be low-risk based on a combination of objective criteria based on a TIMI risk score less than 2 and the provider's subjective clinical risk assessment. The inclusion criteria were consistent with the entry criteria for the OU at the time of the study. Provider discretion was a part of the OU entry criteria in an attempt to prevent the inappropriate placement of patients at high risk for acute cardiac events in the OU. An advantage of including provider discretion as part of the risk assessment is that this mimics clinical reality, which adds external validity. Provider subjectivity may have resulted in selection bias. However, all of the patients included in this study were patients admitted to the OU and were already a highly selected group of ED patients with chest pain. When providers were determining appropriatenesses for OU admission, they were encouraged to use the ACC/AHA framework for risk assessment.¹ Having providers encouraged but not required to follow the framework reflects the reality of clinical practice and the difficulty in standardizing care to include all of the factors that influence clinician judgement.

Additionally, this analysis included patients from a single academic medical center using site-specific objective cardiac testing protocols and times of availability. Although we suspect many academic centers have similar hours of testing availability, the results of this study may not be generalizable to all centers using CCTA. At the study institution, CCTA is only available to ED patients admitted to the OU in order to ensure standardization of care and quality of imaging. Therefore, none of the patients in this study received CCTA in the ED. Institutions with ED CCTA protocols have demonstrated shorter LOS than we report in this study.⁹ Also, our protocol recommended secondary stress testing in patients with a CCTA showing 25% to 50% stenosis and cardiology consultation in patients with > 50% stenosis, which likely prolonged the stays of these patients. While some aspects of our protocol could have prolonged LOS in some CCTA patients, our highly controlled OU environment and equal availability of stress testing and CCTA were ideal for testing LOS differences between these testing modalities. In addition, stress testing at our institution is primarily based on echocardiography rather than nuclear imaging. Because nuclear stress tests often take longer to perform and interpret than stress echocardiography, the LOS reported for our stress testing modalities may be shorter than what would be seen at centers using nuclear imaging as the predominate stress test modality. Finally, few patients presented during the early morning time periods (00:00–03:59 hrs and 04:00–07:59 hrs), which limited the power to detect meaningful differences in LOS in those time strata.

CONCLUSIONS

In this study of observation unit management of low-risk chest pain patients, with equal availability of stress testing and coronary computed tomography angiography testing, use of CCTA was associated with shorter length of stay only in patients presenting to the ED during the interval 08:00–11:59 hrs. This time period was also associated with a greater likelihood of being tested by CCTA, suggesting that ED providers may have intuited the inability of CCTA to shorten length of stay during other time periods.

These findings suggest that ED providers contemplating which objective testing modality to order already consider test availability and patient time of arrival in their decision making. Furthermore, EDs interested in implementing CCTA-based care pathways should recognize that the effect of CCTA on length of stay is highly related to the hours of availability. Therefore, to realize a maximum return on investment of resources in technology and personnel, facilities should make coronary computed tomography angiography available during peak times of chest pain patient presentations.

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Appendix

Coronary CTA was performed using a LightSpeed VCT (GE Healthcare, Milwaukee, WI). After initial scout images, a low-dose non-contrast ECG-triggered acquisition through the heart was performed for the purpose of calcium scoring. A timing scan was performed to determine the appropriate scan delay to achieve maximal contrast opacification in the ascending aorta. Subsequently, an ECG-gated CCTA acquisition was obtained through the heart following triple-phase contrast injection of 100 mL of nonionic iodinated contrast material (Optiray 350; Mallinckrodt Medical, Hazelwood, MO). Raw image data were reconstructed at multiple phases of the cardiac cycle. The multiphase images were then postprocessed and analyzed on independent three-dimensional workstations (Advantage Workstation 4.2, GE Healthcare). Images reviewed consisted of a combination of axial slices, multiplanar reformats, curved multiplanar reformats, and thin-slab maximum

intensity projection images interpreted interactively on a dedicated cardiac analysis workstation. The degree of stenosis was measured with an electronic caliper by comparing the average diameter in the most stenotic region with the average luminal diameter of a normal proximal or distal reference segment located within 1 cm of the stenosis without intervening branch vessels. Interpretations were placed in the electronic medical record with descriptions of examination limitations, if any were present.

Figure 1.
Study flow diagram. CCTA = coronary computed tomography angiography.

Figure 2.

Kaplan Meier curves for each time strata. The 08:00–12:00 graph does not include the time-dependent covariate interaction due to graphing constraints. LOS=length of stay, CCTA=coronary computed tomography angiography. MN = midnight

Table 1

Patient Demographics.

Variable	Number (% , 95% CI)
Mean age, yrs ($\pm$ SD)	46.4 ($\pm$ 9.8)
White	605 (57.0, 53.5–60.2)
Female	515 (61.2, 57.9–64.5)
Stress test	496 (59.0, 55.6–62.3)
Exercise stress echo	419 (49.8, 46.4–53.2)
Dobutamine stress echo	109 (13.0, 10.7–15.2)
Adenosine stress cardiac MRI	30 (3.6, 2.3–4.8)
Coronary CTA	292 (34.7, 31.5–37.9)
Admitted from OU	67 (8.0, 6.1–9.8)
ED presentation time	
00:00 – 03:59	81 (9.6, 7.6–11.6)
04:00 – 07:59	74 (8.8, 6.9–10.7)
08:00 – 11:59	198 (23.5, 20.7–26.4)
12:00 – 15:59	223 (26.6, 23.5–29.5)
16:00 – 19:59	152 (18.1, 15.5–20.7)
20:00 – 23:59	113 (13.4, 11.1–15.7)

MRI = magnetic resonance imaging; CTA = computed tomography angiography; OU = observation unit. Continuous variables are presented as mean and SD, categorical variables are presented as counts, proportions, and 95% CIs.

Table 2

Total cost and charges, professional costs and charges, total work-related RVUs, facility cost and charges for patients with a first test of CCTA versus stress testing.

Test Modality	Professional Cost	Professional Charges	Total Work-related RVUs	Facility Cost	Facility Charges	Total Cost	Total Charges
CCTA	\$176 (157–237)	\$1,044 (923–1,246)	4.8 (4.4–6.7)	\$1,084 (948–1,248)	\$5,009 (4,430–5,685)	\$1,271 (1,126–1,454)	\$6,019 (5,456–6,941)
Stress Test	\$247 (236–314)	\$1,100 (1,050–1,356)	6.9 (6.7–8.7)	\$1,076 (862–1,377)	\$4,888 (3,931–6,215)	\$1,352 (1,105–1,686)	\$5,993 (4,973–7,591)

Data are presented as Median (IQR)

IQR = interquartile range; RVU=relative value unit; CCTA = coronary computed tomography angiography

Table 3

The number of patients, number tested, number receiving stress testing and CCTA, the odds ratio for testing modality choice by time block, adjusted for age, sex, and race, and the hazard ratio for the time-to-ED or -OU disposition by objective testing modality, adjusted for age, sex, and race.

Time block	Total n	Tested n	Stress Test n	CCTA n	OR (95% CI)	HR (95% CI)
00:00 – 03:59	81	77	57	20	0.69 (0.36–1.33)	0.67 (0.38–1.16)
04:00 – 07:59	74	67	34	33	1.77 (0.95–3.27)	0.75 (0.44–1.27)
08:00 – 11:59	198	186	84	102	2.36 (1.44–3.86)	0.38 (0.27–0.51) *
12:00 – 15:59	223	206	149	57	0.75 (0.45–1.24)	1.23 (0.90–1.69)
16:00 – 19:59	152	142	99	43	0.85 (0.50–1.46)	1.06 (0.74–1.54)
20:00 – 23:59	113	110	73	37	Ref	0.93 (0.62–1.39)

CCTA=coronary computed tomography angiography, OR= odds ratio, HR= hazard ratio.

*. Proportional hazards assumption failed in this time block. The HR presented is without the interaction term, providing the average effect of CCTA selection across the time block 08:00 to 11:59. In addition, due to missing data in the 08:00 to 11:59 time block (n=1 missing observation), race was not included as a covariate.