Original Investigation

SYNTAX Score Derived From Coronary CT Angiography for Prediction of Complex Percutaneous Coronary Interventions

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Abbreviations and Acronyms

CABG Coronary artery bypass graft

CAD Coronary artery disease

CCTA Coronary computed tomographic angiography

CIN Contrast-induced nephropathy

ICA Invasive coronary angiography

PCI Percutaneous coronary intervention

Rationale and Objectives: SYNTAX score is a useful metric determined at the time of invasive coronary angiography (ICA) to assess the complexity of coronary artery disease, and improves prediction of complications at the time of percutaneous complex intervention (PCI). We aimed to determine whether SYNTAX score can be reliably determined from coronary computed tomography angiography (CCTA) and whether a CCTA-derived SYNTAX score can predict complex PCI.

Materials and Methods: SYNTAX scores were calculated on per-patient, per-vessel, and per-segment basis in 154 consecutive patients who underwent CCTA and ICA. PCI complexity in 113 patients who underwent intervention was defined by total fluoroscopy time and contrast volume.

Results: Compared to ICA, CCTA detected 285 of 302 (94%) obstructive lesions in 230 vessels, for which PCI was performed for 154 lesions in 131 vessels. Overall, on a per-patient basis, ICA-derived SYNTAX score was lower in comparison to CCTA-derived score (10.2 ± 8.0 vs 10.9 ± 8.3, $P = 0.001$). As compared to lesions in the lowest CCTA-derived segmental SYNTAX tertile, lesions in the highest tertile required longer fluoroscopy time (17.5 ± 12 min vs 11.5 ± 7.9 min, $P = 0.01$) and greater contrast volume (215.4 ± 125.5 mL vs 144.3 ± 49 mL, $P = 0.02$).

Conclusion: SYNTAX scores derived from CCTA are concordant with those derived from ICA and correspond with complex PCI.

Key Words: Multidetector computed tomography; coronary angiography; percutaneous coronary intervention; coronary artery disease; atherosclerotic plaque.

INTRODUCTION

The SYNTAX score is a comprehensive angiographic scoring system commonly used to assess the complexity of coronary artery disease (CAD) by invasive coronary angiography (ICA). The SYNTAX score combines several validated angiographic classifications of CAD complexity based on the location and morphology of obstructive coronary lesions, and allows for robust risk stratification as well as guides appropriate methods of coronary revascularization (1).

Coronary computed tomographic angiography (CCTA) has emerged as a non-invasive test that demonstrates high diagnostic accuracy compared to ICA for identification and exclusion of obstructive coronary stenosis, as well as plaque location, distribution, and extent (2–5).

To date, whether a CCTA-derived SYNTAX score compares favorably to an ICA-derived SYNTAX score has not been

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well evaluated. Further, whether these non-invasive CCTA findings can be applied in the pre-procedural setting to predict the complexity of percutaneous coronary intervention (PCI) is unknown. We sought to determine the feasibility and accuracy of CCTA-derived SYNTAX score when compared to an ICA-derived SYNTAX score as a reference standard. Further, we determined the relationship of a CCTA-derived segmental SYNTAX score to the complexity of PCI.

MATERIALS AND METHODS

Study Population

We retrospectively studied consecutive patients who met the following inclusion criteria: (1) underwent CCTA and ICA within 30 days without intervening clinical cardiac event in the interscan period between CCTA and ICA; (2) were identified by CCTA as having an obstructive coronary stenosis >50% in non-stented segments; (3) no prior coronary artery bypass surgery (CABG). Among 170 eligible patients, 16 were excluded due to severe motion artifacts on CCTA.

Before CCTA, we prospectively collected information on the presence of CAD risk factors. Hypertension was defined as a history of high blood pressure or treatment with antihypertensive medications. Diabetes mellitus was defined by previously made diagnosis and use of insulin or hypoglycemic agents. Dyslipidemia was defined as known but untreated dyslipidemia or current treatment with lipid-lowering medications. A smoking history was defined as current smoking or cessation within 3 months of testing.

The study protocol was approved by the Cedars-Sinai Institutional Review Board. All participating patients provided informed consent for the use of their clinical and imaging data.

CCTA Image Acquisition

CCTA scans were performed on a dual-source CT scanner (Somatom Definition, Siemens Medical Systems, Forchheim, Germany). The CCTA acquisition protocol is detailed in the Appendix.

CCTA Image Reconstruction and Evaluation

Reconstruction of CCTA data was routinely performed at mid-diastole and, for CCTAs acquired by retrospective electrocardiogram helical methods, at end-systole if needed. Two experienced level III equivalent readers, blinded to patient characteristics and ICA findings, visually inspected and assessed all coronary segments >1.5 mm in diameter for presence of an obstructive stenosis, defined by a ≥50% luminal diameter narrowing (6–8). Each obstructive lesion ≥50% was further assessed and scored in accordance with the previously described SYNTAX score (1). CCTA image reconstruction and evaluation protocols, as well as calculation of CCTA-derived SYNTAX scores are detailed in the Appendix. Disagreement between the two readers was resolved by means of consensus. A representative example of CCTA-based SYNTAX scoring can be seen in Figure 1.

ICA Image Acquisition and Evaluation

ICA by standard catheterization techniques was performed (Innova, GE Healthcare, Buckinghamshire, United Kingdom). ICA images were analyzed by dedicated commercially available software (AGFA Heartlab, Greenville, SC).

Two independent expert cardiologists performed image evaluation blinded to CCTA results, clinical information, and whether a PCI was performed. Each coronary segment >1.5 mm in diameter was visually inspected for presence of an obstructive lesion in a similar manner to CCTA interpretation. Each obstructive lesion ≥50% was further assessed and scored in accordance with the previously described SYNTAX score (1). Disagreement between the two readers was resolved by means of consensus, with independent adjudication of all obstructive lesions by CCTA and ICA to ensure cross-correspondence and valid comparison of lesions between the modalities.

Complexity of PCI

There were 14 interventional cardiologists with at least 10 years of experience (range 10–25 years) who performed the PCIs in the studied population. All interventionalists were blinded appropriately to CCTA SYNTAX scores.

Complexity of PCI was determined by two metrics: (1) assessment of total fluoroscopy time of ICA and PCI; (2) volume of contrast use, inclusive of both the diagnostic and interventional portions of the procedure.

Importantly, total fluoroscopy time was employed as a surrogate for overall radiation dose as no reliable metric exists for calculation of effective radiation dose from clinically performed ICA or PCI. Similarly, volume of contrast use was employed as a surrogate marker for risk of contrast-induced nephropathy (CIN). We performed analyses for individuals undergoing serial serum creatinine measurements. Creatinine levels before and within 96 hours after PCI were employed for evaluation. Baseline glomerular filtration rate was calculated by the Modification of Diet in Renal Disease formula (9). CIN was classified as grades 0, 1, and 2, as previously described in the literature (10).

For metric (1) and (2), we assessed the impact of SYNTAX score among all patients who underwent PCI, as well as reserved analysis to cases that involved only a single lesion percutaneous revascularization ($n = 85$ patients). This was done to adequately estimate the impact of a segmental SYNTAX score on fluoroscopy time and contrast use. In exploratory analyses, procedure failure was also evaluated and defined as an inability to successfully cross an obstructive lesion with an intracoronary wire or post-procedural thrombolysis in myocardial infarction flow <3. Procedure-related complications included any serious adverse event, including occurrence of coronary dissection or perforation.