

Diagnostic value of Multi-Slice CT Assessment in Patients with Coronary Chronic Total Occlusion Lesions Prior to Revascularization

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BACKGROUND:

Accurate assessment of CTO lesion is essential to design the strategy of revascularization.

OBJECTIVE:

We aimed to evaluate the significance of multi-slice computed tomography (MSCT) examination in patients with CTO lesion.

METHODS:

Forty patients who were confirmed to have at least one native coronary artery CTO before they underwent elective PCI. Twenty patients (I) undergo evaluation of their CTO segment with MSCT CA with detailed assessment of occluded vessel by calculating occlusion length, amount of calcification, proximal and distal cap, and course of the vessel with calculation of (KCCT, CT RETRACTOR and JCTO SCOREs) before a trial of percutaneous intervention. Reference group include 20 patients (II) with CTO where assessment of the occluded segment was done through invasive CA and calculation of (JCTO, AND PROGRESS scores). The two groups were compared as regard procedure successes rate, time for wire crossing, amount of contrast used, final TIMI flow, procedure related complication, and impact of calculated scores on prediction of procedure success.

CONCLUSION:

From the results of this study it could be suggested that, Although MDCT is an effective tool, its use implies exposure to radiation and contrast material, therefore, do not believe it should be routinely applied in all patients with CTO. Its use should be limited to particularly complex cases (very long or tortuous occlusions, with severe calcification) or previous revascularization failures.

It has been estimated that chronic total occlusions (CTOs) are observed in up to 35% of patients with suspected coronary artery disease who undergo coronary angiography. Despite this high incidence, CTO percutaneous intervention is not routinely

attempted, this is thought to be primarily owing to poor CTO PCI success rates, which have led to the development of novel techniques, equipment, devices and imaging. There are different imaging modalities that can help the success of CTO PCI. Angiographic imaging in CTO will remain essential to predict procedural success, patient selection, procedural planning and follow-up.

In occluded coronary artery segments Invasive coronary angiography provides incomplete information on vessel morphology. On the other hand, coronary CTA reliably visualizes the occluded coronary segment and is able to identify and evaluate morphological (e.g., amount disruption of calcification) and anatomical (e.g., tortuosity, length) features of the occlusion.

Coronary CTA more clearly visualize the distal vessel territory than in invasive angiography. Two- and Three-dimensional reconstructions enable visualization of the exact vessel trajectory with accurate measurement of the occlusion length and precise mapping of vessel tortuosity, Coronary CTA can also be used to identify ostial occlusions that may be missed in invasive angiography.

Advantages of coronary CTA over standard, catheter-based angiography are most apparent in long and tortuous CTO lesions or when the distal CTO segment cannot be visualized in invasive angiography.

The aim of this work was to study the diagnostic value of multislice CT coronary angiography and its impact on the result of percutaneous coronary interventions in patients with CTO with special attention to amount of contrast used, time to wire crossing which reflect on radiation dose and complication related to the intervention.

Our study included **40** patients who were confirmed to have at least one totally occluded native coronary artery.

The present study was designed as follows: ***the first group***, included 20 patients which undergone evaluation of this totally occluded segment with

MSCT coronary angiography. Detailed assessment of occluded vessel by calculating occlusion length, amount of calcification, proximal and distal cap, course of the vessel and calculation of (KCCT, CT RETRACTOR AND JCTO SCOREs) were performed before a trial of percutaneous intervention on this vessel.

As regard the second group, it included 20 patients with assessment of the occluded segment by invasive coronary angiography and calculation of JCTO, AND PROGRESS scores).

All patients underwent trial of revascularization using antegrade or combined antegrade and retrograde approaches.

Patients included in these two groups were matched regarding common risk factors for CAD especially for age, sex, DM, HTN dyslipidemia and smoking status.

These two groups were compared as regard the procedure overall successes rate, time for wire crossing, amount of contrast used, final TIMI flow, and procedure related complication.

The first group cases with succeed and failed revascularization were compared to study impact of MSCT calculated parameters on revascularization such as lesion length, calcification, side branch, tortuosity

Patients were presented to the coronary catheterization labs in both Cardiology department, Tanta University Hospitals and Specialized Heart Center at KobriAlKobba Military Hospital during the Period from January 2016 to October 2017.

MSCT versus Invasive Coronary Angiography

Most studies have consistently reported blunt entry, tortuous or long occlusion, side branch, and calcification as anatomic predictors. CCTA has advantage over CAG for direct visualization of CTO vessel trajectory, the burden of calcification, and visualization of artery from any arbitrary angle.

• **According to the final Results:** Succeeded Revascularization in 16(80%) of group I and 15 patient in group II and failed Revascularization in 4 (20%) in group I and in 5(25%) in group II (without significant difference).

Rolf et al. (2015) reported that performing coronary CTA before PCI of CTO lesions was associated with a higher success rate. In our study, the difference in the success rate between the PCI procedures in patients with versus without pre-coronary CTA was not significant, possibly due to an insufficient sample size in each group or selection bias.

In the present study, some “classic angiographic factors” of failure were irrelevant. This may be due

to the improvements in the material used; particularly the development of guide wires with a greater power of penetration and new techniques for their manipulation and stressing. This aspect may also be due to small number of patients, higher level of experience among our operators.

Regarding Demographic and clinical criteria of the patients:

Our Study showed no Statistically Significant differences between failed and Succeeded patients in both Groups Regarding Age, DM, HTN, Smoking status.

The results of the present study were concordant with those obtained in **Korean Multi-center CTO CT Registry Score (2017)(KCCT)** which is the largest study; where 643 patients were enrolled; that investigated predictive performance of CCTA for CTO PCI procedural result which founded no difference of clinical characteristics and per-patient procedural characteristics.

Our Study results were in concordance with the study conducted by **Ping et al., 2010** who performed similar study on 74 CTO patients with successful PCI in 57 (77%) of patients and reported that patient’s age, DM, HTN, smoking status, previous myocardial infarction had no significant effect on procedure outcome.

On the other hand **Barbara Anna Danek et al., (2016)** in (PROGRESS CTO) Complications Score;studied 1569 CTO PCIs. The results of that study showed that older age was the most important predictor for complications. The incidence of complications was 7% in patients aged >75 years versus 4% in patients aged 66 to 75 years versus 1% in patients aged ≤65 years (P<0.001). This finding is likely related to more complex coronary anatomy with increasing age, higher prevalence of tortuosity and calcification.

Elderly patients are more likely to have diffused aortic atheroma, predisposing them to strokes during coronary intervention. Moreover, elderly patients tend to have more comorbidities.

Vessel treated:

Our Study showed no statistically significant difference between the succeeded and failed patients in both groups regarding which artery is affected, site of CTO. We reported more failure rate when LAD was the treatment target without a statistically significance.

These data were discordant with large USA registry in **2015 (National Cardiovascular Data Registry, n=22 365)** showed higher failure rate in

right coronary artery. Also our results; as regard vessel treated; were in discordant with **Barbara Anna Danek, ET AL (2016)** IN (PROGRESS CTO) Complications Score. They reported that, the right coronary artery was the most common target vessel (56%), followed by the left anterior descending coronary artery (23%) and the left circumflex coronary artery.

In our study we found that the longer duration of occlusion, the more incidence of failure (**CTO Duration** > 9 months carries an increased incidence of failure).

These data were concordant with A Study done by **Choi et al., 2011**, performed for 186 consecutive CTO lesions. The PCI success rate decreased significantly when the duration of occlusion was long. The success rate was 92.9%, 84.8%, and 64.6% when the duration of CTO was 1–3 months, 3–12 months, and >12 months or unknown, respectively. These data were also concordant with **Opolskiet al., (2015)** who analyzed Data from Four centers involving 240 consecutive CTO lesions with pre-procedural coronary computed tomography. Successful guide-wire crossing in less than 30 min was set as an endpoint, and found duration of CTO ≥ 12 months, as independent Predictor of failure of revascularization.

However, these data were Discordant with those obtained by **Antonio de Castro Filho et al., (2015)** who analyzed A total of 168 patients of them treated 122 (72.6%) with (80 < 12 months, 42 \geq 12 months) and found duration was not associated with increased failure rate of the procedure or worse PCI outcomes in CTO.

Time for wire crossing the CTO and amount of contrast used:

The current study founded that group I had a shorter time required for the PTCA guide wire to cross the CTO segment than that for group II with a statically significant difference.

For group I mean time was 22.7 min, while in group II mean time was 34.3 min, this may be due to 3D reconstruction for MSCT-CA image which allow a better vessels tracking.

In The current study we founded a statically significant difference in the contrast volume used in both groups with a mean contrast volume 258.5 cc for group I and mean volume 324.5 cc for group II.

These data were concordant with **Galassi, (2016)** which studied the association of J-CTO score with procedural time, fluoroscopy time, and contrast load Overall, for every 1-point increase in J-CTO score, procedural time increased by 17.47 min,

fluoroscopy time increased by 14.85 min, and contrast load increased by 39.88 ml, Very difficult lesions were significantly associated with longer procedural time, longer fluoroscopy time, and greater use of contrast. The improvement in success rate was achieved at the expense of more time and contrast

These data were concordant with **Hammas, (2011)** which founded that MSCT might be helpful. It has the potential to reduce the fluoroscopy time and contrast and this could eventually result in lower procedure time.

Procedure related complication:

The current study showed no statically significant difference between both groups in procedure related complication, with more complication incidence in CA group when compared with CT CA group, complication related mainly to higher J- CTO SCORE.

Our data were concordant with **Danek et al., (2016)** in (PROGRESS CTO) Complications Score, in which Peri-procedural complications occurred in 44 patients (2.8%). occurred more frequently in CTO PCIs that involved a CTO ≥ 23 mm in length, use of the retrograde approach, or in CTOs with a higher J-CTO score. Complications tended to occur in patients with a blunt or no stump at the proximal end of the CTO and with the presence of interventional collaterals, With older patient age >65 years

Comparison of MSCT variables Occlusion length:

Among univariate angiographic or CCTA predictors, occlusion length is the only continuous parameter and has been reported to be related to procedural success but with variable cutoffs.

The current study revealed that occlusion length was a statistically significant parameter reflecting overall procedure successes occlusion length more than 22 mm carries an increased incidence of failure, occlusion length was more accurate measured by MSCT-CA than with CA.

Current Study results were concordant with **FujinoandOtsuji, (2017)** regarding the assessment of bending and occlusion length, reported that computed tomography had a notable advantage over conventional angiography because it provided a 3-dimensional depiction of the CTO segment. Current Study results were concordant also with **J-CTO** study, in which the optimal cutoff of CCTA occlusion length for successful guide wire crossing ≤ 30 minutes was ≥ 14.6 mm. Therefore, CCTA occlusion length of ≥ 15 mm was included in the analysis

Current Study results were also concordant WITH **Anna Danek et al., (2016)** in (PROGRESS CTO) Complications Score, CTO length was an independent predictor of complications, a finding that (≥ 20 mm length predictive of procedural failure), Longer lesion length may increase the complexity of the procedure and the need for advanced (and potentially more hazardous) crossing strategies, such as antegrade dissection/ reentry and the retrograde approach.

Current Study results were also concordant with the study done by **Qu, (2014)** in which compared the length of the occluded segment which was determined by CTCA examination in all 23 CTOs. With, only 11 CTOs was measured by CAG because of missing collateral angiography. In eleven patients with data acquired both by MSCT and CAG, the length of the CTOs showed no significant difference between two methods.

Current results were also concordant with those obtained by **Ping et al., (2010)** which showed significant increase in procedure failure with longer lesions.

Current results were also concordant with those obtained by **Choi et al., (2011)** included 486 consecutive patients showed longer occlusion length (cutoff ≥ 15 mm) to be associated with increased incidence of failure. However, these data were discordant with those obtained by **Garcia et al., (2009)** and **Martin-Yuste et al., (2012)**, both showed no effect of CTO length on procedure outcome.

Calcification:

Calcification obstructing whole vessel lumen was strongly related to procedural failure. "full-moon" shaped 360° calcification as an extremely high obstacle for crossing guidewire, CTCA had higher sensitivity in the rate of detection of calcification compared with CAG, Also, the length of calcified lesion could be successfully measured by CTCA. CTCA could detect the detailed location (proximal, middle and distal segment) of calcification in occlusive vessels, and facilitated to visualize the tract of the occluded segment. The current study results showed that MSCT is more sensitive than CA in quantification of CTO segment calcifications *CTO segment calcifications:* were detected by Coronary Angiography in **6 patients**, of them: **6 patients (100 %)** were Detectable by the MSCT. *On the other hand,* CTO segment calcifications were not detected by Coronary Angiography in **14 patients**. Of them, 5 patients (35.7%) were Detectable by the MSCT. This gives MSCT *100.00 % Sensitivity and 64.3 % Specificity.*

The current Study results were concordant with the study of **Hsu et al., (2011)** performed in 82 CTOs, evaluated the calcification length ratio, defined as the length of calcification with density >130 HU/occlusion length. A calcification length ratio

>0.5 was found in 77.8% of technical Failures and 50% of procedure failures. The current study results were also concordant with those of **Martin-Yuste et al., 2012** who found a statistically significant increase in procedure failure in case of calcification occupying $> 50\%$ arc in cross section of proximal and mid segment of the CTO. The current study results were also concordant also with those obtained by **Ping et al., 2010** who performed a similar study on 74 CTO patients with successful PCI in 57 (77%) of patients and found significant tendency towards failure with increasing Proximal Cap calcification. Also **Cho et al., (2010)** analyzed the regional calcium score (area of calcification weighted maximal CT attenuation, total calcium score, regional calcium volume and the percentage of calcification of the vessel section, Although all the parameters studied were significantly associated with technical failure, upon multivariate analysis the only factor showing a high positive predictive power was the amount of calcification in the vessel section.

Again **Ehara et al., 2009** reported the results of study investigating MDCT in CTO in which revascularization was carried out by experts in this field; included 110 lesions and identified 3 independent predictive factors of guide wire failure to cross the lesion and concluded that Bending, shrinkage and severe calcification are significant predictors for wiring success, they found that severe calcification is a significant independent predictor of failure.

Also **Garcia et al., 2009** in their study concluded that MSCT is more precise than CA for assessing the anatomical features of a CTO, who found in their study that there was a significant increase in procedure failure in case of severe calcification ($> 50\%$ of vessel CSA), long calcified segment. Multivariate analysis of this study showed that absence of severe calcification is an independent predictor of success.

Side branches and proximal stump:

The current study revealed a statistically significant Tendency towards increased incidence of failure in the presence of Side branches. (Side branch was defined by branches having diameter of ≥ 1.5 mm adjacent to CTO).

Side branches at the CTO Segment: were

detected by Coronary Angiography in **6 patients**, of them: **6 patients (100 %)** were Detectable by the MSCT. On the other hand, Side branches at the CTO Segment were not detected in **14 Patients** by coronary angiography, of them, Side branches were detected in **6 patients** by MSCT. This gives MSCT **100% Sensitivity and 57.2% Specificity**

Current study revealed a Tendency towards increased incidence of failure in the presence of Blunt Proximal stump but we couldn't translate this tendency to a statically significant difference due to small sample size.

Rolf et al., (2013) reported that CTA had a superior ability to detect a blunt stump than conventional angiography because the time needed for coronary CTA may result in the retention of contrast medium in the micro-channel within the CTO segment. Current study data were concordant with those obtained by **Opolski et al., (2015)** who found Blunt Proximal cap as independent Predictor of failure of revascularization. Current study results were also concordant with those obtained by **Choi et al., (2011)** who included 486 consecutive patients showed that more Frequent Side branches to be Associated with increased incidence of failure.

Current study results were also concordant with the study done by **Mollet et al., (2005)** these authors used 16-detector MDCT in 45 patients, and the independent predictive factors of revascularization failure were an occlusion length >15 mm, blunt morphology of the proximal CTO, and the presence of severe calcification. However, these results were discordant with those of **Garcia-Garcia et al., (2009)** who found no significant effect of presence and size of proximal stump or side branches at CTO site. Also, these results were discordant with those obtained by **Martin-Yuste et al., (2012)** who Performed a similar study on 69 patients with a success rate of 62% Their results also showed no significant effect of the proximal stump morphology or size and side branches on the procedure outcome.

Japanese CTO SCORE (J-CTO):

In the current study J-CTO SCORE could predict procedure difficulty level, J- CTO score of zero and 1 had an overall near 100% success rate in both group, while J-CTO score 2 had a 75 % success rate in angiography based group and 100% in MSCT-CA based group, while J-CTO score of 3 had a 70% success rate in CA based group and 50% in MSCT-CA based group, and JCTO score of 4 had 50% success rate in angiography based calculation and 0% present in MSCT based calculation, this reflect more

powerful prediction of procedure outcome when CT CA was used to calculate J-CTO SCORE.

Current Study results were concordant with **Fujino and Otsuji, (2017)** which compared the discriminating accuracy of the **CTA-derived J-CTO score** with that of the conventional coronary angiography-derived J-CTO score for predicting procedural success and 30-min wire crossing during a CTO-PCI procedure and to clarify the performance of CTA to predict procedural difficulties when performing a CTO-PCI. In 45% of the lesions, the CTA-derived J-CTO score equaled that determined by conventional coronary angiography. However, 29.8% of the patients had a CTA-derived J-CTO score greater than that derived by conventional coronary angiography, whereas 25.2% of the patients had a CTA-derived J-CTO score less than the conventional angiography-derived J-CTO score. The CTA derived **J-CTO** score was significantly higher than that of the angiography-derived J-CTO score for predicting a successful CTO-PCI and for 30- min wire crossing, each morphologic parameter of the J-CTO score tended to be higher when assessed using CTA than when assessed using conventional angiography, showing better accuracies of CTA for predicting: 1) procedural success in the evaluation of calcification, bending, and occlusion length; and 2) 30-min wire crossing in the evaluation of entry shape, calcification, and occlusion length. On the other hand, **Li et al., (2010)** reported that J- CTO scores derived from CTA versus conventional angiography showed similar accuracy for predicting a successful CTO-PCI.

Korean Multicenter CTO CT Registry Score (2017) KCCT score:

KCCT score was categorized to simplify the prediction of procedural result According to this KCCT score category, the probability of successful guide-wire crossing ≤30 minutes (100%–29%) and procedural success (100%–60%), It further declined to 30% and 62% in “very difficult” category. Current study results were matched with this KCCT SCORE AS: our result showed that the higher score the more liable to failure, KCCT SCORE OF 1 and 2 showed a 100% success rate while KCCT score of 3 showed 67% success rate, KCCT score of 4 showed only 33% of success and KCCT SCORE of 6 showed a 100% failure rate.

CT RETRACTOR SCORE:

Current study results were matched with this obtained in CT RETRACTOR SCORE AS higher score were more liable to failure, CT RETRACTOR SCORE OF 0 and 1 (easy and intermediate) showed a

100% success rate while CT RETRACTOR SCORE of 2(difficult) showed 75% success rate, CT RETRACTOR SCORE of 3or more (very difficult) showed only 25% of success.

The CT-RECTOR (Computed Tomography Registry of Chronic Total Occlusion.

Revascularization) (2015) score was developed from Data from 4 centers involving 240 consecutive CTO lesions with pre-procedural coronary computed tomography angiography were analyzed. Successful guide-wire (GW) crossing in less than 30 min was set as an endpoint to eliminate operator bias.

CVPR