Impact of Pre-Procedural Coronary CT Angiography on the Procedural Success of CTO PCI.

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- Chronic total occlusions (CTOs) are the most technically challenging lesion subset that interventional cardiologists might face.

- It is seen in more than one-third of patients undergoing coronary angiography and it accounts for 6% to 10% of percutaneous coronary interventions (PCIs).

- It is considered as Type C or high risk lesions with a higher restenosis rate and increased technical failure rate by PCI.

- Most prevalent in the right coronary artery (RCA), followed by the left anterior descending artery (LAD), and are least common in the circumflex artery; they increase with advancing patient age.

*J Am Coll Cardiol* 41:1672-8; 2003
Compared to intervention of non-occluded stenoses, recanalization of chronic total occlusions requires:

- More experienced operator.
- Longer procedure duration.
- More amount of contrast material.
- More radiation dose for the patient and medical staff.
Successful revascularisation of CTOs by PCI has been associated with:

- Improvement in angina.
- Improvement in left ventricular systolic function.
- Avoidance of bypass surgery.
- Improved long term 5- and 10-year survival.
- Lower incidence of death or myocardial infarction.
- Improved tolerance to future coronary events.

Should every cardiologist attack a CTO lesion?
When the occluded vessel is responsible for:

- Medically refractory angina.
- Large area of ischemia by non-invasive study.

Favorable angiographic appearances (e.g., tapered stump, functional occlusion, no side-branch at occlusion site, absence of bridging collaterals).

The likelihood of successful procedure is at least moderately high.

The predicted anticipated procedure related risk is low.

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**Principles for CTO PCI**

- **Concentration for CTO anatomy**
  - Stump.
  - Evaluation of collaterals.
  - Distal run-off.
  - Tortuosity of proximal vessel.

- **Configuration for strategy**
  - Two guiding? One guiding and one diagnostic.
  - Antegrade approach.
  - Retrograde approaches?
  - IVUS guided.
  - Two wires – gradual or jump.

- **Confidence**
  - Continuous accumulation of experiences.
Technical success was defined as:

A) Restoration of the antegrade flow (TIMI grade 2 or grade 3 flow).

B) Final residual stenosis of < 30% as assessed by quantitative coronary angiography.

Despite equipment improvement, technique advancement, and enhancement in operator expertise, the published success rates of CTO PCI are only 55-80% in most experienced centers.

What are the common causes for procedural failure of CTO PCI?

- Inability to cross the lesion into the true lumen of the distal vessel with a guide wire (60%).

- Intimal dissection with creation of a false lumen.

- Contrast extravasation.

- Failure to cross the lesion with a balloon, or failure to dilate adequately.
Predictors of Procedural Failure

1) CTO duration (>3 months).

2) Occlusion morphology.

3) Bridging collaterals.

4) Multivessel disease.

Noguchi T et al., Catheter Cardiovasc Interv 2000;49:258-264

5) Presence of calcifications

- Defined by the presence of calcium which occupies >50% of the luminal cross section area.

- Severe calcification has been demonstrated to be the most significant independent predictor for procedural failure beyond conventional characteristics on ICA.

J Am Coll Cardiol 29:955-63; 1997
Extent of calcification may predict the possibility of penetration of the total occlusion with a guidewire.

A large extent may cause the guidewire to deflect behind the plaque into the subintimal space during the penetration attempt.

Because of the uneven distribution of calcification plaques, the course of the occluded vessel was not visible by contralateral injection.

6) **CTO Length (> 15 mm)**

The length of the occluded segment has long been identified as an important predictor of failed recanalization.

Accurate measurement of lesion length using conventional angiography may be difficult, mainly due:
- Foreshortening.
- Calibration limitations.
- Lack of visualization of the distal vessel in the absence of collateral filling.
The major adverse coronary event (MACE) rate with a successful PCI of CTO is about 2–2.5% but can exceed 5%.

The unsuccessful CTO procedure is not risk free, failed PCI is associated with MACE rate of about 5.6% compared with successful PCI–MACE rate of 2.5%.

So careful selection of those patients with CTO that are most likely to benefit by having a good chance of a successful PCI remains essential.
Manipulation of wires and devices through a CTO during PCI without any means to visually identify vessel-wall boundaries involves an inherent risk of complications such as arterial dissection, perforation and cardiac tamponade.

Multislice computed tomography (MSCT) has now been established as the best non-invasive diagnostic imaging modality of the coronary arteries.

Chronic total occlusions appear as a complete lack of contrast opacification of the artery lumen on MSCT axial images, multiplanar reformations (MPR) and maximum-intensity projections (MIP).

The distal vessel lumen is often opacified, although less intensely, via filling of collaterals.

Lack of contrast in the distal segment should raise the suspicion of an acute or subacute occlusion which is usually associated with higher success rates of PCI.
A short segment of occlusion (absence of contrast-filled lumen) and a tapered stump.

Coronary angiography

Eccentric calcified plaques at the proximal margin of the occluded segment of the proximal right coronary artery

Lumen of the artery distal to the occlusion is opacified by contrast due to collateral circulation.

Advantages of Pre-Procedural Coronary CT Angiography
- It facilitates decision making by providing data that cannot be obtained by coronary angiography.

- Identifying the presence and locations of CTO.

- Better visualization of the occluded segment (proximal and distal to the occlusion can be easily visualized due to contrast in-flow from collaterals).

- It provides an accurate assessment of the lesion length.

*CT-CA shows small eccentric calcified plaques at the proximal and distal margin of the occluded segment.*
- It enables three-dimensional visualization of the anatomical course of the coronary arteries as well as that of the calcification plaque morphology, which improves the clinical success rate of PCI for CTO.

CT 3D image of LAD provides the roadmap for wiring the occluded segment.

- It had a significantly higher sensitivity for the detection of calcification compared to coronary angiography (82% Vs 66%).

- Severity of calcification is underestimated in only 9% with CTCA, while it is underestimated in 30% with CAG.
Preprocedural planning to:

- Shorten procedure times.
- Predict the ease with which a CTO can be crossed.
- Assess the frequency of procedure-related complications such as contrast nephropathy and radiation skin injury.

Postprocedural assessment of the revascularised arterial segments and long-term follow-up on the patency of coronary stents.

Pre-procedural CCTA demonstrated a long, straight segment of chronic total occlusion (44 mm), with minor calcification within the occluded segment.

Invasive coronary angiography demonstrated a chronic total occlusion in the mid-right coronary artery.

PCI was done Successfully
Coronary CT angiogram images showing occlusion of a mid-right coronary artery (RCA) with complete cut-off at the stump and with heavy calcification at the proximal margin of the occlusion, which are unfavourable predictors for percutaneous coronary intervention (PCI).

A conventional coronary angiogram showing chronic total occlusion.

**PCI was failed !!! (due to G/W passage failure)**

Coronary angiography was done first showing favorable morphology in CAG (tapered stump, absence of calcification, occlusion length < 15mm).

**PCI was failed !!! (due to G/W passage failure)**

Maximum intensity projection (MIP) of same MSCT → severely calcified occlusion stump.

Curved multiplanar reconstructed (MPR) MSCT image → severely calcified stump with visible collateral filling distal to occlusion.
Victoria et al., 2012, concluded that MSCT identified a variable that cannot be measured by angiography that can predict failure in PCI of chronic total coronary occlusions.

In selected cases, this parameter could be useful for preprocedure screening.

To Summarise Coronary MSCT role for CTO PCI

C: Calcium scoring as volume and CSA of calcium at entry points (proximal and distal end of CTO) as well as mid-portion of CTO.

T: Tortuousness of CTO segment and anatomical relationship with branches.

O: Objective length of CTO.
Disadvantages of MSCT

- The relatively high radiation exposure during MSCT coronary angiography (reportedly between 6.7 and 13.0 mSv) is still excessive exposure with an associated lifetime risk of cancer of 0.22%. If the patient would then undergo PCI, an additional 39 mSv could be acquired.

- The lack of soft tissue contrast attenuation decreases the ability to accurately delineate the luminal and vessel borders in the occluded segment.

- MSCT cannot show collateral circulation as clearly as traditional coronary angiography as clearly demonstrated by contralateral injection.

- Also, it is not possible on CT to identify bridging collaterals or septal collaterals owing to their intramyocardial location.
The need to use contrast material may pose a limitation to pre-procedural MSCT coronary angiography for interventions scheduled to be performed shortly after scanning (ideally performed one week prior to scheduled intervention).

With all CT angiogram examinations, very-high-grade stenosis may not be reliably differentiated from total occlusion.

Also CTO especially short ones, can be misdiagnosed as high-grade stenosis.

So any possible CTO detected on CCTA should be further evaluated by a catheter angiogram.
MSCT that shows a segment of occlusion with calcification at the mid coronary artery, and a chronic total occlusion is suggested.

Conventional coronary angiogram showing the presence of a subtotal occlusion (99% stenosis).

CTO of mid RCA was made based on CTCA findings. CAG shows the presence of a subtotal occlusion.
Jin-Ho et al., 2012, concluded that Pre procedural CCTA did not show beneficial impact on the procedural success of CTO PCI.

Koji Ueno et al., 2012, concluded that preoperative CTCA does not affect the prevalence of success of the procedure, irradiation time, and the dose of contrast agents, but may be useful to reduce the prevalence of complications during PCIs of CTOs.

Take Home Message
MSCT with the rapid developments in its technology leading to decreased amount of radiation dose should be considered to assess CTO lesions before PCI on a larger scale especially:

- Lesions that are difficult to visualize on ICA.
- Lesions that possess angiographic features on ICA that are negative predictors for procedural success.
- Lesions that have had previous failed attempts at recanalization.

With advancements the software, some centers have begun to incorporate CCTA images into live fluoroscopic images to create hybrid three-dimensional images.

This aims to provide real-time co-registration of data obtained from the two modalities, which can be presented as a fused image to guide interventionalists during PCI.
Thank You!