Is dual-source CT coronary angiography ready for the real world?

Filippo Cademartiri1,2*, Erica Maffei2, and Nico R. Mollet1

1Department of Radiology and Cardiology, Erasmus Medical Center, Rotterdam, The Netherlands; and 2Department of Radiology and Cardiology, Azienda Ospedaliero-Universitaria/University Hospital, Parma, Italy

This editorial refers to ‘Dual-source computed tomography coronary angiography: influence of obesity, calcium load, and heart rate on diagnostic accuracy’† by H. Alkadhi et al., on page 766

CT coronary angiography (CTCA) represents one of the major innovations in cardiac imaging over the past 10 years. The introduction of 64-slice1,2 and dual-source3,4 CT scanners allowed the clinical implementation of this technique in non-invasive coronary artery imaging.

The pros of CTCA are: non-invasiveness; the ability to visualize both the lumen and the coronary artery wall, and consequently to identify atherosclerotic plaques; and the ability to investigate the spatial relationships between cardiac structures.

More than 5000 scanners with 64 slices are installed around the world and more than 4000 have cardiac imaging capabilities. These figures are continually growing.

However, the proper use of this tool is still under discussion and for some researchers is even controversial. Studies dealing with clinical outcome and cost-effectiveness are still lacking, and several limitations and concerns have been raised about the clinical implementation of this imaging modality.

Alkadhi et al.5 report the diagnostic accuracy of dual-source CTCA (DSCT) in a population at intermediate cardiovascular risk, with regard to important parameters such as obesity, calcium load, and heart rate.

Parameters reducing image quality and diagnostic accuracy

Since the first reports on diagnostic accuracy of CTCA with 4- and 16-slice equipment, a few patient parameters have been recognized as being able to compromise image quality significantly. This deterioration of image quality was mainly associated with heart rate (i.e. >60–65 bpm during the angiographic scan) and calcium load (i.e. total coronary Agatston score).5–10 More recently, with the introduction of 64-slice CT equipment and the concomitant diffusion of CTCA into the North American market, patient’s weight [i.e. better expressed as body mass index (BMI)] has also been recognized as a factor influencing image quality and therefore diagnostic accuracy.7,8 The recent introduction of DSCT has brought high expectations in terms of heart rate management capabilities.3,4 If these expectations are fulfilled, the field of application of CTCA may expand to include acute chest pain and unstable patients in whom heart rate is often barely controlled pharmacologically.

BMI, calcium, and heart rate

A heart rate <65–70 bpm (spontaneous or induced by administration of β-blockers) has almost always been reported as an inclusion criterion for CTCA. The mean heart rate reported in the first experiences with 4-slice CT was <60 bpm. Alkadhi et al. show that heart rate does not significantly affect the diagnostic accuracy in a group of patients with a heart rate >66 bpm.5 The same finding holds for BMI >26.5 Regarding calcium load, expressed as overall coronary Agatston score,6 there is a mild influence on diagnostic accuracy. A higher calcium load (i.e. Agatston score >194) determines a reduction in specificity and positive predictive value on segment-based analysis, as previously reported.7–10 With patient-based analysis, the deterioration of diagnostic accuracy parameters was not present or very mild. The number of patients enrolled in this study and in the subgroups is not very high, and it is difficult to say whether the findings will remain the same in a larger population.

However, based on the results, it seems that the new technology (i.e. DSCT) is hardly influenced by conventional parameters. Calcium load seems to affect diagnostic accuracy, albeit mildly. This may be explained by the fact that spatial resolution has not significantly changed in DSCT technology as compared with previous 64-slice technology.

The solution to this problem will be difficult to find, since improvement in spatial resolution is generally associated with a thinning of the individual detector width. With current detector technology, this development leads to an increased load of photons.
(mA/s) in order to maintain a good signal to noise ratio. Newer
detector technology may allow this problem to be overcome.

It is very difficult, from this validation study, to extrapolate rec-
ommendations or calcium load thresholds to use as a gatekeeper
for the CTCA scan. In addition, a measure of the calcium distri-
bution along the coronary tree would be desirable to understand
better the impact of diffused ‘spotty’ calcifications vs. segmental
‘bulky’ calcifications.

Regarding the impact of BMI and heart rate, it can be stated that
in clinical practice all CTCA operators know that a ‘large’ patient
presents more difficulties because of the increased noise in the
images, and they also require a larger X-ray dose. This may pose
questions regarding the proper indications depending on the age
and/or the risk category of the patient.

It is also known that a higher heart rate requires a more
extensive analysis of additional temporal windows (i.e. more time
for the analysis). The time required for the analysis of a CTCA is
affected by heart rate. Therefore, it should also be considered
that lowering the heart rate (e.g. pharmacologically) is a way to
reduce the time for the analysis. It is a kind of ‘investment’ in the
workflow of patients that still needs to be measured. In addition,
for DSCT, the X-ray dose reduction protocol with heart rate adap-
tive pitch and a modifiable high X-ray dose window determines a
progressive reduction in dose with increasing heart rates.
However, most of the previously released dose reduction
systems worked in the opposite way, i.e. a lower heart rate
allowed a lower dose. Different approaches suggest that in those
with low heart rates, prospective ECG triggering of the scan
allows a very low X-ray dose to be delivered. Therefore, the
type of X-ray dose reduction approach may also affect the heart
rate modulation approach.

Intermediate pre-test likelihood/probability/prevalence of disease
Recently, recommendations from the European Society of Cardi-
ology appeared in the literature. In this document, it is suggested
that patients with an intermediate probability of disease are
those that may benefit the most from CTCA.

The population undergoing CTCA in the study of Alkadhi et al.
must this recommendation, and the results in terms of diagnostic
accuracy are very promising.5

CTCA should not be considered as an alternative to stress tests
(i.e. stress-ECG, stress-echocardiography, stress-SPECT), but
should be used as an additional investigation in cases of doubt.

Future perspectives
It should be stressed that current evidence is derived from multiple
validation studies. No outcome studies have been performed. One
of the key considerations remains that extensive expertise is still
necessary to perform a diagnostic CTCA. The selection and prep-
арат of patients are extremely important since radiation and
contrast media issues remain some of the major limitations of
this new imaging modality.

However, in spite of these limitations (that will probably disap-
pear or at least have a reduced impact in the near future), there is a
trend towards changing the clinical approach to coronary artery
disease (CAD) due to the introduction of CTCA in the clinical

---

**Figure 1** Proposed diagnostic algorithm in patients suspected to have CAD. The first line is non-invasive anatomical imaging. Then, depending
on the extent of CAD and the degree of obstruction, the patient may be discharged, perform cardiovascular risk modification, or undergo the
assessment of inducible ischaemia. This algorithm needs to be integrated and individualized with cardiovascular risk stratification and clinical
assessment (modified from Schuijf et al.14). An asterisk indicates that the choice between medical therapy and further testing depends on
the risk stratification of the patients.
field. Some authors suggest a change to the diagnostic algorithm for stratification of patients with suspected CAD (Figure 1).14

Compared with the current algorithm in which the first step consists of collecting information about reversible myocardial ischaemia, the new one suggests morphological imaging as the first step able to classify patients as: normal, with non-obstructive CAD, or with obstructive CAD. The second step should be the functional evaluation of ischaemia induced by the morphological alteration detected. This approach is based on the classification of each patient by the presence/absence and degree of CAD.

Until recently, this information was mainly collected on the basis of epidemiological data (i.e. Framingham risk score) or non-invasive diagnostic modalities such as the coronary calcium score.6,15 The cost-effectiveness of this approach should be assessed in the future.

Chest pain triage

The evaluation of chest pain of uncertain cause represents a new field of application of CTCA. Recent studies suggest the use of CTCA for the evaluation of chest pain of suspected coronary origin. In patients with low to intermediate pre-test probability, this approach has already demonstrated promising results, adding economical value and speed to the diagnostic processes.

Prognostic value/risk stratification

A few studies have appeared in the literature showing the prognostic value of CTCA. It will take years before this kind of information becomes robust and reliable in long-term assessment. However, preliminary studies assessed the prognostic value of negative CTCA in patients with chest pain, and in patients with suspected or known CAD. The follow-up at 1–2 years always showed a good prognostic value of a negative CTCA for the absence of cardiovascular events (close to 100%).

Conclusions

Sixty-four-slice CTCA with heart rate control and DSCT represent non-invasive methods to diagnose CAD which is becoming widely available and useful for various clinical indications. DSCT has been shown to be independent of the BMI and heart rate. There is still some remaining influence of the calcium load. Further research and development should aim to reduce the impact of calcium on CTCA imaging. DSCT seems ready for clinical implementation. However, the guidelines are yet to be improved with the support of strong evidence from large trials.

Conflict of interest: none declared.

References