Describing the risk demonstrated on cardiac CT imaging

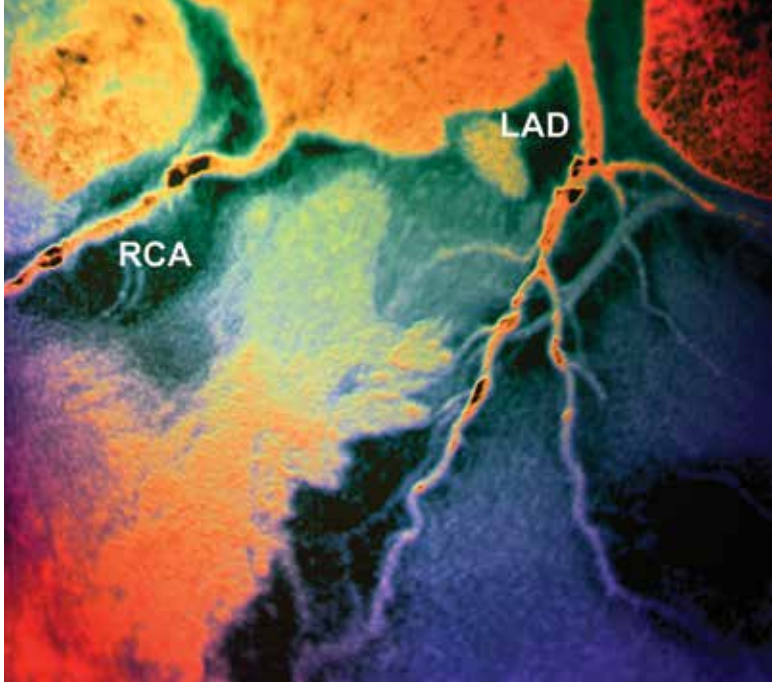
The C-PLUSS approach

WARRICK BISHOP MB BS, FRACP
MATTHEW BUDOFF MD

The C-PLUSS approach can be used to describe the risk-related features demonstrated on cardiac CT imaging. This approach incorporates features relating to coronary calcium together with plaque and vessel specific features, which have been shown to relate to cardiovascular risk. A descriptive risk comment, as part of the cardiac CT report, can then be generated, helping the referring clinician to understand their patient's potential future risks and so provide optimal care.

Key points

- **Coronary calcium scoring is used predominately for risk assessment.**
- **Computed coronary tomography angiography is used predominately for the assessment of stenosis.**
- **Together, cardiac CT provides a snap shot of the health of the arteries.**
- **Different features seen within the arteries have been shown to be associated with future risk.**
- **Describing these features in combination may help future patient management.**



© ZEPHYR/SPL. ABBREVIATIONS: LAD = LEFT ANTERIOR DESCENDING ARTERY; RCA = RIGHT CORONARY ARTERY

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Dr Bishop is a Cardiologist at Calvary Lenah Valley Hospital, Hobart, Tas. He has a strong interest in cardiac CT imaging, lipids and prevention. Professor Budoff is a Professor of Medicine at Los Angeles Biomedical Research Institute, California, USA.

Risk-related features demonstrated on cardiac CT imaging are not reported in a structured way. In 1990 Agatston and colleagues developed the coronary calcium score (CCS),[1] and extensive work since has shown it to be a reproducible discriminator of cardiovascular risk that can be incorporated with standard Framingham-type risk calculation.[2,3] Findings on computed coronary tomography angiography (CCTA) that may impact risk, such as stenosis, noncalcific plaque and remodelling, have been linked with increased rates of a major adverse coronary event (MACE).[4-6] These observations open the possibility of incorporating these features into a risk comment, which combines both the CCS and CCTA findings, as part of the cardiac CT report. Factors that have a bearing on cardiovascular risk include:

- Calcium score
- calcium score Percentile
- Low attenuation plaque (LAP)
- Unfavourable remodelling
- Stenosis
- Site of plaque.

With observational risk data to support each of the above, these features can be incorporated and applied in the 'C-PLUSS' approach.

The C-PLUSS approach

Calcium scoring

A zero CCS in an asymptomatic individual is a powerful negative predictor of a MACE, and CCS alone has been shown reproducibly to be a discriminator of rates of a MACE in longitudinal studies.[1,2,7-10] CCS has also been shown to be the most reliable of the novel cardiovascular risk markers and, importantly, to improve risk stratification in the intermediate-risk patient group.[8,11] Increasing CCS is linked with increasing event rates and compared with standard Framingham-type risk models, CCS adds significant improvement and accuracy in risk assessment, even in people with prediabetes and diabetes.[3,8,9,11,12]

Percentile calcium score

For age and sex, the percentile calcium score has been documented to be linked to the likelihood of a MACE with the higher the percentile,

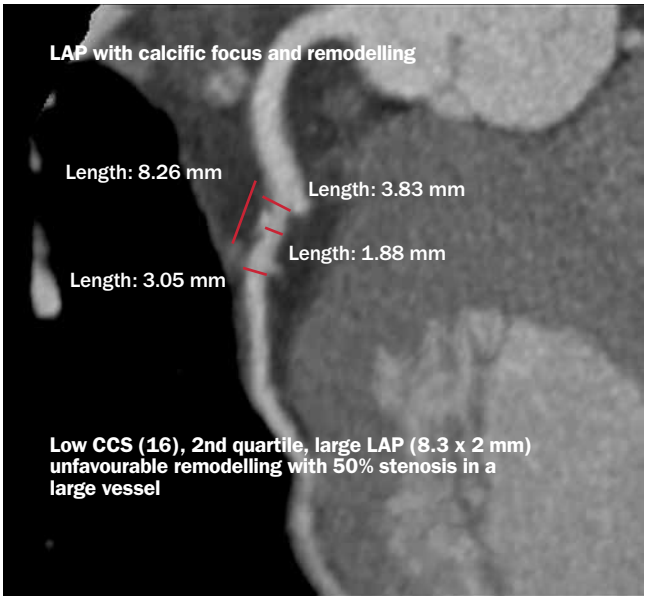

Figure. Proximal left anterior descending (LAD) lesion with high-risk features greater than the coronary calcium score (CCS).
The following is an example of C-PLUSS risk comment of the lesion in the Figure above. LAD artery shows proximal calcific and noncalcific plaque, not flow limiting. The CCS of 16 and CCS percentile for age (2nd quartile) have been observed to be low-risk features, the presence of significant low attenuation plaque (LAP) burden with unfavourable remodelling has been observed to be associated with event rates of up to 20% in two years. These are very high-risk features. The presence of a luminal narrowing of 50% or greater has been observed to be associated with event rates of up to 5% per annum. This is a very high-risk feature. The location of proximal LAD plaque defines a large territory potentially affected by an event. The features of this cardiac CT study have been observed to be a high to very high cardiovascular risk (>>20% risk in 10 years), with a large territory potentially affected. This information should be combined with an evaluation of the patient's other cardiovascular risks for a comprehensive risk profile to help in guiding further management.

the higher the risk.[13] The percentile calcium score is representative of a propensity for atheroma accumulation in an individual compared with an age- and sex-matched distribution, perhaps pointing to an increased lifetime risk. Wong and colleagues demonstrated an increased relative risk of approximately 3.5 for patients in the 3rd quartile and approximately 5.5 for patients in the 4th quartile compared with those in the first quartile of calcium scores.[10]

Low attenuation plaque and noncalcific plaque

LAP with a greater lipid core carries a higher risk of a coronary event than plaque that does not.[14-16] LAP assessment by CCTA has been validated by intravascular ultrasound.[17] Hoffman and colleagues documented that features of increasing LAP volume are linked to an increased rate of coronary events.[4-6,18] It has been observed that the presence of atherosclerotic lesions with a LAP volume of 20 mm^3 or more (approximating LAP >8 mm x 2 mm) together with positive remodelling is a very high-risk feature.[5] Conversely, the relative stability of calcific plaque without noncalcific plaque has also been suggested as a low-risk feature.[5] This suggests a spectrum of increasing risk as LAP volume and proportion within a particular plaque increases.[19] Furthermore, the presence of spotty calcification in LAP is linked to increased risk of a MACE and should be reported.[20,21] In the same way, reporting of the 'napkin-ring' sign, representing thin-cap fibroatheroma associated with a LAP burden, warrants description as a high-risk feature.[22,23]

Unfavourable remodelling

Positive, expansive or glagovian remodelling is the process in which the vessel changes shape (enlarges) to accommodate build up of atheroma within the wall, initially without encroachment on the lumen. This was first described by Glagov who suspected its unfavourable significance from autopsy, and subsequently this has been confirmed to be linked to an increased risk of a MACE.[24,25] Work carried out by Hoffman and colleagues showed the development of positive remodelling being linked to an increased rate of coronary events.[4-6] This has been quantified such that the presence of atherosclerotic lesions with remodelling of greater than 10% (remodelled artery diameter 10% increased) can be associated with a 3.5% event rate in two years.[5]

Although the accepted term is 'positive remodelling', 'unfavourable remodelling' is a deliberate and practical nomenclature to avoid possible ambiguity that could arise with the term 'positive'. 'Unfavourable' is a descriptor to assist the clinician who may not be familiar with cardiac CT terminology and the increased risk 'positive remodelling' can carry (see Figure).

Stenosis

In the coronary arteries, the degree of stenosis has been linked to rates of a coronary event, with the more severe the stenosis, the higher the event rate.[26] CCTA has supported this finding in the Coronary CT Angiography Evaluation For Clinical Outcomes: an International Multicenter (CONFIRM) registry and recent data have suggested luminal narrowing of 50% or more is linked to event rates of over 5% per annum.[6,27,28]

Site of plaque (location)

The site of plaque is described as part of the anatomical assessment of a CCTA; however, it also has significance in regard to prognostication. An event related to plaque rupture in a proximal large vessel supplying a significant territory of myocardium is an important distinction from a similar quality plaque in a distal location supplying a small territory because infarct size and postinfarction left ventricular volume are linked to outcome.[29-31] There is prognostic significance in recognising potential myocardial territory at risk from a specific plaque. Knowing proximal large vessel plaque compared with distally located plaque in a small vessel may give the treating physician more information in choosing the most appropriate therapy for example in a patient having difficulty achieving lipid targets.

What do the results of the C-PLUSS model tell you?

In the C-PLUSS approach, the calcium score is used as the basis of risk assessment. Each subsequent factor is then assessed as either having no significant effect on the CCS risk assessment or having an upregulating effect on the CCS risk assessment. A descriptive risk comment can be generated (see Table), thus providing a structure to interpreting the risk-related features. The reader or reporter of the scan can then incorporate the available data to best fit the findings, therefore providing a conclusion that is complimentary to standard risk calculation with low, intermediate, high and very high risk features (representing <10%, 10–20%, >20% and >>20% 10-year risk of a MACE, respectively). This information can then be used as an adjunct to standard risk assessment. It should not be considered as a replacement for existing risk modelling based on Framingham-type calculators.

An example of how the C-PLUSS model aids in dealing with patient risk based on the CCS and how this may require adjustment based on lesion-specific findings is shown in the Figure. Combining the C-PLUSS conclusion with an evaluation of standard risk factors for the patient is mandatory because the cardiac CT represents one moment in time and other risk factors the future. The clinician therefore needs to comprehensively bring all this information together to achieve optimal patient care.

Table. Summary of C-PLUSS features and associated risk of a major adverse coronary event

C-PLUSS feature	Magnitude	Risk level
CCS	<50	Low
	50 to 400	Intermediate
	>400	High
CCS percentile	>3rd quartile	Upregulates CCS risk by up to threefold, and increases lifetime risk
	>4th quartile	Upregulates CCS risk by up to fourfold, and increases lifetime risk
LAP volume (<30 Hounsfield units) spectrum	Calcium >> LAP (ratio)	May not further increase risk significantly
	Calcium = LAP (ratio)	May further increase risk
	LAP >> calcium (ratio)	Likely to further increase risk
Significant LAP with or without napkin-ring sign	>2 x 8 mm lesion Volume approx >20 mm^3	High risk (up to 5% event rate in two years or >25% in 10 years)
Unfavourable remodelling	>10% increase in diameter	High risk (up to 5% event rate in two years or >25% in 10 years)
Significant LAP with or without napkin-ring sign and unfavourable remodelling	Soft plaque >2 x 8 mm lesion Plus >10% increase in diameter	Very high risk (up to 20% event rate in two years or approaching 100% in 10 years)
Stenosis	>50%	Very high risk (event rates of 5% or more per annum or >50% in 10 years)
Site	Major/minor artery, proximal or distal plaque	Comment on amount of territory at risk

Abbreviations: CCS = coronary calcium score; LAP = low attenuation plaque.

Objective of the C-PLUSS approach

The objective of the C-PLUSS approach is to provide a structure for describing cardiac CT features that have been shown to relate to risk. It is intended to use the CCS as a basis for risk assessment then allow description of the 'PLUSS' findings by the reader or reporter of the study who can then provide an experienced, educated and informed comment on the risk features demonstrated by the cardiac CT. There will always be a spectrum of risk findings that will need interpretation because exact details will not exist. It is then the role of the treating physician to assess all risk factors of the patient to best plan management. Some patients may undergo CCS scoring without CCTA, and some may undergo CCTA without CCS. This is a decision of the local service or referrer. Using both however will provide the most information to aid in risk evaluation.

Using the C-PLUSS approach in clinical practice

Despite the absence of outcome data, the C-PLUSS approach will be driven by clinicians wanting to incorporate as much information as possible to achieve the best assessment and care for their patients. A risk comment would help the General Practitioner who refers patients for nonrebatable risk assessment, and who receives reports from patients who have had a rebatable scan. Clinicians could ask their local cardiac CT service to provide a C-PLUSS comment. Using CCS as the first step of risk assessment, the C-PLUSS approach aims to facilitate a reproducible way to describe the risk-related features demonstrated on cardiac CT imaging. **CT**

References

A list of references is included in the website version (www.medicinetoday.com.au) of this article.

COMPETING INTERESTS: Dr Bishop has a financial and professional association with the iMed HeartView Cardiac CT service. Professor Budoff is a Research Consultant for General Electric Company.

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