

Non-Invasive Imaging of Atherosclerotic Plaque
Prior to Percutaneous Interventional Procedures

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ABSTRACT

Atherosclerosis is a disease which has impacted our health like no other in the last half century. The detection of this disease range from biomarkers, stress-testing to invasive imaging by way of angiography or other intravascular methods. In recent years, technological developments in multi-detector computed tomography (MDCT) and magnetic resonance imaging (MRI) has allowed us to visualize atherosclerotic plaque non-invasively. This has great appeal as they carry very little risk in comparison to invasive angiography and provide information of plaque composition in addition to stenosis severity.

The identification of plaques which are high-risk or ‘vulnerable’ to subsequent complications such as myocardial infarction or stroke would be highly valuable in our approach to incremental risk assessment and perhaps future treatment. Certain procedures in interventional cardiology such as saphenous vein graft (SVG) intervention and carotid stenting carry increased risk of embolic complications compared to coronary stenting. Non-invasive imaging could potentially identify certain plaque features which may be associated with an increased risk of embolization before embarking on such procedures. This thesis examines the utility of MDCT and MRI in atherosclerotic plaque imaging prior to SVG interventions and carotid stenting.

Our initial chapter investigates the angiographic parameters associated with embolization during SVG intervention. We correlate the amount of debris captured by distal protection devices during intervention with angiographic markers and subsequently, with impaired blood flow by way of Thrombolysis In Myocardial Infarction (TIMI) frame count.

Our next step involved the accuracy and reproducibility of MDCT and MRI in plaque quantification in comparison to our reference standard of intravascular ultrasound. We measured the luminal, vessel wall and plaque areas, and then calculated the resultant plaque volume of SVG lesions for all three modalities.

Having gained an understanding of the accuracy of MDCT and MRI, we investigated the relationships of MDCT plaque volume and density with embolic debris captured by distal protection device during SVG intervention. We then undertook histological assessment of the debris utilizing semi-automated image analysis software. We quantified the various plaque components including red blood cells, thrombus, lipid, cholesterol clefts and fibrous tissue. Finally, we explored the relationship between the histological findings with plaque volume, density and amount of embolization which occurred.

Our last original chapter investigates the utility of multi-weighted MRI to assess carotid plaque prior to stenting. We measured plaque volumes and characterized plaques as calcific, fibrotic or lipidic according to MRI findings. This information is then correlated to the amount of embolic debris captured by the distal protection device used during stenting.

In comparison to invasive imaging modalities like intravascular ultrasound, research into plaque characterization by MDCT and MRI is just beginning. Almost all of the current studies have been on coronary artery plaques. This thesis breaks new ground by studying SVG plaques and demonstrating links between plaque volume, composition and embolization during intervention. It builds on our knowledge of these non-invasive modalities and help us define their future roles.

DECLARATION

I declare that this thesis contains no material that has been accepted for the award of any other degree or diploma in any university or other tertiary institution to Gary Y. H. Liew. To the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference has been made in the text.

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THESIS RELATED PUBLICATIONS

GYH Liew, M Feneley, SG Worthley. Noninvasive Coronary Artery Imaging: Current Clinical Applications. CSANZ Practice Guidelines. Heart, Lung and Circulation 2011;20:425–437

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Manuscripts In Submission

Liew GYH, Hammett CJ, Thomas AC, Dundon BK, Worthley MI, Zaman AG, Worthley SG. Saphenous vein graft plaque characterization by multi-detector computed tomography with histopathological correlation of embolic debris during intervention.

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THESIS RELATED PUBLISHED ABSTRACTS

1. **Liew GYH**, Hammett CJ, Dundon BK, Teo KSL, Worthley MI, Nicholls SJ, Zaman AG, Worthley SG. Plaque Volume by Multi-detector Computed Tomography (MDCT) Best Predicts Outcomes After Saphenous Vein Graft Intervention. *Circulation Journal*. 2007; 71(S1): 160-161. Oral Presentation.
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- intravascular ultrasound. *Journal of Cardiovascular Magnetic Resonance* 2008, 10(Suppl 1):A395
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THESIS RELATED SCHOLARSHIP AND AWARDS

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ABBREVIATIONS

ACS	Acute coronary syndrome
AHA	American Heart Association
AMI	Acute myocardial infarction
CABG	Coronary artery bypass graft
CAD	Coronary artery disease
CAS	Carotid artery stenting
CDUS	Carotid Doppler ultrasound
CEA	Carotid endarterectomy
CSA	Cross sectional area
CTA	Computed tomography angiography
DPD	Distal protection device
ECG	Electrocardiograph
EEM	External elastic membrane
EPD	Embolic protection device
FDG	Fluorodeoxyglucose
FOV	Field of view
HU	Hounsfield Unit
IVUS	Intravascular ultrasound
LAD	Left anterior descending artery
LCx	Left circumflex artery
MACE	Major adverse cardiac events
MBG	Myocardial blush grade

MDCT	Multi-detector computed tomography
MRI	Magnetic resonance imaging
PCI	Percutaneous coronary intervention
PDW	Proton density weighted
QCA	Quantitative coronary analysis
RCA	Right coronary artery
ROI	Region of interest
SVG	Saphenous vein graft
T	Tesla
TCFA	Thin cap fibroatheroma
TE	Echo time
TFC	TIMI frame count
TIMI	Thrombolysis In Myocardial Infarction
TMPG	TIMI perfusion grade
TR	Repetition time
T1W	T1 weighted
T2W	T2 weighted