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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Gary Y. H. Liew

May 2012

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University of Adelaide
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THESIS RELATED PUBLICATIONS


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6. **Liew GYH**, Hammett CJ, Dundon BK, Teo KSL, Worthley MI, Zaman AG, Worthley SG. Saphenous vein graft plaque quantification utilizing magnetic resonance imaging and multidetector computed tomography: A comparison with


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THESIS RELATED SCHOLARSHIP AND AWARDS

Post-graduate Biomedical Scholarship, National Health and Medical Research Council of Australia. 2008-2010

Travel Grant from Japanese Circulation Society to present at 71st Scientific Meeting – Japanese Circulation Society, Kobe, Japan. 2007

Travel Grant from National Heart Foundation of Australia to present at 57th Annual Scientific Sessions of the American College of Cardiology, Chicago, USA. 2008

Cardiac Society of Australia & New Zealand Travelling Fellowship to present at 58th Annual Scientific Sessions of the American College of Cardiology, Orlando, USA. 2009

Cardiovascular Lipid Travel Grant to present at 4th Annual Scientific Meeting of Society of Cardiovascular Computed Tomography, Orlando USA. 2010

Best Poster - Finalist, 55th ASM of Cardiac Society of Australia & New Zealand, Christchurch, New Zealand. 2007


Highly Commended Poster, University of Adelaide Research Expo, Adelaide, SA, Australia. 2008

Liew GYH, Hammett CJ, Dundon BK, Teo KSL, Worthley MI, Zaman AG, Worthley SG. Saphenous vein graft plaque quantification utilizing magnetic resonance imaging and multidetector computed tomography: A comparison with intravascular ultrasound
# Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ACS</td>
<td>Acute coronary syndrome</td>
</tr>
<tr>
<td>AHA</td>
<td>American Heart Association</td>
</tr>
<tr>
<td>AMI</td>
<td>Acute myocardial infarction</td>
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<tr>
<td>CABG</td>
<td>Coronary artery bypass graft</td>
</tr>
<tr>
<td>CAD</td>
<td>Coronary artery disease</td>
</tr>
<tr>
<td>CAS</td>
<td>Carotid artery stenting</td>
</tr>
<tr>
<td>CDUS</td>
<td>Carotid Doppler ultrasound</td>
</tr>
<tr>
<td>CEA</td>
<td>Carotid endarterectomy</td>
</tr>
<tr>
<td>CSA</td>
<td>Cross sectional area</td>
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<tr>
<td>CTA</td>
<td>Computed tomography angiography</td>
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<tr>
<td>DPD</td>
<td>Distal protection device</td>
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<tr>
<td>ECG</td>
<td>Electrocardiograph</td>
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<tr>
<td>EEM</td>
<td>External elastic membrane</td>
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<tr>
<td>EPD</td>
<td>Embolic protection device</td>
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<tr>
<td>FDG</td>
<td>Fluorodeoxyglucose</td>
</tr>
<tr>
<td>FOV</td>
<td>Field of view</td>
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<tr>
<td>HU</td>
<td>Hounsfield Unit</td>
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<tr>
<td>IVUS</td>
<td>Intravascular ultrasound</td>
</tr>
<tr>
<td>LAD</td>
<td>Left anterior descending artery</td>
</tr>
<tr>
<td>LCx</td>
<td>Left circumflex artery</td>
</tr>
<tr>
<td>MACE</td>
<td>Major adverse cardiac events</td>
</tr>
<tr>
<td>MBG</td>
<td>Myocardial blush grade</td>
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<td>Abbreviation</td>
<td>Full Form</td>
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<td>--------------</td>
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</tr>
<tr>
<td>MDCT</td>
<td>Multi-detector computed tomography</td>
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<td>MRI</td>
<td>Magnetic resonance imaging</td>
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<tr>
<td>PCI</td>
<td>Percutaneous coronary intervention</td>
</tr>
<tr>
<td>PDW</td>
<td>Proton density weighted</td>
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<tr>
<td>QCA</td>
<td>Quantitative coronary analysis</td>
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<tr>
<td>RCA</td>
<td>Right coronary artery</td>
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<tr>
<td>ROI</td>
<td>Region of interest</td>
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<tr>
<td>SVG</td>
<td>Saphenous vein graft</td>
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<td>T</td>
<td>Tesla</td>
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<tr>
<td>TCFA</td>
<td>Thin cap fibroatheroma</td>
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<tr>
<td>TE</td>
<td>Echo time</td>
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<tr>
<td>TFC</td>
<td>TIMI frame count</td>
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<tr>
<td>TIMI</td>
<td>Thrombolysis In Myocardial Infarction</td>
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<tr>
<td>TMPG</td>
<td>TIMI perfusion grade</td>
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<td>TR</td>
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