MONTRÉAL ELECTIVE REPORT

Edward Stephenson

Montréal Elective Report

What are the common indications for cardiovascular magnetic resonance (CMR) scans in Canada? Do they differ from those in the UK?

From the most recent review of cardiovascular magnetic resonance (CMR) indications (from the Libin Cardiovascular Institute of Alberta in Calgary), diseases of heart muscle – whether of the muscle itself (cardiomyopathy) or inflammatory (myocarditis) – were the commonest indications for CMR, accounting for 41% of the scans.[1] Of these 41%, the majority (56%) had scans for suspected or confirmed cardiomyopathy. Another important indication in Canada was for patients with coronary artery disease (CAD, 17%), CMR can be used in this context to define the area of infarction as well as identifying myocardium that could be salvaged by future coronary intervention.

Comparing the indications from this Canadian study of more than 6,000 patients to the European CMR registry (about 27,000 patients, including some from the UK (London and Leeds)) it is clear that cardiomyopathies and CAD are the main reason for CMR in both European and Canadian CMR centres.[2] However, the use of CMR for CAD and myocardial viability is increased in Europe compared to Canada (49% vs. 17%). The European study also highlighted the different indications for CMR dependent on age (Figure 1, adapted from Bruder O *et al, 2013*[2]).

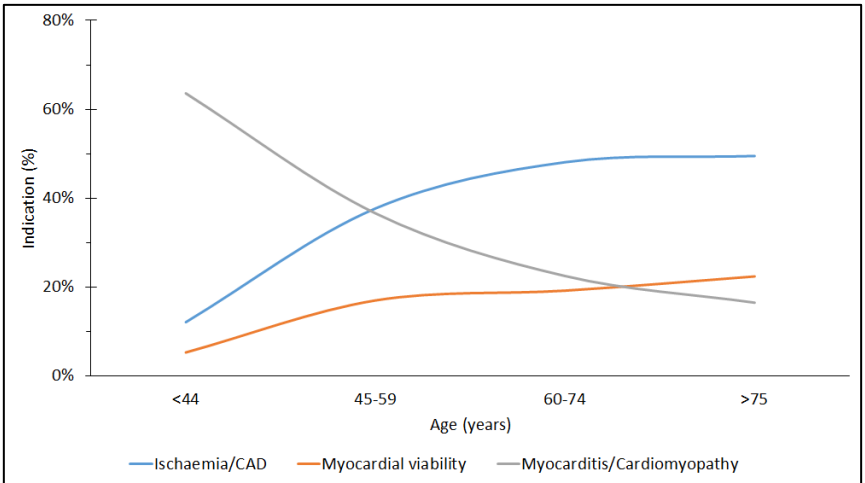

***Figure 1**; Data from European CMR registry demonstrating the different indications for CMR depending upon the age of the patients. This highlights the difference in age ranges for two common cardiac disease groups (ischaemia/coronary artery disease (CAD)) and cardiomyopathies. Until 60, there is a similar trajectory to the ischaemia/CAD and myocardial viability curves but after that age, there is a slight decrease in the myocardial viability scans.*

How are cardiac imaging services organised and delivered at the Montreal Heart Institute (MHI)? How does this differ from the UK?

In the UK, healthcare is provided by the National Health Service (NHS) which is a service that is free at the point of use for all UK citizens. The NHS is funded through taxation and patients must be referred by a doctor or present themselves to the emergency department with a cardiac complaint to access cardiac imaging. Many different healthcare professionals can refer patients to basic cardiac imaging such as an echocardiographic examination and these can be performed at almost all hospitals within the UK, regardless of size. Referral to advanced cardiovascular imaging, such as CMR or cardiac CT, is done through specialist referral by cardiologists or specialists in other fields who are caring for a patient with a disease that may also involve the heart. Advanced cardiovascular imaging is usually only accessed in large tertiary centres.

Since its beginnings, the Canadian healthcare system has been delivered privately and required private health insurance to be accessed. Following the Canada Health Act (adopted in 1984), a system of socialised health insurance plans were set up to allow for healthcare provision that is free at the point of care, similar to the NHS (Figure 2). The Montreal Heart Institute (MHI) is a cardiac-only hospital with 153 beds and departments for all cardiac imaging modalities. Similar to the UK, advanced cardiovascular imaging must be approved by a specialist. The MHI has two CMR scanners, one that has a magnetic field strength of 1.5 Tesla (T) – this is used only for clinical scans only. The second machine, with a 3T field strength, is owned by the CMR research group at the MHI. The MHI hospital can pay to use this research scanner for clinical scans.

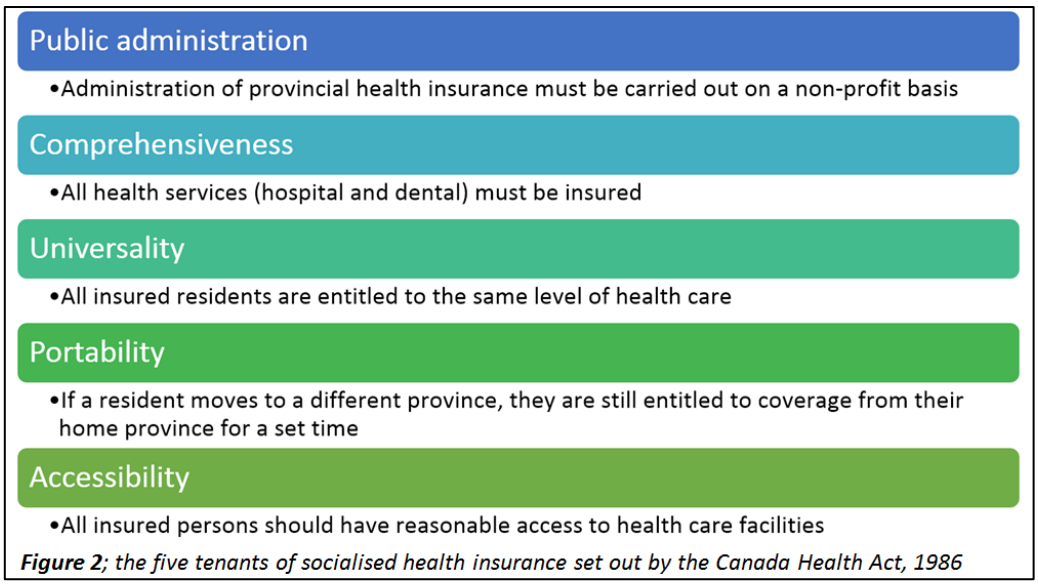

***Figure 2**; the five tenants of socialised health insurance set out by the Canada Health Act, 1986*

How is myocarditis most reliably diagnosed by CMR?

Due to the problems associated with endomyocardial biopsy (EMB), used to diagnose myocarditis, such as sampling error (leading to the diagnosis of myocarditis being missed in 37-42%), interpretation variability and side effects from this invasive procedure (complication rate of 1-9% - most commonly perforation, with or without cardiac tamponade, and right bundle branch block), research to use alternative investigations (such as CMR) to diagnose myocarditis became important.[3-12]

From the mid-1990s, several case reports demonstrated an increase in T2-weighted signal in patients with myocarditis suggesting tissue oedema.[13-15] More recently, the method for reporting oedema uses T2-weighted short inversion time (TI) inversion recovery (STIR) pulse sequence images. The TI is selected to null the signal intensity (SI) of fat and blood, muscle yields a medium SI and fluid the highest SI.[16]

In 1998, Friedrich *et al* demonstrated myocardial inflammation using T1-weighted CMR images with a gadolinium-based contrast.[17] Gadolinium is a contrast agent that moves into extracellular fluid space – increased in myocarditis where there is reduced integrity of the cell membrane – and in these 44 patients, there was, on average, a fourfold increase in SI of the inflamed myocardium compared to the pre-contrast myocardial tissue on T1-weighted images. This is the basis of late gadolinium enhancement (LGE) – visualising myocardial scar and fibrosis.

A third feature of myocarditis is hyperaemia and capillary leak; the resulting increase in blood volume can be demonstrated on CMR by early gadolinium enhancement (EGE) imaging. A ratio is used to detect an increase in the area of gadolinium distribution during the early washout – the early gadolinium enhancement ratio – indicating the presence of hyperaemia. However, one problem with this method of quantifying EGE is that in myocarditis there is often a co-existent myositis.[18] Remote myocardium which does not display enhancement can also be used to calculate the EGEr as well as absolute myocardial enhancement.

Consensus was reached to diagnose myocarditis by CMR with the Lake Louise criteria which require the demonstration of at least two of; oedema (from T2-STIR imaging), hyperaemia (early gadolinium enhancement (EGE) on T1-weighted contrast imaging) and myocardial scar (LGE) (Figure 3, see acknowledgements).[19] By using three different criteria, and excluding ischaemic distributions of LGE, the sensitivity and specificity of CMR for diagnosing myocarditis is 67% and 91% respectively.

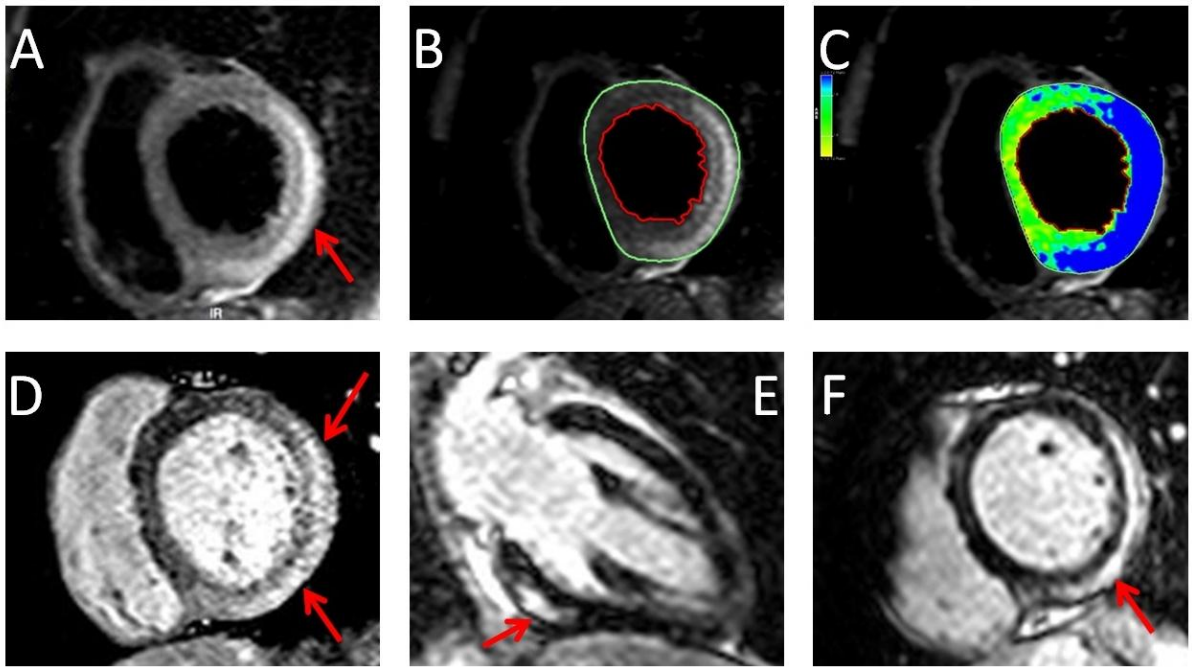

***Figure 3**; CMR images from a 24 year old female who presented with chest pain, demonstrated inferolateral ST elevation on ECG and was found to have a troponin T of approximately 2000 with normal coronary angiography. CMR images display features of myocarditis according to Lake Louise criteria. **Top row;** T2-weighted short axis image of basal left ventricle demonstrating oedema in the lateral and inferolateral segments **(A)**. The T2 signal intensity ratio is calculated at 2.2 compared to skeletal muscle **(B, C)** (blue colours represent increased signal intensity ratio in **(C)**). **Bottom row**; there is hyperaemia or capillary leak shown in the early gadolinium short axis image in the same area as the increased T2 signal **(D)**. Long axis 2 chamber **(E)** and short axis basal **(F)** T1 images demonstrate late gadolinium enhancement suggesting myocyte necrosis and fibrosis of the basal inferior and inferolateral segments. The localisation of ST elevation on the ECG correlated well with the CMR findings in this patient.*

Reflect on the differences in research organisations between the UK and Canada in respect of CMR

From my experience of research in Canada and the UK, it seems that both countries have a very strong ethos towards collaborative research. This increases the size and heterogeneity of study populations in CMR research which is advantageous due to the relatively low availability of CMR in both the UK and Canada.

For example, the UK biobank project, which has been running since 2005, has involved 500,000 adults aged 40 to 69 who have undergone genetic testing and are being followed-up through accessing their health records.[20] It is now hoped that 100,000 of these participants could have MRI imaging (brain, cardiac and abdominal) with a non-contrast CMR protocol to minimise side effects although the analysis will be advanced – including strain and strain rate.[21] In Canada, a similar large scale study involving CMR is the Canadian Alliance for Healthy Hearts and Minds which will include patients from British Columbia, Alberta, Ontario, Quebec and Atlantic Canada. A significant challenge for both of these projects with large study populations is incidental findings and disclosing them to the study population.

Word count

1,313

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