Evaluation of Cardiac Function in Chronic Kidney and Liver Disease

Charlotte E Buchanan[1,2], Claire Grant[2], Eleanor F Cox[1], Nick M Selby[2,3], Chris W McIntyre[2,4], Maarten W Taal[2], and Susan T Francis[1]
[1]*SPMIC, University of Nottingham, Nottingham, Nottinghamshire, United Kingdom,* [2]*Division of Medical Sciences and Graduate Entry Medicine, Royal Derby Hospital, Nottingham, United Kingdom,* [3]*Department of Renal Medicine, Royal Derby Hospital, Derby, United Kingdom,* [4]*Schulich School of Medicine and Dentistry, University of Western Ontario, London, Ontario, Canada*

TARGET AUDIENCE: MR researchers and clinicians interested in the assessment of cardiac function in kidney and liver disease.

PURPOSE: Patients with chronic kidney disease (CKD) and chronic liver disease (CLD) have significantly higher rates of cardiovascular mortality compared to the normal population [1,2]. The link between end stage CKD and heart disease is well known, but it has not been established at what stage CKD alters cardiovascular function. Cirrhosis of the liver can also affect the micro-circulation of the heart, leading to a condition called cirrhotic cardiomyopathy, with up to 50% of patients undergoing a liver transplant being found to have damage to their hearts. This study evaluates cardiac function in patients with chronic liver and kidney disease in response to a handgrip challenge [3], which may be more effective at discriminating normal from abnormal cardiovascular function.

Aim: To observe the changes in cardiac response in patients with chronic liver disease or chronic kidney disease in response to a handgrip exercise challenge and compare these results with age-matched controls.

METHODS:

30 subjects were scanned: 10 stage 3 CKD patients, 10 CLD patients (Child's A cirrhosis) and 10 healthy age-matched controls (HC). No subjects had known cardiovascular disease. Scanning was performed on a 3T Phillips Achieva scanner (MultiTransmit, 16-channel SENSE torso receive coil). The aorta was identified using localiser images in 3 orthogonal planes. Phase contrast (PC) data was acquired using a single slice TFE sequence with the imaging slice placed perpendicular to the aorta. 30 phases across the cardiac cycle were acquired whilst free breathing in approximately 2 minutes (TE/TR = 3.7/2.3 ms, FA = 15^o, NEX = 3, reconstruction resolution = 0.97 x 0.97 x 10 mm^3, TFE factor = 5, V_{ENC} = 300 cm/s). The heart rate was recorded throughout the handgrip challenge.

Handgrip Challenge: A handgrip exercise paradigm (Figure 1) was performed using a Grip Force Bimanual Fibre Optic Response Pad (Current Designs, Philadelphia). Subjects were asked to squeeze against the resistance in the hand grips until they reached a target maximum force level, with feed-back to subjects by viewing a screen, and then to hold this force level for 8 minutes. The paradigm comprised two rest and two handgrip challenge periods.

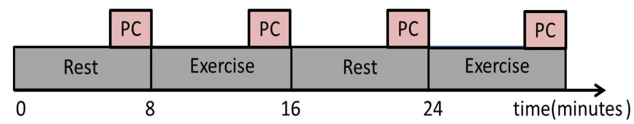

Figure 1: Handgrip exercise paradigm

Data Analysis: Q-flow software (Philips Medical Systems) was used to draw a region of interest over the aorta to calculate the mean velocity (cm/s) and vessel area (mm^2) across the cardiac cycle, the stroke volume (ml) and the cardiac output (L/min). In addition, cardiac index (cardiac output/body surface area) and aortic strain (percentage change in aorta area across the cardiac cycle) were calculated. The heart rate over the exercise paradigm was calculated from the MR scanner physiological logs. Comparisons between groups were made using student t-tests.

RESULTS:

There was no significant difference in age, gender or BMI between the groups (Group average: age = 54 ± 9 yrs, BMI = 25 ± 3 kg/m^2). The cardiac response to exercise is summarised in Figure 2 (mean ± SD across two repeats of rest and handgrip challenge). ***Aorta Velocity (AV)**:* Significant increase in AV on exercise in all groups, which was higher in CLD compared to CKD. ***Aorta area (AA)***: CKD and CLD had a trend for a larger AA compared to HC at rest. For CKD and HC, AA significantly increased on exercise, but not for CLD. ***Cardiac output (CO)***: No significant difference in CO between groups at rest. CO significantly increased on exercise, with highest significance for HC then CKD then CLD. CO in CLD did not recover to baseline in the second rest period. There were no significant difference in cardiac index between any group. ***Aortic strain (AS)***: CKD and CLD had a lower AS compared to HC at rest. AS significantly reduced on exercise for CKD and HC, but not for CLD, with significant differences in AS between all groups on exercise. ***Stroke volume (SV)***: No significant difference at rest between groups. SV significantly increased on exercise in CLD, but not CKD or HC. ***Heart Rate (HR)***: CKD and CLD patients had significantly higher HR at rest compared to HC group. All groups showed a significant increase in HR between rest and exercise, with CKD returning to a significantly lower HR during the second rest period compared to the first.

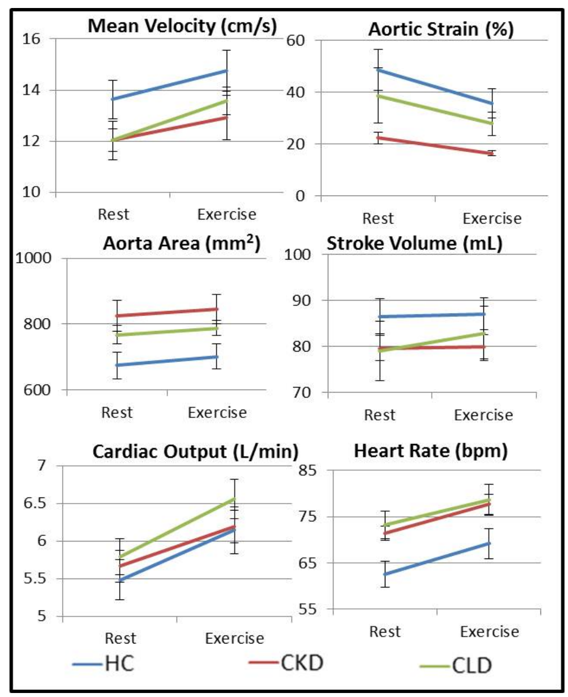

Figure 2: Response to handgrip exercise challenge

DISCUSSION: This demonstrates the use of a handgrip exercise challenge to measure cardiac function in CKD and CLD patients. CLD patients have a significant increase in stroke volume on exercise, which is not seen in CKD or HC. On exercise, aortic strain decreased. CKD patients showed a significant reduction in aortic strain, with no significant reduction in CLD patients. These observations indicate that the mechanisms, whereby cardiovascular function is adversely affected, differ between CKD and CLD.

References [1] Alani H *et al*, World J Nephrol, 3(4) 156-68, 2014. [2] Fouad YM, World J Hepatol 6(1) 41-45, 2014. [3] Knobelsdorff-Brenkenhoff *et al.*, JMRI, 37, 1342-1350, 2013..