Dynamic CT myocardial perfusion measurements of resting and hyperaemic blood flow in low-risk subjects with 128-slice dual-source CT

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Aims
The aim of the study was to measure rest and stress myocardial blood flow (MBF) values prospectively in a low-risk population with 128-slice dual-source computed tomography (CT) and to compare MBF/coronary flow reserve (CFR) values to that of a second population with a documented coronary artery disease (CAD).

Methods and results
This study evaluates resting and hyperaemic MBF in 35 low-risk individuals identified by the modified Framingham Risk score and a calcium score of $<100$. The patients were scanned using 80 kV and quantitative blood flow values were generated using complete time–attenuation curves. Global resting and hyperaemic MBF was $74.08 \pm 16.30$ and $135.24 \pm 28.89$ mL/100 g/min, respectively, with CFR of $1.86 \pm 0.38$. Resting MBF was $76.98 \pm 25.68$, $66.98 \pm 19.66$, $81.34 \pm 21.40$, and $63.35 \pm 16.35$ mL/100 g/min in anterior, septal, lateral, and inferior walls, respectively, and corresponding hyperaemic MBF was $133.25 \pm 29.80$, $123.47 \pm 31.03$, $148.60 \pm 32.69$, and $124.21 \pm 31.54$ mL/100 g/min, respectively. In the population with CAD, global resting and hyperaemic MBF were $82.29 \pm 16.87$ and $81.98 \pm 18.54$ mL/100 g/min and $107.95 \pm 25.25$ and $106.93 \pm 32.91$ mL/100 g/min in the group with ischaemia only and infarction only, respectively, with corresponding CFR of $1.33 \pm 0.27$ and $1.33 \pm 0.46$, respectively (statistically different from the low-risk population). Radiation dose for CT myocardial perfusion imaging (CTMPI) was $6.72 \pm 2.71$ and $6.19 \pm 2.19$ mSv for stress and rest scans, respectively. This was 30% lower than a radiation dose in the scanning historical cohort at 100 kV. There was no significant difference in the signal-to-noise ratio and contrast-to-noise ratio between low-risk cohort and historical cohort scanned at 80 and 100 kV, respectively.

Conclusions
Baseline, hyperaemic MBF and CFR values in a low-risk cohort can be evaluated with dynamic myocardial perfusion imaging using 80 kV.

Keywords
Dynamic CT myocardial perfusion • Normal myocardial perfusion values • Low-risk subjects

Introduction
There is a growing body of literature on the utility of computed tomography (CT) to measure myocardial perfusion. Since the initial reports with electron beam CT, there have been multiple publications since 2009 on both dynamic and static perfused blood volume studies. These studies have reported the ability to detect myocardial ischaemia and infarction, and compared CT perfusion data with that obtained by other imaging modalities.

It is possible to image myocardial perfusion by three methods: qualitative, semi-quantitative, and quantitative techniques. The quantitative technique, afforded by dynamic perfusion studies, provides absolute quantitation of myocardial perfusion, and may provide more objective and reproducible assessment of coronary artery disease (CAD) beyond the detection of epicardial disease compared with the other two, in terms of severity of ischaemia, prognostication, viability assessment, and detection of microvascular disease. This is on the basis of experience with qualitative and quantitative studies of CAD in other imaging modalities such as nuclear, PET, and MRI, and emerging reports in CT perfusion imaging. In dynamic perfusion imaging, changes in contrast enhancement of the myocardium and its input artery over time are monitored, allowing for detailed modelling of the tissue contrast distribution with time. This allows measurements of myocardial perfusion...
blood flow (MBF) at rest and stress. Knowledge of normal values helps in the recognition of disease states. While there have been publications regarding MBF values with PET, there is a paucity of literature on MBF values in low-risk individuals as measured by dynamic CT.

The purpose of this study was two-fold: (i) to describe rest and stress MBF values in a low-risk population as measured prospectively with the 128-slice dual-source CT, and (ii) to compare the resting and stress MBF and coronary flow reserve (CFR) of the low-risk population with that of a second population with documented clinical CAD (retrospective comparison).

Methods

Patient population and preparation

The study and its protocols were approved by the Mount Alvernia Hospital Ethics Board. All study subjects gave written informed consent to participate. To overcome the difficulties in identifying a group of normal subjects, the Framingham risk classification system was used to define a low-risk population for coronary heart disease (CHD). Individuals were eligible for the study if they were not known to have a CAD, and had a 10-year CHD risk of <10% on the basis of the modified Framingham risk score for Asians. Subjects were screened for contraindications to cardiac CT and vasodilator administration (allergy to iodinated contrast, abnormal renal function (serum creatinine >200 mmol/L), history of active asthma/severe obstructive lung disease, Mobitz Type II or third-degree atrioventricular block without a functioning pacemaker, systolic blood pressure <90 mmHg, and intake of xanthine-containing compounds within the previous 12 h of administration of dipyridamole). Subjects were instructed to avoid caffeine use for at least 12 h prior to stress-testing. An 18-gauge venula was inserted into the right antecubital vein for dipyridamole administration.

Rest perfusion scan

This was obtained after a coronary CT angiogram (CTA) of the heart. Patients were instructed on the perfusion imaging procedure and breath-hold commands. Following a topogram of the chest, a low-dose ECG-gated scan of the heart was acquired. The perfusion scan ranged were adjusted over the left ventricular (LV) myocardium. ECG, heart rate (HR), and blood pressure were monitored during the imaging procedure. Contrast (Omnipaque 350) was loaded into a power injector with heatable syringe holders (Medrad Stellant). A test bolus scan at the mid-left ventricular level was acquired with an injection of 18 mL of contrast followed by 50 mL of saline (flow rate of 5 mL/s). Rest perfusion images of the LV were next acquired with injection of 50 mL of contrast followed by 50 cc of saline (flow rate of 5 mL/s). The scan started 3 s before arrival of the contrast in the left ventricle.

CT perfusion imaging

All acquisitions were performed on a dual-source CT scanner (Definition FLASH, Siemens Healthcare). Dynamic CT perfusion imaging requires acquisition of time-attenuation curve (TACs) for each voxel of the target tissue. This represents the change of contrast concentration in tissue with time following the contrast injection. An ECG-triggered axial shuttle mode was used. Repeated acquisition of a volume of 73 mm length at a HR-dependent sampling rate of one sample every 2–4 s, yielded complete TACs of the aorta and LV myocardium in the end-systolic phase (gantry rotation time 280 ms, slice collimation 128 × 0.6 mm, 80 kV tube voltage for both X-ray tubes, tube current 370 mAs/rot). It was prospectively decided that patients with body mass index (BMI) >30 kg/m² would be scanned with 100 kV, and all others were scanned with 80 kV.

Dipyridamole-stress perfusion protocol

This was performed after the rest scan. All patients underwent continuous ECG monitoring. Dipyridamole was infused intravenously at a dose of 0.56 mg/kg/min over a 4-min period. Stress perfusion imaging commenced 3 min after completion of dipyridamole infusion. The scan was timed to take place during the maximum attenuation based on the TAC in the aorta. Image acquisition for the stress scan was identical to that described for the rest scan. Once stress image acquisition was completed, intravenous aminophylline (1.5 mg/kg body weight) was administered over a 5-min period to reverse the effects of dipyridamole.

Image processing and analysis

Image reconstruction

Images of the myocardium were reconstructed with a slice thickness of 3 mm, increment of 2 mm, and a smooth reconstruction algorithm (B22 kernel). A dedicated reconstruction algorithm for myocardial perfusion yielded images with a high temporal resolution, while maintaining CT value stability.

Computation of MBF

MBF was computed from the 4D volume data sets using commercially available software (Volume Perfusion CT Body, Siemens). Post-processing was done on an offline workstation (Syngo 3D, MMW, Siemens). A motion-correction algorithm was applied. Parametric de-convolution was used to fit a TAC model to the time series of attenuation values for each voxel of the myocardium and the descending aorta. This was used as the arterial input function, yielding a 3D CT data set of the myocardium with intensity values representing MBF (mL of blood/100 g of tissue/s; Figure 1A and B).

Data evaluation

An automatic algorithm compensated for motion between rest and stress CT-MBF data sets. The myocardium was evaluated at the apex, mid-ventricular, and basal ventricular levels and read in standard long- and short-axis reformations. Two readers reviewed the rest and stress scans for the presence or absence of a perfusion defect, and recorded values of MBF in both rest and stress data sets. MBF was determined in each of the three vascular territories by manually placing a region of interest (ROI) in a representative myocardial region, excluding a 1 mm subendocardial zone directly adjacent to the contrast-filled left ventricle, and a 1 mm subepicardial zone, to avoid any influence of measurements by beam hardening artefacts or partial volume effects. The LV myocardium was defined as one ROI by manually applying hand-traced endo- and epicardial contours. A mid-myocardial line was used to further separate the LV myocardial ROI into an endo- and epimyocardial layer. MBF was computed for the whole left ventricle (global left ventricular flow) and also for each of the three vascular territories of the heart [left anterior descending coronary artery (LAD) (septum and anterior wall), left circumflex coronary artery (lateral wall), and right coronary artery (inferior wall)], the subendocardial and subepicardial regions of the myocardium, and the corresponding transmural perfusion ratio (ratio of the subendocardial-to-subepicardial flow).

MBF was expressed as mL/min/100 g. To account for the changes in MBF produced by cardiac workload, baseline MBF was corrected for
the rate pressure product (RPP), an index of myocardial oxygen consumption, using the formula: \( \text{MBF}_{\text{corr}} = \left( \frac{\text{MBF}_{\text{baseline}}}{\text{RPP}} \right) \times 10^4 \). CFR was calculated as the ratio of \( \text{MBF}_{\text{stress}} \) to \( \text{MBF}_{\text{rest}} \). In addition, CFR was also calculated using baseline MBF corrected for RPP as \( \text{CFR}_{\text{corr}} = \frac{\text{MBF}_{\text{dipyridamole}}}{\text{MBF}_{\text{corr}}} \). 17

**Image analysis**

Maximal enhancement and noise were measured in the LV cavity on an axial image with 1 mm slice thickness using a 5.0 cm² ROI. 18,19

Signal-to-noise ratio (SNR) and contrast-to-noise ratio (CNR) were determined on a patient-by-patient basis with the following equations:
Evaluation of low-risk subjects using CT myocardial perfusion

**Statistical analysis**

All values are reported as mean ± SD, unless otherwise specified. Statistical analysis was performed using Microsoft Excel 2007 (Redmond, USA). Relative standard deviation (RSD) was used to demonstrate the degree of variability of MBF. Paired t-tests were used to compare regional MBF within individuals at a single time point and unpaired t-tests used to compare differences between subjects or gender. Analysis of variance (ANOVA) was used when multiple comparisons were made. Statistical significance was defined as P < 0.05.

**Results**

**Patient characteristics**

Thirty-eight patients were scanned successfully, of which three were deleted from analysis. Two were found to have consumed caffeine-containing beverages within 6 h prior to scanning, and another had a calcium score (CaSc) of 381. The final population comprised 35 low-risk individuals, age 47 ± 8 years (range 25–64 years), 24 males (69%), and BMI 23.91 ± 3.49 kg/m². All were at low-risk of CAD (10-year risk of < 10% for myocardial infarction (MI) or coronary death on the basis of the modified Framingham risk score for the local population). Untreated systolic blood pressure (SBP) was 111 ± 0.90 mmol/L. None of the subjects had a history of smoking.

The second population of 35 patients with documented CAD was from a previously published study. Twenty-one patients had coronary ischaemia and 14 previous MI, as documented by nuclear stress imaging. Age was 56 ± 12 years, 30 (86%) were male, BMI 24.56 ± 4.77 kg/m² (P = ns), 14 (40%) had previous MI, and 20 (57%) had undergone previous coronary revascularization. Eight (23%) had diabetes, 24 (69%) hypertension, 35 (100%) dyslipidaemia, and 8 (23%) were smokers.

**CaSc and coronary CTA**

In the population of 35 low-risk individuals, the mean CaSc was 10 ± 25 (median 0, range 0–99). Twenty-eight individuals had a CaSc of zero. Twenty-eight of the 35 patients had no detectable coronary atherosclerotic plaque and 5 had single minor plaques (3 subjects in 1 single coronary segment and 2 in up to 3 segments), all resulting in < 25% luminal narrowing. All coronary CTA results were fully interpretable, and all 17 coronary segments were of diagnostic quality.

**Radiation dosimetry**

The average radiation dose for CT myocardial perfusion imaging (CTMPI) was 6.19 ± 2.19 mSv (rest scan) and 6.72 ± 2.71 mSv (stress scan), total 12.91 ± 4.32 mSv for both rest and stress perfusion studies. Three of the 35 low-risk individuals were imaged using 100 kV as the BMI was > 30.0 kg/m². For the historic cohort scanned with 100 kV, the radiation dose was 9.15 ± 1.32 mSv for the stress scan and 9.09 ± 1.40 mSv for the rest scan.

**Comparison between SNR and CNR in scans obtained with 80 and 100 kV**

SNR and CNR between the low-risk population scanned predominantly at 80 kV (32 of the 35 subjects) and the population with ischaemia or infarction scanned at 100 kV (35 of the 35 subjects) were 4.8 ± 1.3 and 4.7 ± 1.7, respectively (P = ns), and 18.4 ± 6.5 and 21.2 ± 7.3, respectively (P = ns).

**Extent of coverage of myocardium by shuttle mode**

This was complete in 91% of our population. There were previous reports that the limited field of coverage was inadequate for all myocardial regions. However, in the low-risk cohort, none of the hearts were dilated and in 32 of the 35, the entire heart was successfully captured in the field of view.

**Rest and stress perfusion results**

All 35 patients successfully completed the dipyridamole-stress CT myocardial perfusion protocol. There was no adverse patient outcome. All patients were able to comply with the breath-hold instructions, and processing of data with the motion-correction software resulted in interpretable images in all patients. The mean resting HR was 66 ± 10 (range 40–84) bpm, and SBP and DBP were 111 ± 17 and 62 ± 13 mmHg, respectively. During stress, HR was 88.54 ± 11.45 bpm; stress SBP and DBP were 105 ± 12 and 56 ± 10 mmHg, respectively. The RPP increased from 7973 ± 1247 at rest to 9039 ± 2090 mmHg × bpm at stress (Figure 1).

**Rest and stress MBF**

Global rest MBF was 74.08 ± 16.30 mL/min/100 g (range 46.37–138.94 mL/min/100 g, RSD 22%) and global rest MBFcorr 95.43 ± 17.20 mL/min/100 g (range 73.38–137.84 mL/min/100 g, RSD 18%). Global rest MBF was significantly lower in men than women (68.46 ± 11.49 vs. 86.35 ± 19.56 mL/min/100 g, P = 0.002; Figure 1).

Global stress MBF rose significantly (P < 0.0001) from rest to 135.24 ± 28.89 mL/min/100 g (range 76.37–208.43 mL/min/100 g, RSD 21%), and global stress MBFcorr was 156.06 ± 24.47 mL/min/100 g (range 88.71–203.52 mL/min/100 g, RSD 18%; Figure 1). Global stress MBF was also marginally lower in men than women (129.26 ± 23.51 vs. 148.29 ± 37.11 mL/min/100 g), but this was not statistically significant (P = 0.07).

**Coronary flow reserve**

Global CFR (uncorrected) with dipyridamole was 1.86 ± 0.38 (range 1.30–2.94, RSD 20%) and global CFRcorr was 1.57 ± 0.31 (range 1.08–2.19, RSD 19.8%). Despite the higher global rest MBF seen in women, the differences in the global CFR between men and women were not significantly different (1.92 ± 0.38 vs. 1.73 ± 0.36, P = 0.19; Figure 1).

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\text{SNR} = \frac{\text{HU}_{\text{baseline}}}{\text{noise}_{\text{baseline}}}.
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\text{CNR} = \frac{[\text{HU}_{\text{peaktime}} - \text{HU}_{\text{baseline}}]}{\text{noise}}.
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**Spatial heterogeneity of rest and stress MBF**

Rest MBF was 76.98 ± 25.68 mL/100 g/min in the anterior, 66.98 ± 19.66 mL/100 g/min in the septal, 81.34 ± 21.40 mL/100 g/min in the lateral, and 63.35 ± 16.35 mL/100 g/min in the inferior walls. Single-factor ANOVA for regional MBF showed that rest MBF was highest in the lateral wall (α = 0.05, P = 0.001, F-factor 5.42).

Stress MBF was 133.25 ± 29.80 mL/100 g/min in the anterior, 123.47 ± 31.03 mL/100 g/min in the septal, 148.60 ± 32.69 mL/100 g/min in the lateral, and 124.21 ± 31.54 mL/100 g/min in the inferior walls. Single-factor ANOVA for regional MBF showed that stress MBF was significantly higher in the lateral wall (α = 0.05, P = 0.004, F-factor 4.75).

At rest, mean endocardial MBF was significantly higher than epicardial MBF (78.98 ± 25.09 vs. 64.87 ± 20.69 mL/100 g/min, P < 0.0001). This was also seen during stress (138.90 ± 34.81 vs. 126.08 ± 33.73 mL/100 g/min, P < 0.0001). The endocardial–epicardial perfusion ratio or the transmural gradient was significantly higher at rest than stress (1.23 ± 0.21 vs. 1.11 ± 0.14, P < 0.0001).

**Comparison between rest and stress MBF of the low-risk population to a separate population with documented CAD**

There was no statistically significant difference in global rest MBF between individuals without prior infarct but with coronary ischaemia, compared with the low-risk cohort (82.29 ± 16.87 vs. 74.08 ± 16.3 mL/100 g/min, P = 0.09), and between individuals with prior infarction compared with the low-risk cohort (81.98 ± 18.54 vs. 74.08 ± 16.3 mL/100 g/min, P = 0.17; Figure 2).

Global stress MBF was significantly higher for the low-risk population compared with the population with prior infarction (141.92 ± 30.83 vs. 106.93 ± 32.91 mL/100 g/min, P = 0.008), and also compared with the population without prior infarct but with coronary ischaemia (141.92 ± 30.83 vs. 107.95 ± 25.25 mL/100 g/min, P = 0.009).

CVR was also significantly higher in the low-risk population compared with that in patients with prior infarction (1.84 ± 0.42 vs. 1.33 ± 0.46 mL/100 g/min, P = 0.001) and when compared with patients with only cardiac ischaemia (1.84 ± 0.42 vs. 1.33 ± 0.27, P < 0.0001). There was no difference in CFR between patients with prior infarction and those with only cardiac ischaemia (1.33 ± 0.46 vs. 1.33 ± 0.27, P = 0.98).

**Discussion**

Review of current literature on CT perfusion imaging has not yielded reports on normal values of MBF. We therefore studied 35 subjects at low risk of CAD, with no symptoms of heart disease and a CaSc of < 100. Global rest MBF was 74.08 ± 16.28 mL/min/100 g and global stress MBF was 135.24 ± 28.89 mL/min/100 g, with a global CFR with dipiridamole of 1.86 ± 0.38. These stress MBF values were significantly different from patients in the historic control group with coronary ischaemia (107.98 ± 25.25 mL/min/100 g) and previous infarction, global stress MBF (109.93 ± 32.91 mL/100 g/min), with a corresponding difference in CFR of 1.33 ± 0.27 and 1.33 ± 0.46, respectively, though there was no significant difference in rest MBF between the low-risk individuals and historic control group.

All this imaging was performed with the radiation parameters of 6.19 ± 2.19 mSv for the rest scan, and 6.72 ± 2.71 mSv for the stress scan, using 80 kV in 32 of 35 subjects, with no demonstrable difference in CNR and SNR between the current low-risk population and the historic control group scanned at 100 kV.

**MBF and CFR measurements by cardiac CT in low-risk individuals**

Our population was selected on the basis of a 10-year CHD risk of < 10%, as calculated by the modified Framingham risk score, taking...
into account local epidemiological data and published in the local Ministry of Health Guidelines. This was further refined by excluding individuals with a CaSc of >100. Both measures are widely used in clinical practice and are more precise than attempting to identify a population of ‘normal individuals’.

Previous studies documented the ability of CTMPI to detect ischaemia and infarcts comparably to existing imaging modalities. There have also been studies with static perfusion imaging demonstrating detection of intramyocardial subendocardial–subepicardial perfusion gradients. To the best of our knowledge, this is the first quantitative CT study documenting the range of resting and hyperaemic blood flow values in low-risk individuals, and the quantitative measurement of the intramyocardial perfusion gradient.

Most of the existing reports on global myocardial flow have utilized PET imaging, with values of rest and hyperaemic flow ranging from 0.65 to 1.10 and 1.86 to 4.35 mL/g/min, and a CFR value of 3.16–4.99. The rest and hyperaemic flow in the present study is within the documented range of that in PET studies, though the CFR is lower. It is uncertain if this difference is related to differences in the techniques and contrast kinetics. While the global baseline MBF was significantly lower in men than women, there was no significant difference in the hyperaemic MBF between men and women. This gender difference in baseline MBF has been previously reported in the PET literature and is thought to be in part related to effects of oestrogen on vascular tone.

There is also a known difference in CFR estimation between studies utilizing dipyridamole, adenosine, or regadenoson as the vasodilating agent, which may account for the lower CFR estimates in this study utilizing dipyridamole. The quantitative regional differences in MBF across coronary territories have been documented in the PET and MR literature. Reports in the CT literature have been largely qualitative to date. To the best of our knowledge, this is the first quantitative CT report on the subject.

The difference in myocardial perfusion between the subepicardium and subendocardium has been documented in MR studies. This is due to the better spatial resolution of MR compared with modalities such as PET. It has been reported as a ratio in static CT perfusion studies. The first manifestations of ischaemia are believed to occur in the subendocardium, accounting for a reduction in the endocardial/epicardial flow ratio. In our study, the ratio in low-risk individuals of 1.08 ± 0.23 is consistent with previous findings in the literature. Other authors have noted that absolute hyperaemic perfusion is more sensitive in detecting an abnormal perfusion than a ratio such as CFR. A higher variability in normal values requires a greater absolute difference between normal and pathological values to detect abnormality. This may result in an advantage of absolute quantification of myocardial perfusion over methods determining relative perfusion values.

### Differences in MBF values between low-risk population and population with documented CAD

The global hyperaemic and CFR values were significantly lower in the population with a documented CAD than in the low-risk population. There is a known difference in 10-year risk of cardiac events between populations with established CAD (>20%) and those without (<10%). Such data regarding MBF in both these populations may perhaps serve as the basis for future prognostic studies in populations.

### Radiation dose and image quality

Previous dynamic CT perfusion studies have reported relatively high mean radiation doses of 9.2–12.5 mSv with tube voltage of 100 kV and tube current of 300–330 mAs. This is in part related to the repeated imaging of the field of view with the shuttle mode to generate complete time–attenuation curves. In comparison, the mean doses in static perfusion imaging are ~5.3 mSv. There have been two recent reports of dynamic CT perfusion studies employing different dose reduction strategies. The first utilized automatic tube current modulation with 100 kV protocols, and the other, an 80 kV/370 mAs protocol, with doses of 7.7 ± 2.5 and 6.1 ± 1.1 mSv, respectively. Our study utilized the 80 kV/370 mAs protocol for 32 of the 35 patients, resulting in a dose reduction of 30%, and with no significant difference in SNR and CNR compared with the historical cohort imaged with 100 kV/370 mAs. These doses are similar to those obtained in static perfusion studies. With the potentially improved diagnostic accuracy provided by perfusion quantitation, and a reduction in radiation cost, there may be greater potential applications for dynamic perfusion imaging.

### Study limitations

This was a study with a small sample size of 35. All subjects were Asian (except for 1 Caucasian) with a relatively low body weight. This made scanning easier than in larger patients of different races. The study did not verify the CT MBF measurements to that with obtained with other modalities, such as PET. There was also no validation of the results by invasive techniques, such as fractional flow reserve. However, the intention was to document values for CT myocardial perfusion in clinically low-risk individuals, and not to attempt a cross-comparison to measurements obtained from other modalities. To this end, the low risk of the population was verified by the low modified Framingham risk score, the low CaSc, and the near-normal CT angiography results. Moreover, there were ethical concerns about subjecting low-risk individuals to multiple imaging tests with exposure to radiation.

The technology in this study was limited to dual-source CT, and we were not able to document MBF values with non-dual-source CT techniques. The use of the shuttle mode does not allow images to be captured at every heartbeat for every level of the myocardium. This results in less precise curves.

### Clinical implications

Quantification of MBF has been described with PET and MRI, and a number of potential clinical applications have been suggested for these measures in both ischaemic and non-ischaemic heart disease pathology. MBF quantification may enable definition of the spectrum of vascular dysfunction: from endothelial dysfunction related to cardiovascular risk factors or early atherosclerosis and non-coronary cardiac diseases, to advanced diffuse atherosclerotic disease. Our study may contribute to the field as there is no study to date documenting these values in a group of low-risk individuals. The data also draw a comparison with the global MBF and myocardial flow reserve values in another group of 35 individuals with documented
CAD. These latter values are significantly lower, giving further substantiation to the ‘low risk’ of the study cohort.

The measurements of MBF in absolute units with dynamic CT perfusion assessment may expand the scope of CT studies of the human circulatory function. While this capability may allow improved characterization of the extent and severity of CAD, as with PET and MR studies where myocardial perfusion can be quantitatively assessed, its future impact may be potentially greater in patients with microvascular disorders. In this disease, flow measurements may offer a means for estimating the true ischaemic burden of the myocardium and the associated cardiac risk. Ultimately, future research will be required to show that combining CT perfusion with CTA not only improves diagnostic accuracy, but may also lead to better patient outcomes. In many fields of imaging, this has been achieved by the establishment of quantitation in the techniques. This study attempts to contribute to the effort.

Conclusion

This study measures baseline and hyperaemic MBF, and CFR in a cohort of low-risk patients. Measurements documenting a gradient in subendocardial and subepicardial flow, and regional differences in MBF are presented. The radiation dose is 30% lower using an 80 kV protocol, than in a historical study of 35 patients using a 100 kV protocol, with no significant reduction in the CNR and SNR. Our findings add to the body of existing knowledge on CT myocardial perfusion, in establishing that dynamic flow imaging is clinically feasible, yielding useful clinical data at reduced radiation cost utilizing 80 kV protocols compared with 100 kV protocols.

Conflict of interest: K.-T.H. received research grant support for this study from Siemens Healthcare, and is on the Siemens Bureau of Speakers. G.T. is an employee of Siemens Healthcare. H.-Y.O and Q.-W.Y. have no conflicts of interest.

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