DCE-MRI for the evaluation of atherosclerosis in patients with exposure to particulate matter

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Background: Air Pollution, particularly exposure to particulate matter (PM) has been associated with significant adverse health effects leading to increased morbidity and mortality. Cumulative epidemiological and experimental data have shown that exposure to air pollutants leads to increased cardiovascular ischemic events and increased atherosclerosis. As a result of their greater propensity to induce systemic oxidative and proinflammatory effects, exposure to smaller particles is believed to be more pathogenic. An estimated 60,000 men and women worked at "Ground Zero" and Staten Island Landfill (wreckage depository site) after 11 September, 2001 and were exposed to thousands of tons of fine PM, cement dust, glass fibers, asbestos, lead, PCBs, and other pollutants. Among this group include law enforcement personnel in whom we attempt to evaluate the effect of this PM exposure on atherosclerosis using dynamic contrast enhanced (DCE) MRI and reactive hyperemia peripheral arterial tonometry (PAT).

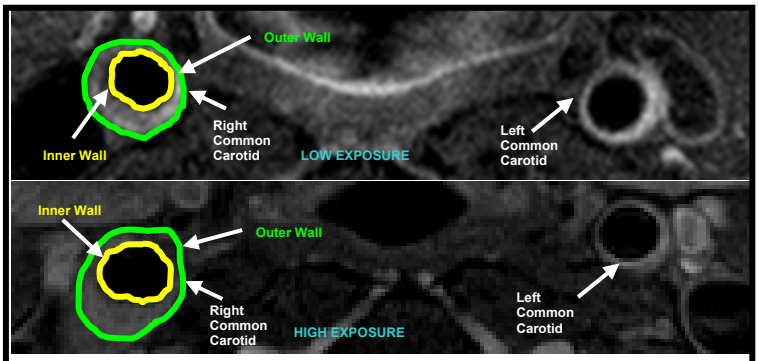

Figure 1: Sample carotid images from patients with low (top) and high (bottom) PM exposure

Hypothesis: We hypothesize that DCE-MRI and PAT can be used to evaluate differences in atherosclerosis in law enforcement personnel subjected to high and low PM exposure.

Table 1: DCE-MRI and PAT for the low and high PM exposures

	Exposure	N	Mean	Std. Deviation	p-value
AUC1 Right Carotid	LOW	5	20.9060	10.04009	0.212
	HIGH	12	14.3283	9.26524	
AUC2 Right Carotid	LOW	5	57.5040	25.97819	0.167
	HIGH	12	41.8792	17.68759	
AUC7 Right carotid	LOW	5	350.9520	93.23058	**0.008**
	HIGH	12	216.9142	78.46576	
AUC1 Left Carotid	LOW	5	28.1140	11.80217	0.080
	HIGH	12	18.8617	8.15998	
AUC2 Left Carotid	LOW	5	74.4480	38.30808	0.183
	HIGH	12	53.7733	22.85591	
AUC7 Left Carotid	LOW	5	368.4820	107.80063	**0.046**
	HIGH	12	255.0775	93.94292	
PAT	LOW	8	1.9675	.40063	0.058
	HIGH	14	1.6850	.25990	

Methods: 22 subjects (20 male) with either high (n=14) or low (n=8) exposure to PM underwent PAT followed by an MRI scan on a 3T Philips whole body scanner. 4 slices just below the right carotid bifurcation were first obtained using 2D black blood T1, T2 and PD weighted Fast Spin Echo images from all subjects. Imaging parameters were as follows: pixel size: 0.5 x 0.5 mm^2; slice thickness = 3mm; gap = 0.3mm; SPIR fat saturation; FOV = 16 x 16cm; TR = 2000ms(T2W, PDW)/1000ms (T1W); TE = 8.3ms(T1W, PDW)/50ms (T2W); Echo Train Length = 15 and NEX = 4. Subsequently, T1W black blood DCE images following injection of 0.1mMol/kg of Gd-DTPA as contrast agent were also obtained using similar parameters as T1W imaging except for NEX = 1 and number of acquisition = 25 with a temporal resolution of 32 seconds. Morphometric analysis was performed on T2-W FSE images yielding wall area, lumen area and wall thickness measurements for all patients. Area under the signal intensity vs. time curve for 1 minute, 2 minutes and 7 minutes (AUC1, AUC2 and AUC7) were obtained from the DCE images using a custom software program in MATLAB by manually tracing both the lumen and outer vessel walls of left and right common carotid arteries. Sample black blood T2W images and AUC7 maps obtained from low and high PM exposure patients are shown in **Figures 1 and 2**. MRI measures were correlated with PAT using Pearson's correlation. The differences in DCE-MRI parameters and PAT between the high and low exposure groups were compared using independent samples t-test. A p-value <0.05 was considered statistically significant.

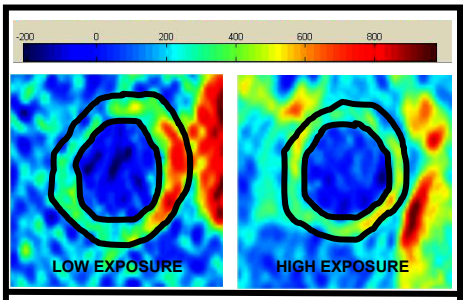

Figure 2: Sample DCE MRI AUC (7 minutes) images from a low and high PM exposure patients

Results: There was a significant correlation between DCE-MRI AUC measures and vascular reactivity (surrogate for endothelial function) measured by PAT (higher values of PAT indicate better endothelial function, **Figure 3**). There were NO significant differences between the low and high exposure groups in terms of patient characteristics (total cholesterol, LDL, HDL, blood pressure, BMI, fasting blood sugar, testosterone and waist to hip ratio) and vessel wall morphometrics (lumen area, total vessel area, vessel wall area and wall thickness for both carotids). However, the high exposure group had significantly lower AUC7 for both left and right carotids. DCE-MRI AUC measures and PAT values for the low and high PM exposure groups are shown in Table 1.

Conclusions: DCE-MRI AUC measures correlate with PAT and may be used to evaluate differences in atherosclerosis due to different levels of PM exposure.

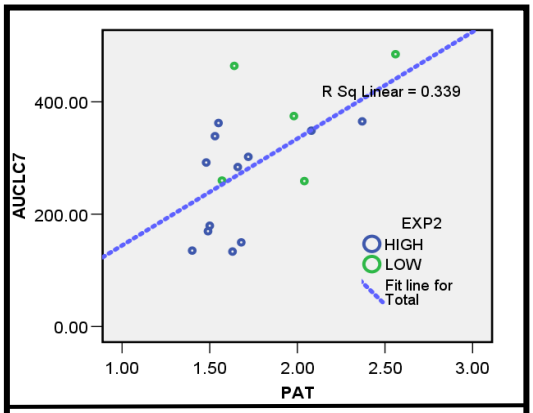

Figure 3: Correlation between DCE-MRI AUC 7 minutes and PAT; p < 0.05