Aging and hypertension increase the susceptibility of brain tissue to ischemic injury: animal brain MR imaging study

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INTRODUCTION:

Age and hypertension are the most significant risk factors for stroke [1]. A few studies have investigated apparent diffusion coefficient (ADC) and cerebral blood flow (CBF) in normal rat brain and studied the influence of aging and hypertension on diffusion and perfusion images [2][3]. In the present study, we aimed to explore the possible mechanisms of aging and hypertension as potential risk factors for ischemic injury by using diffusion and perfusion MRI in normal rat brains and correlate the image findings with the post-ischemic brain damage.

METHODS:

Four groups of male rats were studied, including (1) young normotensive Wistar-Kyoto (WKY) rat, (2) aged normotensive WKY rat, (3) young spontaneous hypertensive rat (SHR), and (4) aged SHR. Data were acquired on a 3T clinical Tim-Trio MR system (Siemens, Erlangen, Germany). T2-weighted coronal images were acquired using a fast spin-echo sequence (TR/TE= 4000/102 ms, ETL = 21). The diffusion-weighted imaging (DWI) used a spin-echo echo-planar imaging (EPI) sequence (TR/TE= 3100/98 ms) with diffusion gradients applied in x, y and z-axes (b = 1000 mm/s^2). The ADC of the three directions (x, y and z) were measured and averaged for the calculation of the isotropic ADC value. Dynamic susceptibility contrast MRI was applied for perfusion imaging by using a spin-echo EPI sequence (TR/TE= 700/80 ms). The contrast media(1.2ml/kg, Magnevist) was manually injected as a bolus into the femoral vein. Bilateral common carotid artery occlusion was used as chronic ischemic model. Hematoxylin-eosin staining was used to study the severity of brain damage after ischemia. We measured the ADC and rCBF in the parietal cortex, hippocampus and thalamus of non-ischemic rat.(Fig.1)

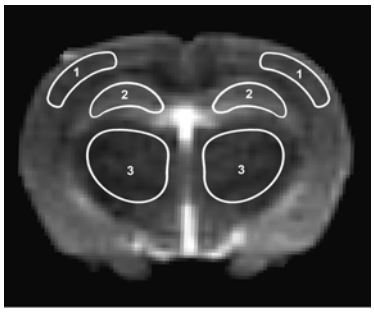

Figure 1

ROIs overlaid on a T2-weighted image. (1=parietalcortex,2=hippocampus,3=thalamus)

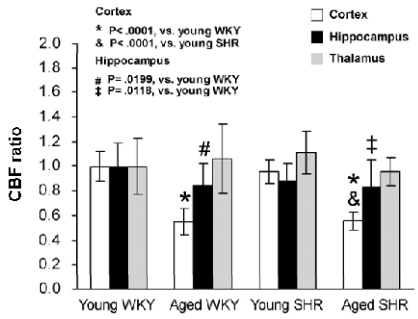

Figure 2:

Relative CBFs from three ROIs in normal, young and aged, WKY rats and SHR.

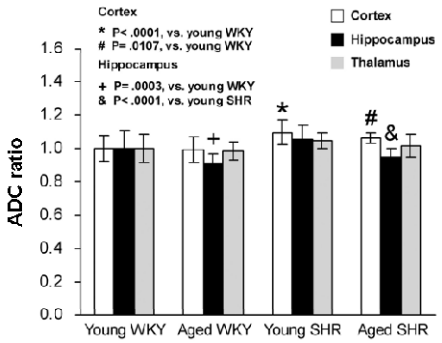

Figure3:

ADCs from three ROIs in normal, young and aged, WKY rats and SHR.

RESULTS:

Significantly higher ADCs (1.000±0.079 vs. 1.057±0.030, P= 0.016) but lower CBFs (1.000±0.175 vs. 0.587±0.090, P< 0.001) were found in the parietal cortex of aged SHRs when compared with young WKY rats but not in the hippocampus and thalamus and in other groups of rats (P> 0.05). The CBF and ADC ratio was significantly higher in aged SHRs and aged WKY rats when compared with young WKY rats (1.919±0.268 and 1.862±0.477 vs. 1.000±0.096, P< 0.0001)(Fig.2 and 3) with a higher ratio in aged SHRs. After ischemia, hematoxylin-eosin staining demonstrated significantly larger damaged volumes in the parietal cortex of aged SHRs when compared with young WKY rats (39.933±19.469% vs. 0.214±0.140%, P= 0.006), but was not seen in the hippocampus and thalamus (P> 0.05).(table1)

CONCLUSIONS:

Compared to young normotensive rats, this study found aging and hypertension may induce a significant diffusion/perfusion disparity on brain MR images. This diffusion/perfusion disparity may carry a potential risk for the ischemic injury.

ADC/CBF\ ratio (mean value±SD)				
Brain region	WKY rats		SHR	
	Young (n=13)	Aged (n=13)	Young (n=13)	Aged (n=13)
Parietal cortex	1.000±0.096	1.862±0.477*	1.143±0.152	1.919±0.268*&
Hippocampus	1.000±0.211	1.098±0.270	1.198±0.236	1.174±0.292
Thalamus	1.000±0.242	0.947±0.281	0.911±0.133	1.024±0.162

ANOVA with posthoc test, * P<0.0001 vs. young WKY
ANOVA with posthoc test, & P<0.0001 vs. young SHR

Table 1.

ADC and CBF ratio in normal, young and aged, normotensive Wistar-Kyoto (WKY) rat and spontaneous hypertensive rat (SHR)

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