Reduced amygdala volume in smokers

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Target audience

Neurologists, psychiatrists, addiction reseachers

Purpose

Tobacco remains the biggest killer, yet most preventable cause of death globally. WHO estimates suggest that tobacco use is responsible for 5.4 million deaths per year worldwide [1]. The main addictive constituent of tobacco, nicotine, initiates synaptic and cellular changes [2] which, besides an enhanced brain atrophy rate [3], may lead to a variety of structural alterations [4]. Functional [5] and neurochemical [6] findings indicate involvement of the amygdala in nicotine dependence. However, whilst prenatal exposure to maternal cigarette smoking has been observed to reduce amygdala volume [7], the direct effects of smoking on amygdala volume in adults have not been studied. We used high-resolution T1-weighted MR imaging at 3 tesla to measure the amygdala volume of smokers, ex-smokers and never-smokers, and explored the results for relationships to smoking behavior.

Methods

In 76 healthy subjects the volumetry of the amygdalae was assessed by MRI. All subjects gave written informed consent. Twenty six of them were never-smokers, 25 ex-smokers and 25 smokers, with near-equal fractions of the sexes. No subject had a history of neurological, major medical, or psychiatric disorder. Smoking behavior was examined using the Fagerström test. Images were collected on a 3T Verio scanner (Siemens Medical Systems, Erlangen, Germany) using a 12 channel head coil. Anatomical images were acquired using an MPRAGE sequence with repetition time = 2.3 ms; echo time = 3.03 ms; tip angle = 9˚; 256 x 256 x 192 matrix, 1 x 1 x 1 mm^3 voxel size. For volumetry of brain structures the software Freesurfer [8] was used. Visual inspection was carried out prior to volume analysis to verify the quality of the segmentations and make manual corrections if necessary.

Results and Discussion

The mean total brain volumes were about the same in the three groups. Likewise, intracranial volumes were not significantly different. The amygdala volume of subjects with a smoking history was lower than that of the group of never-smokers (Table). Specifically, an ANOVA controlled for intracranial volume, age and sex showed the volume of the amygdala to be significantly larger in never-smokers than in ex-smokers and smokers, with $p < 0.001$ for right (Fig. 1) and $p = 0.04$ for left amygdala. With increasing number of pack years, ie number of cigarettes smoked over a long period of time, the total amygdala volume was significantly reduced (Fig. 2) with $r = -0.302$ and $p = 0.033$.

	Amygdala volume ± SD / mm^3		
	never-smokers	ex-smokers	smokers
Right	1808 ± 240	1708 ± 249	1673 ± 229
Left	1740 ± 203	1756 ± 227	1662 ± 278

Conclusion

The results indicate a possible loss of amygdala volume in subjects with a smoking history and point to an involvement of the amygdala in addiction. These findings are in line with emerging evidence for a role of the amygdala in nicotine dependence and may help to find strategies for its manipulation to impact on the effects of nicotine [6].
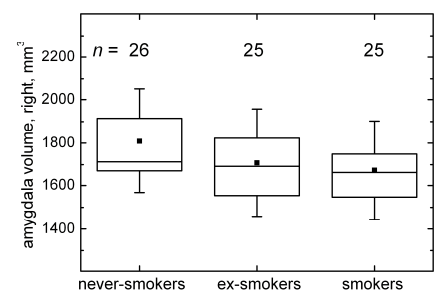

Figure 1: Volume of right amygdala in the three groups studied. Shown are mean, median, quartiles and standard deviation.
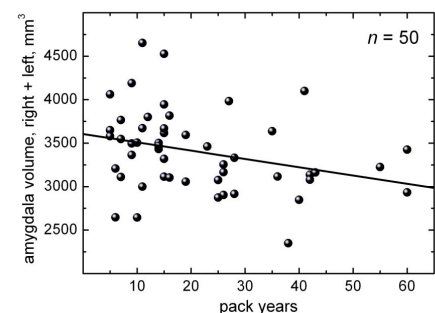

Figure 2: Dependence of amygdala volume on pack years in smokers and ex-smokers.

References

1. www.emro.who.int/press-releases/2008/the-who-report-on-the-global-tobacco-epidemic-2008.html
2. Dani JA and Harris RA, Nature Neurosci 2005; 8: 1465
3. Durazzo TC et al, Alzheimers Dement 2012; 8: 513
4. Gallinat J et al, Eur J Neurosci 2006; 24: 1744
5. Mihov Y and Hurlemann R, Neuropsychologia 2012; 50: 1719
6. Markou A, Phil Trans R Soc B 2008; 363: 3159
7. Haghighi A et al, Arch Gen Psychiatry 2012; doi: 10.1001/archgenpsychiatry.2012.1101, Epub ahead of print
8. http://surfer.nmr.mgh.harvard.edu