Persistent regional frontotemporal hypoactivity in violent offenders at follow-up

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Abstract

Since cross-sectional brain imaging studies demonstrating frontotemporal cerebral hypoactivity in violent offenders have generally been carried out around the time of trial and sentencing, the findings might be influenced by the stressful situation of the subjects. It seems that no group of offenders with this finding has been followed longitudinally so far. We have re-examined nine offenders convicted of lethal or near-lethal violence in whom single photon emission tomography (SPECT) previously had demonstrated frontotemporal hypoperfusions. The mean interval between the initial and the follow-up examination was 4 years. The initially observed hypoactivity was found to have remained virtually unchanged at follow-up: no mean change in the group exceeded 5 % in 12 assessed regions of interest. Although preliminary due to the small sample size, this study suggests that frontotemporal brain hypoactivity is a trait rather than a state in perpetrators of severe violent crimes.

Key words: CBF, SPECT, violence, frontotemporal hypoperfusion, aggression, forensic

1. Introduction

Hypoactivity in frontal and temporal brain areas of violent offenders has been reported in imaging studies made in the context of pre-trial forensic investigations (Raine et al., 1994, Soderstrom et al., 2000). Without longitudinal follow-ups of such findings, confounding by state effects associated with the pending trial cannot be ruled out. To follow up cerebral hypoperfusions detected in violent offenders at pre-trial SPECT investigations, various legal, logistic, and ethical issues inherent in studies that call for the participation of patients and prisoners deprived of liberty have to be solved. Having obtained permissions from prison and special hospital authorities as well as from the local ethics committee, we were able to re-assess 9 subjects serving time in locked institutions.

2. Subjects and Methods

Nine subjects (8 men and 1 woman), aged 27-58, median 39 years, sentenced to prison or special hospital for violent crimes that had resulted in at least 14 deaths (Table 1), gave their informed consent to participate in the present follow-up study**.** Previous registrations of regional cerebral blood flow (rCBF), performed 1.7-4.8 years ago (in mean 3.8 years), had shown clinically significant hypoperfusions, i.e. ≥ 5 % reduction in at least one frontal and/or temporal lobe compared to the controls described by Soderstrom and coworkers (2000). Crimes, DSM-IV diagnoses, and MRI findings are given in Table 1. All subjects were free from psychotic symptoms, substance abuse, and psychopharmacological medication at follow-up. All were clinically improved according to the Clinical Global Impression scale (Guy, 1976) and had low scores (mean 1.6, range 3.5-0.5) on the Montgomery-Asberg Depression Rating Scale (MADRS) (Montgomery and Asberg, 1979). High scores (mean 26, range12-37) on the

Life History of Aggression scale (LHA) reflected a lifetime of aggressive behaviour, but no violent outbursts leading to re-convictions or disciplinary measures had occurred during the sanction periods.

All SPECT examinations were performed according to the same protocol as that used in the initial studies (Soderstrom et al., 2000 and 2002). A standard dose of 1000 MBq radioactive blood flow marker ([99mTc]-d, I-HMPAO) was administered intravenously during rest with closed eyes. The first 7 cases had their baseline scan on a three-headed GE Neurocam (General Electric Medical Systems, Milwaukee, WI, USA) and the remaining 2 on a three-headed Picker IRIX (Picker International, Cleveland, Ohio, USA) gammacamera. Follow-ups were performed on a two-headed GE Millenium (GE, see above) gammacamera. Data were reconstructed in 128x128 pixel slices using filtered back-projection (FBP) on an Odyssey FX 820 workstation (Picker, see above) and post-processed using in-house software based on IDL (Research Systems Inc., Boulder, CO, USA) to minimise the effects of camera change.

The maximum counts/pixel in each region of interest (ROI) was used as an estimate of grey matter rCBF (Arlig et al., 1994), and divided by the cerebellar count ratio to assess the relative regional CBF (rrCBF). Magnetic Resonance Imaging (MRI) was used both at the first and the follow-up examination. The ratios between baseline and follow-up rrCBF for each ROI were used to assess changes in rrCBF over time. Since a sample size of 9 subjects has low statistical power with high risk of type 2 errors in paired group comparisons of means, we chose a threshold of 5 % change in mean rrCBF as a significant change between baseline and follow-up.

3. Results

No new structural pathology was shown by MRI, including T1- and T2-weighted sequences (Soderstrom et al., 2002). The mean (± standard deviations) ratios between baseline and follow-up rrCBF are depicted for all ROIs in Figure 1. The average changes in all ROIs were below the 5 % from baseline and in all but one region the no-change (100%) line was within 1 SD range. The most pronounced changes were noted in the thalamus and the hippocampus, but these small regions also showed the largest standard deviations. The only region in which the standard deviation of the change did not include the zero change level was the inferior frontal gyrus, but even then the effect was far from statistical significance, even without correction for multiple comparisons.

4. Discussion

Despite considerably improved mental wellbeing, our subjects showed virtually unchanged frontotemporal hypoactivity several years after the initial SPECT investigation. Frontotemporal hypoactivity thus seems to be a trait rather than a state in our study group of extremely aggressive offenders. It is important to keep in mind, however, that the evidence linking regional brain hypoactivity to specific behavioural patterns is still weak, as no studies have included non-violent controls with the same range of unspecific psychosocial and neuropsychiatric loads (Anckarsäter, 2006). Such a control group would be difficult to establish, as non-violent offenders deprived of liberty, thieves for instance, tend to be more ill, have more substance abuse, and be referred to forensic psychiatric investigations less often than violent offenders, at least in Scandinavia. Studies addressing the possible link between reduced frontotemporal activity and violence/ aggression must thus develop new approaches besides the case-control comparisons of imaging findings.

Data from functional magnetic resonance imaging (fMRI) studies in subjects with psychopathy implicates the frontotemporal regions as involved in distorted affective processing (Müller et al., 2003) and poorly differentiated verbal processing (Kiehl et al., 2004). Our findings of persistent frontotemporal hypoperfusions in violent offenders lend further support to the idea that dysfunction in these regions is a factor in antisocial behaviour.

Though our findings must be regarded as preliminary and interpreted with great caution due to the small sample size and the psychiatric heterogeneity of our subjects at inclusion, the study adds to the literature in this field as the first to address the issue of stability over time of frontotemporal hypoactivity in perpetrators of extremely violent crimes. It paves the way for identification of potential clinical implications in more extensive studies using modern research paradigms to assess possible relationships between neuropsychological dysfunctions and frontotemporal hypoactivity.

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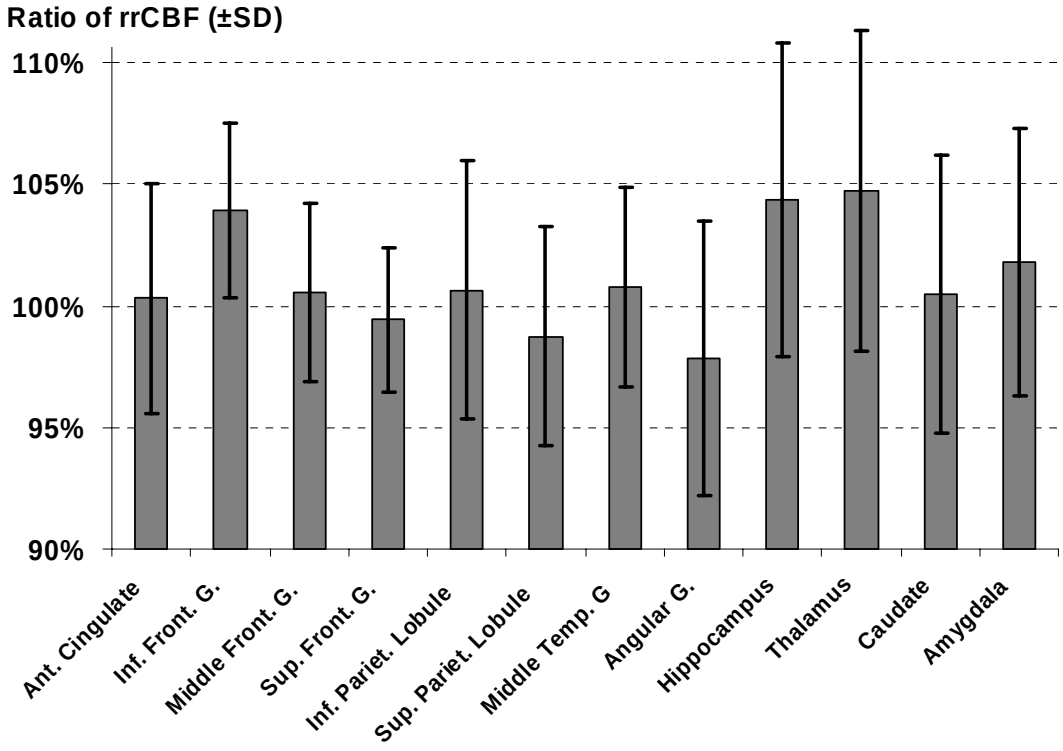
Table 1. Crimes, diagnoses and MRI findings

Subject # (sex)	Crime	Sanction	DSM-IV diagnosis at first investigation	DSM-IV diagnosis at follow-up	MRI at first investigation
1 (M)	Murder	Prison	301.90 Personality disorder NOS	301.90 Personality disorder NOS	No intracranial abnormalities
2 (M)	Kidnapping, aggravated rape	Prison	300.02 Generalized anxiety disorder 305.00 Alcohol abuse 301.83 Borderline personality disorder	301.83 Borderline personality disorder	Small chronic infarct left lentiform nucleus. Minimal small vessel disease
3 (F)	Murder	Special hospital	305.00 Alcohol abuse 298.8 Brief psychotic disorder 309.0 Adjustment disorder with depressed mood Borderline personality disorder	301.83 Borderline personality disorder	No intracranial abnormalities
4 (M)	Causing the death of another person, rape	Prison	304.80 Poly-substance dependence	None	Probable small hamartoma in the left internal capsule

5 (M)	Murder	Prison	305.00 Alcohol abuse 301.90 Personality disorder NOS	301.90 Personality disorder NOS	No intracranial abnormalities
6 (M)	Murder	Special hospital	304.80 Poly-substance dependence 301.90 Personality disorder NOS	301.90 Personality disorder NOS	No intracranial abnormalities
7 (M)	Murder	Special hospital	312.34 Intermittent explosive disorder 298.8 Brief psychotic disorder 305.00 Alcohol abuse 299.80 Pervasive developmental disorder NOS 301.81 Narcissistic personality disorder	299.80 Pervasive developmental disorder NOS 301.81 Narcissistic personality disorder	No intracranial abnormalities
8 (M)	Murder	Special hospital	296.34 Major depressive disorder, recurrent	296.34 Major depressive disorder, recurrent	No intracranial abnormalities
9 (M)	Murder/man-slaughter	Special hospital	294.9 Cognitive disorder NOS 301.7 Antisocial personality disorder	294.9 Cognitive disorder NOS 301.7 Antisocial personality disorder	Minimal bilateral frontal and parietal cortical atrophy

Legend to the Figure

The CBF changes over time expressed as mean ratios between rrCBF in the follow-up and the baseline scan. ROIs with values >100% show increase in rrCBF with time.


Ratio of rrCBF (±SD)
110%
105%
100%
95%
90%
Ant. Cingulate
Inf. Front. G.
Middle Front. G.
Sup. Front. G.
Inf. Pariet. Lobule
Sup. Pariet. Lobule
Middle Temp. G
Angular G.
Hippocampus
Thalamus
Caudate
Amygdala