Corpus callosum morphology and relationship to orbitofrontal and lateral ventricular volume in teenagers with first-presentation borderline personality disorder

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1. Introduction

Structural and functional neuroimaging studies in adults with borderline personality disorder (BPD) have shown alterations in the prefrontal cortex, particularly the orbitofrontal cortex and adjacent ventral medial cortex (including the anterior cingulate gyrus), in addition to the hippocampus and amygdala. Previous studies have demonstrated alterations to fronto-limbic circuitry and callosal structure in borderline personality disorder (BPD). We predicted that a first-presentation BPD cohort who demonstrated orbitofrontal cortex (OFC) reductions would show regional reductions in the anterior corpus callosum.

Method: Twenty teenage first-presentation BPD patients and twenty matched healthy controls underwent Magnetic resonance imaging (MRI) performed in 20 teed first-presentation BPD patients and 20 matched healthy controls. Corpus callosum size and shape and ventricular volume were estimated using established methods and compared between the two groups. The relationship between illness variables and callosal morphology was also examined. OFC volume was correlated with callosal and ventricular variables.

Results: BPD participants and controls did not differ on measures of callosal size or shape, or ventricular size. BPD participants showed an alteration to the pattern of age-related expansions seen in the callosum. BPD participants with a history of trauma did not demonstrate significant neuroanatomical differences from those without. OFC volumes did not correlate with the thickness of the anterior corpus callosum.

Conclusion: Gross neuroanatomical changes are not present at the level of the callosum in teenagers with first-presentation BPD. Changes seen in other studies might reflect factors associated with the duration of BPD, such as recurrent comorbidity with Axis I disorders, or treatment.
These findings suggest that prefrontal-limbic structures, particularly the OFC, are relevant to the early course of BPD in young people. Prefrontal cortical fibres from the orbitofrontal and ventral medial cortex pass between the hemispheres through the corpus callosum (CC), in the region of the genu (Pandya and Seltzer, 1986), whereas amygdala and hippocampal fibres do not. The CC, the brain's largest white matter bundle, connects functionally related interhemispheric regions of the cerebral cortex, predominantly through homotopic connections that connect a given specialized cortical area with its contralateral homolog, but also through heterotopic connections that connect non-homologous areas (Clarke and Zaidel, 1994; de Lacoste et al., 1985; Witelson, 1989). Disorders that produce significant grey matter atrophy such as Alzheimer's disease, vascular dementia and frontotemporal dementia result in regional callosal reductions in the areas connecting atrophic cortical regions (Hallam et al., 2008; Kaufer et al., 1997; Yamauchi et al., 2000); if white matter changes in BPD are indeed secondary to reductions in grey matter regions, subtle alterations at the level of the anterior CC may then be detectable in BPD.

Disrupted interhemispheric connectivity has also been implicated in underlying the mood dysregulation characteristic of major affective disorders (Brambilla et al., 2003, 2004), which can show symptomatic overlap and co-occurrence with BPD (Akiskal, 2004; Paris et al., 2007). Additionally, the corpus callosum appears particularly vulnerable to the effects of childhood abuse and trauma, with children suffering abuse and neglect demonstrating abnormal callosal development and reduced callosal size compared to non-abused children (DeBellis et al., 1999; Teicher et al., 1997, 2004), which may alter the developmental trajectory of interhemispheric integration and functional cerebral lateralization (Schiffer et al., 1995). The callosum develops in a non-linear way, and shows quadratic trajectories of micro- and macro-structural changes across the lifespan, particularly in adolescence and early adulthood (Hasan et al., 2008a,b, 2009); these trajectories may be disrupted by the pathophysiology of trauma and major affective illness, which may be reflected in changes in callosal structure.

Few studies have examined CC in BPD patients and no studies have examined young people early in the course of BPD. Two recent studies have examined CC structure in BPD patients compared with healthy controls (Rüscher et al., 2007a; Zanetti et al., 2007). Zanetti et al. (2007) found no differences in CC structure between patients and controls. Rüscher et al. studied BPD patients with comorbid attention-deficit hyperactivity disorder (ADHD) and found a thinner isthmus of the callosum (connecting parietal and temporal cortices). In this study, BPD patients with an abuse history also demonstrated reductions in the anterior CC may then be detectable in BPD.

2. Methods

2.1. Participants

Twenty patients meeting Structured Clinical Interview for DSM-IV Axis II Disorders (SCID-II (First et al., 1997)) criteria for BPD were recruited from the HYPE Clinic (Chanen et al., 2009), a specialized early intervention program for BPD at ORYGEN Youth Health in Melbourne, Australia. They had minimal exposure to psychiatric interventions and had never received specific treatment for BPD. Potential BPD participants were excluded from the study if they had a schizophrenia spectrum or affective psychotic disorder, anorexia nervosa, and current alcohol dependence with a duration of 2 months or longer. The characteristics of this sample have been previously described (Chanen et al., 2008). Briefly, common comorbidities included disruptive behavior disorders (N = 10), anxiety disorder (N = 9, including one case of PTSD), mood disorder (N = 7, 4 with major depressive disorder, 2 with dysthymic disorder, and 1 with bipolar I disorder), and/or substance abuse or dependence (N = 6). No participant had comorbid ADHD. Seventeen participants were medication-free; one was taking citalopram, one was taking venlafaxine, and one was on both sertraline and methadone maintenance therapy.

Lifetime trauma exposures (physical, sexual or emotional), along with a number of parasuicidal and violent episodes over the previous 6 months, were assessed by a semi-structured interview (developed by the investigators and available upon request). Interview data on abuse or trauma were available for 19 BPD participants; 10 denied any experience of abuse and 9 reported experience of physical (N = 6), sexual (N = 5), and/or emotional (N = 5) abuse.

Twenty control participants were drawn from a pool of healthy volunteers, carefully screened for no personal or family history of psychiatric illness, substance abuse or neurological disorder, and were recruited via advertisements placed in an employment centre and colleges, and local newspaper advertisements in the community from which the patient group was drawn. Control participants were also subsequently recruited via word-of-mouth from other control participants. BPD screens were performed by a psychiatrist (DV), clinical neuropsychologist and an experienced graduate research assistant trained in clinical diagnosis, using a checklist derived from the SCID-II. Control participants were matched exactly by sex and as closely as possible for age and handedness.

All participants were physically healthy, based upon medical history, and none had a history of serious head injury, loss of consciousness (≥ 10 min), seizure, neurological diseases, thyroid disorder or other significant medical illnesses. The study was approved by the local Research and Ethics Committees. Written informed consent was obtained from all participants or from a parent or guardian. BPD participants were remunerated AU$50.

2.2. Assessment

Axis I diagnoses were made with the Structured Clinical Interview for DSM-IV patient version (SCID-I/P (First et al., 1996)), supplemented by the Kiddie-SADS-Present and Lifetime Version (K-SADS-PL) Disruptive Behavior Disorders section (Kaufman et al., 1997). Axis II diagnoses were made with the SCID-II (First et al., 1997). In common with previous research (Chanen et al., 2007), a PD feature was scored positive if it was present for 2 years and did not occur exclusively in the context of an Axis I disorder, and a total score for the nine borderline personality disorder items on the SCID-II was calculated.

BPD participants less than 18 years old completed the Youth Self-Report (YSR (Achenbach, 1991)) and those 18 years and above completed the Young Adult Self-Report (YASR (Achenbach, 1997)). Consistent with previous research (Chanen et al., 2007), mean scores...
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