



Selective serotonin reuptake inhibitor effects on neural biomarkers of perinatal depression

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Abstract

The effect of perinatal selective serotonin reuptake inhibitors (SSRIs) on brain-derived neurotrophic factor (BDNF) and S100 calcium binding protein B (S100B) has not been investigated. Using a cohort of 86 pregnant women, we found that SSRIs significantly increase BDNF levels in late pregnancy and that S100B, but not BDNF, is associated with maternal depression in SSRI-treated women only. This shows that serum S100B could be a unique biomarker to determine efficacy of SSRIs during gestation.

Keywords Depression · Anxiety · Antidepressants · Gestation · Motherhood · Neuroplasticity

Introduction

Our understanding and use of biomarkers that reflect the pathophysiology of maternal depression remain limited. Serum brain-derived neurotrophic factor (BDNF) has been proposed as a biomarker for perinatal depression (Christian et al. 2016; Gao et al. 2016; Guintivano et al. 2017). BDNF is a neurotrophin involved in neuroplasticity and implicated in the pathophysiology and treatment of mood disorders (Castren et al. 2007): with lower serum BDNF levels being associated with depression (aan het Rot et al. 2009). Similarly, during the perinatal period, low serum BDNF levels are associated with increased third trimester depressive symptoms (Christian et al. 2016) and serum BDNF levels are

significantly lower in women with postpartum depression (Gao et al. 2016; Lommatzsch et al. 2006). Recent research in rodent models has also shown that gestational stress can reduce levels of BDNF in the hippocampus of the mother (Vanmierlo et al. 2018).

Selective serotonin reuptake inhibitors (SSRIs) are the treatment of choice for perinatal depression and are prescribed to up to 10% of pregnant women (Oberlander et al. 2006; Pawluski et al. 2017). These medications can act, in part, by increasing BDNF levels, which can alleviate depression symptoms by their actions in the brain (aan het Rot et al. 2009; Gupta et al. 2017). Serum BDNF levels are positively correlated with serum 5-hydroxytryptamine (5-HT) levels during gestation and the postpartum period (Lommatzsch et al. 2006). However, the impact of SSRIs on BDNF during the perinatal period has not been assessed.

Recent attention has turned to S100 calcium-binding protein B (S100B) as another biomarker of perinatal depression in women (Pawluski et al. 2009). The production of S100B by astrocytes is regulated by serotonin and is involved in the outgrowth and survival of neurons and the stimulation of glial cell proliferation. In SSRI-treated women, serum S100B levels are elevated but it is not known how S100B is related to maternal mood (Bellissima et al. 2015; Pawluski et al. 2009). We therefore sought to determine how perinatal SSRIs influence maternal serum BDNF and S100B levels during late pregnancy and at delivery and how changes in serum levels of these factors might be related to maternal depressive and anxiety symptoms.

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Materials and methods

Subjects Maternal serum samples were obtained for analysis of BDNF and S100B from a cohort ($n = 86$) of mothers recruited in their early second trimester to participate in a study of psychotropic medication use during the perinatal period. This was done with approval from The University of British Columbia Research Ethics Board, Children's and Women's Health Centre of British Columbia Research Review Committee, and informed consent. For the present study, serum BDNF and S100B levels were assayed from SSRI-treated ($n = 22$ – 25) and non-SSRI-treated ($n = 33$ – 38) women during late gestation and at delivery. Non-SSRI-treated women were considered healthy controls. However, mood symptoms were assessed in all participants during the study. This subset of women chosen was based on serum availability for analysis.

None of the mothers took other serotonergic medications during their pregnancies. In the SSRI-treated group, four women also took another antidepressant medication and five women were also prescribed an antipsychotic. Women in the treated group were on SSRIs for an average of 261.07 ± 44.19 (range 94–290) days, and except for two women, all women in the SSRI-treated group were on medication for at least 247 days of gestation and all continued SSRI medication up to the time of delivery. Outcomes were compared with mothers not using any medication. Mode of delivery was recorded (vaginal versus C-section). Neonatal outcomes were tabulated from the immediate newborn period. Apgar scores at 1 and 5 min, sex, birth weight, head circumference, body length, and gestational age were obtained. Only Apgar scores at 1 min and gestational age were different between SSRI-exposed and non-exposed neonates where lower Apgar scores at 1 min and slightly younger gestational ages were evident (Pawluski et al. 2012). Demographic information and neonatal characteristics from this cohort of mothers has been published, and details can be found there (Pawluski et al. 2012).

Maternal mood During pregnancy, maternal anxiety and depression were assessed at the time of study enrollment (approximately 26–28 weeks) and again at 36 weeks gestation (36.2 ± 0.7 weeks). *The Hamilton Rating Scale for Depression (HAMD)*, *the Hamilton Rating Scale for Anxiety (HAMA)*, and *the Edinburgh Postnatal Depression Scale (EPDS)* were used. Self-reported history of depression or anxiety was also asked of each participant at the first visit.

Serum BDNF and S100B analysis Blood samples were collected at 36 weeks' gestation, serum samples were taken at 8 am, 2.5 h before SSRI medication was taken. Delivery blood samples were taken at term and up to 2 h after delivery of the placenta from the antecubital fossa (arm). Thirty-three to 38 samples of non-SSRI-treated women and 22–25 samples of SSRI-treated women were assessed at 36 weeks' gestation and

delivery. Samples were centrifuged at 1300g for 8 min at 4 °C. Serum was collected and stored at -80 °C until analysis.

Serum samples were analyzed in duplicate using a commercially available ELISA kits for BDNF (Human BDNF, R&D systems, #DBD00, USA) and S100B (Human S100B ELISA, BioVendor, #RD192090100R, Czech Republic). The sensitivity was estimated to be 20 pg/ml for the BDNF assay and 15 pg/ml for the S100B assay. Average intra-assay and inter-assay coefficients of variation were less than 10%. The majority of S100B levels at 36 weeks' gestation were below the detection limit, so only S100B levels from delivery were used for analyses.

Statistical analysis Using Statistica software (Statsoft) analysis of variance tests (ANOVAs) were calculated on maternal mood symptoms and serum levels of BDNF or S100B levels as a within-subjects factor and treatment (SSRI-treated, non-SSRI-treated) as a between-subject factor. An analysis of covariance (ANCOVA) was performed on BDNF and S100B levels using measures of maternal mood (HAMD) and mode of delivery and neonatal characteristics (Apgar scores at 5 min, gestational age, etc.), as well as maternal BMI and ethnicity as covariates. Both maternal BMI and ethnicity are known to affect BDNF levels (Ben Abdesselam et al. 2003; Christian et al. 2016; Lommatzsch et al. 2006; Lommatzsch et al. 2005). Chi-square tests were computed for self-reported history of depression or anxiety between groups. Pearson correlations were conducted between maternal mood scores (HAMD), maternal BDNF, and S100B levels in SSRI-treated and non-treated women. Pearson correlations were also conducted on maternal measures of affective symptoms in the HAMD, HAMA, and EPDS. Linear regression models were also computed to assess the contribution of multiple factors on the correlations (such as mode of delivery, gestational length, maternal mood scores, duration of SSRI use during pregnancy). Significance was set at $p < 0.05$.

Results

The HAMD, HAMA, and EPDS scores were significantly positively correlated (r 's = 0.55–0.85, p 's = 0.00); thus, to avoid redundancy, HAMD scores were used throughout as our focus was on mood symptoms (HAMA assesses anxiety and the EPDS assesses both depression and anxiety (Rowe et al. 2008; Tuohy and McVey 2008)). The SSRI-treated women at 36 weeks' gestation had significantly higher HAMD scores compared to non-SSRI-treated women ($F(1, 61) = 5.43$, $p = .02$, Table 1). SSRI-treated women were significantly more likely than non-SSRI-treated women to self-report a history of depression ($\chi^2 = 46.33$, $p = 0.00001$) and anxiety ($\chi^2 = 11.64$, $p = 0.0006$; Table 1). Eighty-three percent of the participants identified as being white, and there were no significant differences between groups in ethnic diversity ($p = 0.5$). SSRI-treated

Table 1 Mean (\pm SEM) history of depression or anxiety (% per groups), scores on the HAMD, HAMA, and EPDS, and serum levels of BDNF (ng/ml) and S100B (pg/ml). Asterisk denotes significantly different from non-SSRI-treated women, $p < 0.05$

	Non-SSRI-treated	SSRI-treated
Depression history (self-report)	13%	90%*
Anxiety history (self-report)	24%	62%*
HAMD at 36 weeks' gestation	7.42 \pm 0.98	10.80 \pm 0.97*
HAMA at 36 weeks' gestation	9.52 \pm 1.1	11.84 \pm 1.0
EPDS at 36 weeks' gestation	4.90 \pm 0.74	6.31 \pm 0.85
BDNF at delivery (ng/ml)	16.61 \pm 0.92	17.17 \pm 0.89
S100B at delivery (pg/ml)	29.90 \pm 5.38	34.66 \pm 7.18

women had a significantly higher BMI at 36 weeks' gestation ($F(1, 82) = 6.3602, p = 0.01, 27.4 \pm 3.7$ for non-treated and 29.9 ± 5.4 for SSRI-treated).

Women prescribed SSRIs had significantly higher serum levels of BDNF at 36 weeks' gestation ($F(1, 59) = 5.7386, p =$

0.02, controlling for BMI and ethnicity, Fig. 1a). Furthermore, lower BDNF levels at delivery were marginally associated with increased maternal depressed symptoms during late gestation (36 weeks) in non-SSRI-treated women (Pearson correlation: $r = -0.32, p = 0.058$) but not SSRI-treated (Pearson correlation: $r = 0.07, p = 0.77$, Fig. 1b).

Lower S100B levels at delivery were significantly associated with higher maternal depression symptoms in SSRI-treated women (Pearson correlation: $r = -0.62, p = 0.003$, regardless of BMI or ethnicity; Fig. 1c), and there was no relationship between S100B and maternal mood symptoms in non-SSRI-treated women (Pearson correlation: $r = -0.13, p = 0.47$). There were no other significant differences between groups.

Discussion

In the present cohort, SSRI-treated women had increased depression symptoms at 36 weeks' gestation compared to non-SSRI-

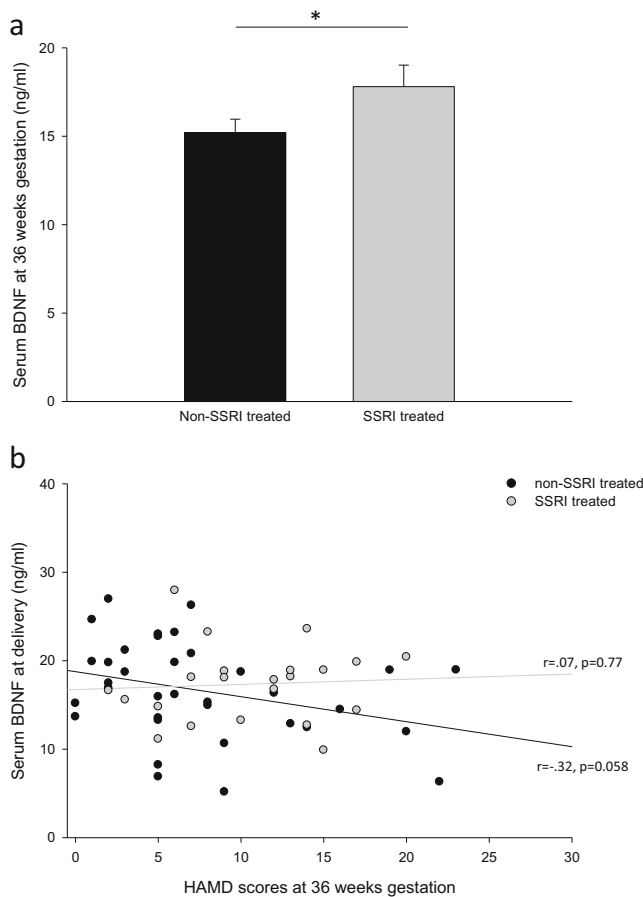
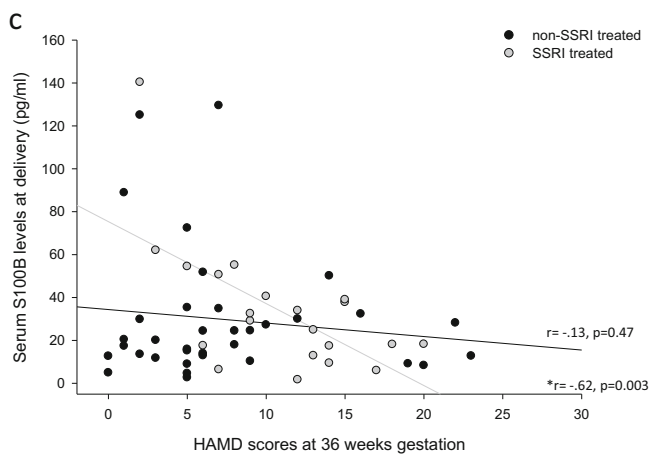


Fig. 1 Serum biomarkers (S100B and BDNF) and maternal depression symptoms in SSRI-treated and non-SSRI-treated women. **a** Mean (\pm SEM) serum BDNF levels at 36 weeks' gestation ($F(1, 59) = 5.7, p = 0.02$). **b** Correlations between serum BDNF levels at delivery and maternal depression symptoms (non-SSRI-treated women $r = -0.32, p =$



0.058; SSRI-treated women $r = 0.07, p = 0.77$). **c** Correlations between serum S100B levels at delivery and maternal depression symptoms (non-SSRI-treated women $r = -0.13, p = 0.47$; SSRI-treated women $r = -0.62, p = 0.003$). * denotes significant $p < 0.05$.

treated women. Both SSRI-treated and non-treated pregnant women showed a wide range in symptoms of depression which allowed for investigation of the association between serum biomarkers and depressive symptoms. Our main findings show that in SSRI-treated women, there is a significant increase in serum BDNF levels during late pregnancy which is in line with previous work showing the BDNF is associated with increased 5HT during in the peripartum period (Lommatzsch et al. 2006). This finding also expands previous work in non-pregnant individuals showing a positive association between antidepressant medications and serum BDNF levels (Duman and Monteggia 2006). How increased levels of serum BDNF with SSRIs translate to changes in neurochemistry and neural activity in the maternal brain remain to be determined.

It has been reported that serum BDNF levels are negatively associated with perinatal depressive symptoms and maternal stress (Christian et al. 2016; Gao et al. 2016; Lommatzsch et al. 2006; Vanmierlo et al. 2018). In the present study, this relationship was not evident in SSRI-treated pregnant women suggesting that the increase in BDNF with SSRI-treatment is not acting to alleviate depressive symptoms and that BDNF is not a biomarker of depressive symptoms in women prescribed SSRIs during pregnancy. As with previous reports showing a negative relationship between serum BDNF levels and perinatal depression (Christian et al. 2016; Gao et al. 2016), we do show a marginal negative correlation between serum BDNF levels and depressive symptoms during late pregnancy, but in non SSRI-treated women only.

When looking at serum S100B levels, we found that SSRI-treated women have a significant negative correlation between serum S100B levels and maternal mood scores. Serotonin can increase S100B levels (Whitaker-Azmitia et al. 1990), and S100B is known to alleviate depressive-like symptoms via its actions on the 5-HT₇ receptor (Stroth and Svenningsson 2015); thus, it may be that the increase in serotonin activity at the synaptic cleft, after SSRI treatment, increases S100B and decreases symptoms of depression via actions on the 5-HT₇ receptor.

Conclusion

Taken together, this work points a significant role of SSRIs on neuro-biomarkers of maternal depressive symptoms during the perinatal period. This work also shows that S100B may be a unique biomarker for determining the efficacy of SSRIs in treating maternal affective disorders during gestation. Further work is needed to determine the direct neurobiological effects of SSRIs on the maternal brain.

Compliance with ethical standards

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the

institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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