Psychoneuroendocrinology 98 (2018) 168–176

Contents lists available at ScienceDirect

Psychoneuroendocrinology

journal homepage: www.elsevier.com/locate/psyneuen

Maternal experiences of trauma and hair cortisol in early childhood in a prospective cohort

Natalie Slopen[a,*], Andrea L. Roberts[b], Kaja Z. LeWinn[c], Nicole R. Bush[c,d], Cynthia R. Rovnaghi[e], Frances Tylavsky[f], Kanwaljeet J.S. Anand[g]

[a] Department of Epidemiology and Biostatistics, School of Public Health, University of Maryland, College Park, MA, United States
[b] Harvard TH Chan School of Public Health, Boston, MA, United States
[c] Department of Psychiatry, Weill Institute for Neurosciences, University of California, San Francisco, CA, United States
[d] Department of Pediatrics, University of California, San Francisco, CA, United States
[e] Pain/Stress Neurobiology Lab, Child Health Research Institute, Stanford University School of Medicine, Stanford, CA, United States
[f] Department of Preventive Medicine, University of Tennessee Health Science Center, Nashville, TN, United States
[g] Department of Pediatrics, Stanford University School of Medicine, Stanford, CA, United States

ARTICLE INFO

Keywords:
Children
Cortisol
Hair
Trauma
Mother
Stress
HPA axis

ABSTRACT

Background and Objective: Maternal trauma can have intergenerational consequences but little is known about whether maternal traumas affect key biological domains associated with mental health in their offspring. The objective of this study was to examine maternal lifetime history of traumatic events through mid-gestation in relation to offspring cortisol production in early childhood.

Methods: The sample was comprised of 660 children (49.9% Black, 44.4% White) from a longitudinal study of mother-offspring dyads in Shelby County, Tennessee, followed from mid-gestation to child age 4 years (enrolled 2006–2011). Maternal lifetime history of traumatic life events were assessed mid-gestation using the Traumatic Life Events Questionnaire. Total cortisol output among offspring was measured using hair cortisol concentrations at ages 1 to 4 years.

Results: Associations of maternal trauma history with child hair cortisol varied by child's age. No association was observed at age 1 or 2. In adjusted regression models, at ages 3 and 4, offspring of mothers in the third ($\beta = 0.99$, $P < .01$), fourth ($\beta = 0.72$, $P < .05$), and fifth ($\beta = 0.83$, $P < .01$) quintiles of trauma exposure history had elevated (natural log) hair cortisol concentrations, relative to mothers in the lowest quintile (P-trend = 0.003). The associations were not attenuated after adjustment for theorized pathways, including premature birth, maternal postpartum depression, and maternal parenting stress.

Conclusions: Maternal lifetime trauma exposures are associated with offspring hair cortisol concentrations. Future research is needed to determine intermediary mechanisms and functional significance of elevated hair cortisol concentration in young children.

1. Introduction

Traumatic life events, such as natural disasters, sudden death of a loved one, and childhood abuse, are commonplace and critical issues for public health (Herrenkohl et al., 2015; Magruder et al., 2016). Over two-thirds of US adults have been exposed to at least one potentially traumatic event (Goldstein et al., 2016), and cumulative lifetime trauma exposure is associated with serious physical and mental health outcomes across the lifespan (Anda et al., 2006; McLaughlin et al., 2010; Suglia et al., 2015). Maternal trauma can have intergenerational consequences for child wellbeing, including elevated risk of behavioral and mental health problems (Dubowitz et al., 2001; Roberts et al., 2014, 2013; van Ee et al., 2012). The extent to which maternal traumas affect offspring in key biological domains associated with mental health, such as regulation of the child's hypothalamic-pituitary-adrenal (HPA) axis, has rarely been examined. Since HPA axis dysregulation

Abbreviations: HPA, hypothalamic pituitary adrenal; CANDLE, Conditions Affecting Neurocognitive Development and Learning in Early Childhood; PTSD, post-traumatic stress disorder; TLEQ, Traumatic Life Events Questionnaire; BMI, body mass index; BSI, Brief Symptoms Inventory; PSI, Parental Stress Index Short Form; CAPI, Child Abuse Potential Inventory

* Corresponding author at: Department of Epidemiology and Biostatistics, School of Public Health, University of Maryland, College Park, 20742, United States.
E-mail address: nslopen@umd.edu (N. Slopen).

https://doi.org/10.1016/j.psyneuen.2018.08.027
Received 6 April 2018; Received in revised form 17 August 2018; Accepted 20 August 2018

predicts physical, social, and mental health outcomes across the life span (Miller et al., 2011), an association between maternal trauma history and children's cortisol dysregulation in early life may have important clinical and public health implications. The objective of this study was to examine maternal experiences of traumatic events assessed mid-gestation in relation to hair cortisol concentration in their young children.

Children of mothers exposed to trauma may have dysregulated stress response systems due to biological programming that occurred during gestation via placental transfer of maternal stress hormones during pregnancy (Entringer et al., 2015) and/or due to exposure to stressors associated with maternal histories of adversity during the postnatal period (Porche et al., 2011) (Berlin et al., 2011; Roberts et al., 2015, 2004). There is evidence for biological pathways that transmit traumatic experiences across generations (Bowers and Yehuda, 2016; Entringer et al., 2015; Meaney, 2001; Thomas et al., 2018; Yehuda et al., 2014), including alterations in HPA axis functioning during pregnancy (Bublitz and Stroud, 2012; Shea et al., 2007; Thomas et al., 2018), which may program her offspring's HPA axis to over- (Brennan et al., 2008) or under-produce cortisol (Brand et al., 2010; Schury et al., 2017).

In the post-natal period, children of mothers exposed to trauma are at risk for a range of chronic stressors, including lower socioeconomic position (Porche et al., 2011), maternal psychopathology (Roberts et al., 2015), low quality parenting behaviors (Roberts et al., 2004), and abuse (Berlin et al., 2011). These adverse conditions in childhood are associated with dysregulated patterns of cortisol secretion: children exposed to chronic stressors or trauma display both enhanced (Ouellet-Morin et al., 2011; Smeekens et al., 2007) and blunted (Carpenter et al., 2011; MacMillan et al., 2009; White et al., 2017) cortisol responses to acute stressors and atypical diurnal secretion (Cicchetti et al., 2010; Gunnar and Vazques, 2001; Suglia et al., 2010). Some research suggests that trauma in early life, relative to trauma in adulthood, may be particularly detrimental to HPA regulation (Klaassens, 2010; Meewisse et al., 2007). A meta-analysis on trauma associations with cortisol reported lower cortisol among participants with PTSD due to childhood sexual or physical abuse relative to controls (n = 5 studies), but no differences between controls and participants with PTSD due to other traumas (Meewisse et al., 2007).

Hair cortisol concentration has been proposed as a retrospective, integrated assessment of long-term cortisol production, and may serve as a potential biomarker for prolonged physiologic stress (Stalder et al., 2017; Staufenbiel et al., 2013). A study of 70 Australian children (mean age = 9.5 years) reported that lifetime trauma exposure was associated with higher hair cortisol (Simmons et al., 2016), and similarly, among 2484 participants in the Generation R cohort, lower income was associated with elevated hair cortisol at six years of age (Rippe et al., 2016). In a subsample of participants in the Conditions Affecting Neurocognitive Development and Learning in Early Childhood (CANDLE) study (n = 297), the same cohort as the present study, parenting stress was associated with elevated infant hair cortisol, whereas maternal depression was associated with lower infant hair cortisol (Palmer et al., 2013). We are aware of two studies that have examined maternal stress or trauma before or during pregnancy in relation to offspring hair cortisol (Karlén et al., 2015; Schury et al., 2017). In a study of 209 infants in Sweden, maternal psychosocial stressors during pregnancy were associated with higher infant hair cortisol in a dose-response fashion (Karlén et al., 2015). In a small study that included 30 infants in Germany, maternal experiences of child maltreatment was positively, but not significantly associated with higher DHEA and cortisol levels ($p = 0.07$ and $p = 0.19$, respectively), in newborn hair (Schury et al., 2017).

In this prospective study, we examined the association between lifetime maternal trauma exposure through mid-gestation and offspring hair cortisol concentration assessed from one to four years of age, and tested if the association was moderated by individual differences in child sex, race, or age. We did not limit the maternal traumas to those occurring in pregnancy, based on research that maternal traumas early in life are associated with offspring development (Dubowitz et al., 2001; Roberts et al., 2014, 2013; van Ee et al., 2012). Based on prior studies that have documented a positive association between stressors and hair cortisol concentration in children (Karlén et al., 2015; Rippe et al., 2016; Simmons et al., 2016), we hypothesized a dose-response relationship between mother's lifetime trauma exposure reported at mid-gestation and children's hair cortisol concentration. In addition, we assessed whether any observed associations could be explained by premature birth or post-natal risk factors, and examined the association between maternal childhood abuse (*i.e.*, a specific subset of lifetime traumas) and offspring cortisol.

2. Method

2.1. Sample

Participants were members of the CANDLE study, which has followed the development of a racially-diverse cohort of women and children in Shelby County, TN. At baseline, the study enrolled 1503 women (ages 16–40 years) in the second trimester of pregnancy at an urban hospital obstetric clinic and community obstetric practices. Women were excluded if they had a chronic disease requiring medication, any known pregnancy complication, or planned to deliver at non-participating hospitals. Follow-up occurred during the third trimester, birth, four weeks postpartum, and annually up to the child's age of 4 years. At the 1-, 2-, 3- and 4-year clinical follow-up examinations, children were asked to provide a hair sample. We included all children with a valid hair cortisol measure at any of these 4 visits (age range = 0.85–5.96 years), and individuals could contribute more than one hair cortisol measure to the analysis. Data on 660 children were available (381 hair cortisol measures at child visit 1, 338 at visit 2, 239 at visit 3, and 61 at visit 4). Fewer mothers gave consent for hair sampling at older ages, and many CANDLE subjects had not received their 4-year clinic visits at the closure of the hair cortisol sub-study.

CANDLE children with and without cortisol data showed no differences in the maternal exposures to types of traumatic events (included subjects: mean trauma types = 3.7; excluded subjects: mean trauma types = 3.6, $p > 0.05$) or maternal exposure to number of types of childhood abuse (included subjects, mean = 0.5 types; excluded subjects, mean = 0.5 types, $p > 0.05$). The CANDLE children with hair samples were more likely to be white and less likely to be black relative to those without cortisol data (included subjects: 44.4% white, 49.8% black, 1.2% Asian, 4.6% other races; not included: 17.9% white, 78.4% black, 0.5% Asian, 3.0% other races). The University of Tennessee Health Science Center's Institutional Review Board approved each phase of the study and parents gave informed consent.

2.2. Lifetime traumatic events

Maternal traumatic life events were assessed at the second prenatal visit using the Traumatic Life Events Questionnaire (TLEQ) (Kubany et al., 2000), a validated self-report inventory of exposure to 20 potentially traumatic events (*e.g.*, natural disaster, assault, childhood abuse, *etc.*). We examined the accumulation of these events using quintiles (Roberts et al., 2014).

2.3. Childhood abuse

Three of the 20 TLEQ items assessed traumas specific to childhood: "physically punished growing up", "witnessed violence growing up", and "sexual molestation before 13th birthday". We examined each type of childhood abuse independently and created a count of types (coded 0–3).