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Blood pressure recovery to social stress in parentally bereaved and non-bereaved youths

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Abstract

Objective: To examine differences in blood pressure response and recovery in a sample of bereaved and non-bereaved youths during an acute stress task conducted 5 years after time of parental death.

Methods: One-hundred and ninety-two ($n = 192$) bereaved and non-bereaved offspring (ages 11–29) participated in an adaptation of the Trier Social Stress Task (TSST) 5-years after the time of parental death. Blood pressure measurements were collected before, during, and after the laboratory stress protocol. Mixed models for repeated measures were used to analyze the effects of bereavement status and course of psychiatric disorder in the 5-year period after parental death in both offspring and caregivers on blood pressure response; linear regression was used to examine these associations with blood pressure recovery.

Results: Although there were no differences across groups in diastolic (DBP) or systolic blood pressure (SBP) response to stress, bereaved offspring demonstrated less SBP recovery to the TSST as compared to non-bereaved offspring. A significant interaction between bereavement status and race, and a marginally significant interaction between bereavement status and sex indicated poor SBP recovery for parentally bereaved racial/ethnic minority offspring as compared to parentally bereaved Caucasian offspring, and for parentally bereaved males compared to parentally bereaved females.

Conclusions: Parentally bereaved youths demonstrate blood pressure response to social stress tasks similar to that of non-bereaved youths, but parentally bereaved ethnic/ racial minority youths and parentally bereaved males evidence a less complete recovery from the effects of stress. The health consequences of poor blood pressure recovery in bereaved youths are discussed.

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Parental death is widely recognized to be one of the most traumatic events that a child can experience¹. Record linkage, retrospective, and prospective studies suggest trajectories of negative psychological and physiological outcomes for parentally bereaved children and adolescents². Studies have shown that parentally bereaved youths are at high risk for depression, behavior problems, posttraumatic stress disorder (PTSD), and health risk behaviors (e.g. substance abuse), as well as poor academic and interpersonal functioning^{3–5}. Bereavement may confer risks to the well-being of youths from exposure to high level of stress subsequent to parental bereavement, such as caregiver psychopathology, lack of social support, and low family coherence⁶. Several mechanisms have been proposed to explain the correlation of the emotional stress of bereavement with cardiovascular risk⁷. Sustained exposure to high levels of stress may increase activity of the sympathetic nervous system, resulting in higher resting blood pressure and heart rate, which are risk factors for arterial stiffness and cardiovascular events. Chronic stress also may result in enhanced activation of the hypothalamic pituitary adrenal axis, and increase inflammatory processes that are associated with poor physical health outcomes and the progression of cardiovascular disease. Lastly, stress may increase incident of health-risk behaviors related to the development of cardiovascular disease and mortality⁸, such as poor diet, use of substances (i.e., alcohol, tobacco), physical inactivity, and behaviors that unintentionally contribute to injury, violence towards others, and/or result in unintended pregnancy or sexually transmitted infections.

To date, there have been no population-based, controlled, longitudinal studies of the effects of parental bereavement in childhood on cardiovascular health in adults. However, cross-sectional studies of young adults who experienced parental bereavement as youths have found evidence of cardiovascular dysfunction as compared to non-bereaved controls, but report inconsistent patterns of blood pressure response in parentally bereaved adults. Lueken and colleagues (1998) examined blood pressure reactivity during two laboratory based stress tasks in a group of university students who lost one parent before the age of 16 (n=30) and a non-bereaved control group (n=31)⁹. The loss group demonstrated significantly higher systolic and diastolic blood pressure at baseline, during each task, and at recovery than did the no-loss group, suggesting that early adversity may lower bereaved youths' reactivity to stress and result in heightened physiological responses to minor stressors not seen in non-bereaved youths. In a follow-up study, Luecken et al (2005) compared the blood pressure responses of young adults from families marked by parental loss, divorce, or intact marriages to an acute stress laboratory task⁶. While no main effects for family group emerged, young adults in the parental loss group endorsing lower quality family relationships demonstrated blunted blood pressure reactivity during the task and a lower magnitude of blood pressure recovery after the task. Hence, a weak physiological response to stress and incomplete recovery from stress may also indicate an altered cardiovascular response in the bereaved group.

Luecken and colleagues' studies may have produced different patterns of results in due to several limitations including small sample sizes and a lack of attention to the presence of psychiatric disorders common in bereaved youths and their caregivers after the death of a parent. The few prospective studies that examine the impact of parental loss on children have found heightened risk for psychiatric disorder and impairment 5–12 years after the death. Reinherz et al. (1999) found that parental loss before the age of 9 conveyed a 13-fold

increased risk for major depression in young adult women who had been followed longitudinally from middle childhood until young adulthood¹⁰. Brent and colleagues (2008) find that parentally bereaved youths are at increased risk for depression, post-traumatic stress disorder, and alcohol/ substance disorder for up to 21 months after the death^{4,5}. In addition, a subset of these bereaved children were found to show a prolonged grief reaction that showed no change 33 months after parental death and which was associated with functional impairment¹¹. Depression and posttraumatic stress disorder (PTSD) are associated with poor health outcomes, including cardiovascular disease^{12,13}. Schizophrenic patients demonstrated a greater delay in blood pressure recovery to a mental stress task than healthy individuals, suggesting a dysfunction of autonomic function possibly related to stress-related changes in the amygdala and prefrontal processing¹⁴. At the same time, high incident of psychiatric disorders in surviving caregivers may also indirectly increased the stress to which parentally bereaved youths are exposed. Depression, PTSD, and substance use disorders in surviving caregivers subsequent to the death may decrease their ability to be sensitive, responsive, and emotionally available to parentally bereaved children and adolescents. Impaired caregivers may be less effective in buffering bereaved youths from stress, and may increase the activation of the stress system. Over time, chronic stress may decrease the efficiency of the stress system¹⁵.

An additional area of focus and debate has been which index of cardiovascular function, high blood pressure reactivity or poor blood pressure recovery, is a better marker of later cardiovascular risk^{16–18}. Early literature on the relationship between cardiovascular response to stress and later risk for hypertension focused exclusively on the role of BP reactivity with the hypothesis that young adults who display a large BP response to psychological stress may be at increased risk for hypertension in the future¹⁹. However, more recent studies have examined BP recovery or return to baseline after a stressor as another indicator of cardiovascular health. A recent meta-analysis by Panaite and colleagues (2015) provided support for the hypothesis that slower recovery to baseline after exercise or psychological stress predicts adverse cardiovascular outcomes in adults²⁰. They found similar effect sizes for poor recovery and high reactivity to stress in predicting poor cardiovascular health outcomes in adults, and suggest that examining cardiovascular recovery from psychological and physiological challenge is an important aspect of cardiovascular health and accounts for unique variance over reactivity in predicting adverse cardiovascular outcomes. Similarly, a meta-analysis by Chida and Steptoe (2010) found strong associations of both BP recovery and reactivity with subsequent cardiovascular risk status¹⁷. A growing literature suggests that poor blood pressure recovery is predictive of long-term high blood pressure, even in healthy, normotensive adults^{21,22}. Stewart and colleagues (2001) conducted one of the few longitudinal studies of adolescents and young adults that found a positive association between delayed SBP recovery on acute stress tasks and later hypertension²². Taken together, these findings provide strong support for examining BP recovery as well as reactivity as potential indicators of later cardiovascular risk in parentally bereaved youths.

This study examined blood pressure reactivity and recovery to an acute social stress task in a sample of parentally bereaved and non-bereaved youths 5-years after time of parental (proband) death. We hypothesized that parentally bereaved youths would be more likely to have greater blood pressure reactivity and poor blood pressure recovery to acute stress than

their non-bereaved peers. In this paper, psychiatric disorders associated with blood pressure reactivity and response in offspring were considered as possible confounds and were controlled in order to isolate the influence of bereavement on the acute stress responses of participants. Exploratory analyses investigated differences in blood pressure response to acute social stressors within the bereavement group depending upon the type of proband death (sudden natural death, accidental death, or suicide). We examined stress reactivity and recovery of offspring bereaved by different type of proband death for several reasons: first, we have found differences in cortisol reactivity within bereaved youths, with blunted cortisol responses to acute stress in those who have had a parent die by suicide²³. In addition, we were also interested to explore differences in blood pressure reactivity and recovery in the sample of bereaved youths whose parents died of sudden natural death, most of which were due to cardiac events. We wished to examine whether this group of bereaved youths evidenced distinct patterns of blood pressure reactivity and recovery to social stress that may suggest a familial risk for poor cardiovascular function.

Method

Participants

Participants were 100 parentally bereaved and 92 non-bereaved offspring followed-up for the third wave of longitudinal data collection in the Impact of Parental Death Study on Children and Families. Over one-third of participants (35.9%) had at least one sibling in the study, and participants were drawn from 69 parentally bereaved families and 54 non-bereaved families. The overwhelming majority of participants in this study were children and adolescents at the time of recruitment (mean age of 12.86, range 7–24 years, with only 4.6% (n = 9) older than 18 years) and at 5-year follow-up (mean age of 17.36, range 11–29). Thus, we refer to participants in this study as “youths” with the understanding that our sample encompassed a wide developmental range but that the majority of participants were under 18 years of age at the time of study recruitment and 5-year follow-up.

Parentally bereaved youths were separated into 3 groups by deceased parents (probands) type of death: those who died within 24 hours of definite verdicts of either suicide (n = 25), accidental death (n = 15; 7 drug-overdoses, 3 motor vehicle accidents, 1 accidental fall, and 4 others, such as drowning, exposure to cold), or sudden natural death (n = 29; myocardial infarction or other heart condition (n = 22), infection (n = 1), and 6 less frequent causes, such as stroke, aneurysm, pneumonia). Non-bereaved families were recruited by frequency matching to the deceased probands on sex, age, and neighborhood. Non-bereaved offspring had two living biological parents, lived in the home of at least one of them, and had no first-degree relatives who had died within the two years prior to recruitment. The University of Pittsburgh institutional review board approved this study, and all participants gave written consent or assent.

Procedures

At the time of the 5-year assessment, bereaved and non-bereaved offspring and their caregivers completed a structured diagnostic interview and questionnaires regarding psychiatric symptoms and other measures of well-being. Offspring participated in 1-hour

laboratory protocol of physiological responses to social stress, wherein blood pressure was collected before, during, and after a 15-minute social stress task. Participants were asked to refrain from alcohol or smoking in the 24 hours prior to the test, and from eating, and ingesting caffeine in the 2 hours prior to the test. All protocols were conducted in the afternoon to control for diurnal changes in cortisol. Three measures of blood pressure, collected in the first 10 minutes of the laboratory protocol, were averaged to estimate baseline blood pressure for participants. The first measurement was dropped to adjust for adaptation to laboratory protocol.

Measures

Psychiatric Disorders.—The Schedule for Affective Disorders and Schizophrenia for School-Age Children – Present and Lifetime Version was conducted with offspring younger than 18 years of age to assess for psychiatric disorders in the past month (current) and since time of previous data collection (33 months after death of proband)²⁴. The Structured Clinical Interview for DSM-IV Axis I Disorders (SCID-I)²⁵ was administered to assess for psychiatric disorders in adult offspring and caregivers. High inter-rater reliability was maintained on psychiatric diagnoses, as indicated by kappa values of 0.74–0.85. At study entry, caregivers and offspring reported on their history of psychiatric disorders prior to the time of proband death and a psychiatric assessment of the proband was conducted, using a psychological autopsy procedure²⁶ and the SCID-I²⁵. The course of disorders in the offspring and caregiver was documented with the Longitudinal Interview for Follow-Up Evaluations²⁷, or the adolescent version.

At the time of the 5-year follow-up, retrospective and prospective psychiatric interviews yielded diagnostic information about offspring and caregivers across three periods of time: 1) psychiatric disorders prior to proband's death, 2) psychiatric disorders early in the bereavement period, 0–33 months after proband's death, and 3) psychiatric disorders later in the bereavement period, 34–62 months after death. Six individual psychiatric disorders in offspring were investigated as they related to blood pressure reactivity and recovery: depression (Major Depressive Disorder, Dysthymia, and Depressive Disorder NOS), anxiety (Generalized Anxiety Disorder, Separation Anxiety, Panic, Overanxious, and Obsessive Compulsive Disorders, Simple Phobia, Social Phobia, and Agoraphobia), Post-Traumatic Stress Disorder (PTSD), Alcohol/ Substance Disorders, Attention Deficit Hyperactivity Disorder (ADHD), and behavior disorders (Conduct Disorder, Oppositional Defiant Disorder). In addition, two composite psychiatric disorders in offspring were examined as they related to blood pressure reactivity and recovery: any psychiatric disorder and type of psychiatric disorder (internalizing, externalizing, or both internalizing and externalizing disorders). The same psychiatric variables were investigated for caregivers except for ADHD and behavior disorders, as there were too few cases ($n = 2$ and $n = 0$, respectively).

Trier Social Stress Task (TSST).—The blood pressure measurements were taken a total of 14 times before, during, and after a modified Trier Social Stress Task (TSST)²⁸, a procedure designed to induce an acute stress response in youths. Participants were seated throughout the protocol, with a cuff affixed to their upper arm for repeated, blood pressure readings using a hospital-grade, automatic non-invasive blood pressure monitor (Welch-

Allyn Blood Pressure Monitor). Participants watched a 10-minute travel video during which 3 baseline measures of blood pressure were obtained (0 minutes) and recorded. Seven blood pressure measurements were obtained as participants prepared and delivered a brief speech, and then performed a mental arithmetic task while being observed by research staff (15 minutes after baseline). Blood pressure was taken two times during the first 10-minute period after the social stress tasks (25 minutes after baseline), and two times during the second 10-minute period after the acute stress tasks were completed (35 minutes after baseline).

Blood Pressure Response and Recovery.—Diastolic blood pressure (DBP) and systolic blood pressure (SBP) were analyzed separately, as each serves a different function in the initiation and regulation of cardiovascular response to stress. Because individual blood pressure measurements are variable, individual DBP and SBP ratings were averaged to represent four time periods during the laboratory protocol: baseline (0 minutes), TSST (15 minutes), early resting state (25 minutes), and late resting state (35 minutes). DBP and SBP recovery were calculated by subtracting baseline blood pressure (0 minutes) from late resting state blood pressure (35 minutes), with positive/ higher values representing less recovery.

Covariates.—Age, sex, race (0= racial/ ethnic minority, 1= Caucasian), and history of physical or sexual abuse (0= no, 1= yes) were assessed via interview. Participants also completed an inventory of food, caffeine, tobacco, and medication usage on the day of blood pressure collection. These variables were examined as potential confounds of blood pressure reactivity and recovery in both bereaved and non-bereaved groups.

Analytic Strategy

Mixed effects regression models were used to evaluate group differences in DBP and SBP response using the *xtmixed* command in STATA 11.0, with repeated blood pressure measures nested within subjects and subjects nested within families. A level-1 variable, blood pressure sample order, modeled the pattern of within-subjects responses over time. Bereavement status served as the between-subjects dimension and non-bereaved offspring as the referent condition. As the TSST elicits blood pressure responses that are not typically linear, we compared each set of mixed effects models with time as linear versus time as a quadratic function (time²) using a likelihood ratio test. The test indicated that inclusion of the quadratic time variable significantly improved model fit (DSP $\chi^2_1=306.38$, $p<0.001$; SBP $\chi^2_1=330.07$, $p<0.001$) for our primary analyses, hence we used the linear and linear plus quadratic terms to test for change in blood pressure over time. Age, sex, and race were included as covariates based on empirical precedent and documented differences in blood pressure response to stress⁴. History of abuse, food intake or caffeine in the 2 hours prior to testing, and smoking or medications on day of testing were not associated with DBP or SBP response in this sample, and were not included as covariates in subsequent analyses.

Linear regression analyses were conducted to examine the relationship between bereavement status and SBP and DBP recovery. In addition to age, sex, and race, DBP or SBP at baseline (0 minutes) and at peak response (15 minutes) were added as covariates to regression

models. Again, history of abuse, food intake or caffeine in the 2 hours prior to testing, and smoking or medications on day of testing were not associated with DBP or SBP recovery, and were not included as covariates in subsequent analyses.

Secondary analyses included mixed effects regression and linear regression models to examine univariate associations between blood pressure response and recovery and the psychiatric histories of offspring, caregivers, and probands prior to time of proband death, and the incident psychiatric disorders in offspring and caregivers in the 0–33 months and 34–62 months after death. Offspring, caregiver, and/ or proband psychiatric variables that showed a significant effect on offspring blood pressure response were identified, to be included as covariates in our final models.

Exploratory analyses assessed differences in DBP and SBP response and recovery of offspring bereaved by accidental death, sudden natural death, and suicide as compared to non-bereaved controls. Type of death was dummy coded (1=accident, 2=sudden natural death, and 3=suicide), with healthy controls as the reference category.

Results

Descriptive Results

Out of 427 recruited at study entry, 284 youths were available for follow-up and 192 (68%) completed the acute laboratory social stress task. Youths who participated in the laboratory protocol were similar to youths who did not participate, except that youths who participated in the laboratory protocol were less likely to have a history of physical or sexual abuse ($\chi^2_1 = 4.76$, $p = 0.03$), were more likely to have a diagnosis of anxiety at study entry ($\chi^2_1 = 4.26$, $p = 0.04$), and were less likely to be either a member of a racial or ethnic minority group ($\chi^2_1 = 5.69$, $p = 0.02$).

The demographic characteristics of the 100 bereaved and 92 non-bereaved offspring are presented in Table 1. Psychiatric disorders before the time of proband death and in the 0–33 months after proband death have been presented in previous papers^{4,5,23}. The psychiatric status of bereaved and non-bereaved offspring and their caregivers in the 34–62 months after proband death are described in Table 2.

Blood Pressure Response and Recovery in Bereaved and Non-bereaved Offspring

Mixed effects regression models yielded no significant interactions between bereavement status and time for DBP or SBP, indicating no significant differences in the trajectories of blood pressure response to acute stress in bereaved and non-bereaved offspring. However, bereaved offspring evidenced a significant difference in SBP recovery as compared to non-bereaved controls ($\beta = 1.90$, standard error [SE] = 0.96, $t = 1.98$, $p = 0.05$, $d = 0.30$): parentally bereaved offspring had higher sustained SBP during the late resting period (35 minutes), whereas non-bereaved offspring demonstrated a continued decrease in SBP at 35-minutes. Bereavement status continued to be significant when covariates, age, sex, race, SBP at baseline (0 minutes) and at peak response (15 minutes) were included in the linear regression model (see Table 4). Figure 1 depicts the mean SBP scores of bereaved and non-bereaved offspring before, during and after TSST to further illustrate differences in recovery.

Subsequent analyses were limited to SBP recovery, as this was the only blood pressure variable that was significantly associated with youths' bereavement status.

SBP Recovery and Psychiatric Disorders in Offspring and Caregivers

Associations between SBP recovery and 1) psychiatric histories of offspring and caregivers before time of proband death, 2) psychiatric disorders in offspring and caregivers in the 0–33 months after death, and 3) psychiatric disorders in offspring and caregivers in the 34–62 months after proband death are presented in Table 3. All linear regressions were conducted controlling for bereavement status, a significant predictor of SBP recovery. There were no significant associations between SBP recovery to the TSST and the presence of psychiatric disorders in offspring or in caregivers before or after the time of the proband's death. Hence, psychiatric conditions in offspring and caregivers prior and subsequent to the time of proband death did not account for differences in SBP recovery between bereaved and non-bereaved youths.

Moderators.

There were no significant interactions between bereavement status and age on SBP recovery. There was a significant interaction between bereavement status and race ($\beta = 5.9$, $SE = 1.88$, $t = 3.1$, $p = 0.002$), and an interaction approaching significance between bereavement status and sex ($\beta = -2.8$, $SE = 1.44$, $t = -1.9$, $p = 0.06$) on SBP recovery. These interactions were examined by estimating and comparing the simple slopes using methods described by Aiken & West (1991) for probing interactions in regressions that contain dichotomous variables²⁹. Bereaved offspring who were racial or ethnic minorities were more likely to evidence an incomplete SBP recovery after the social stress task than were bereaved offspring who were Caucasian (see Figure 2). Bereaved offspring who were male were more likely to evidence an incomplete SBP recovery after the social stress task than were bereaved offspring who were female (see Figure 3). There was no significant 3-way interaction between bereavement status, race, and sex on SBP recovery.

Blood Pressure Response and Recovery Among Bereaved Offspring

Exploratory analyses were conducted to investigate differences in blood pressure response and recovery among parentally bereaved offspring based on proband death type: accident, sudden natural death, or suicide. Hierarchical mixed effects models indicated no significant differences in DBP or SBP reactivity over time among bereaved offspring. Linear regression models estimated the association between DBP and SBP recovery and type of proband death experienced by bereaved offspring as compared to controls. There were no significant differences in DSP or SBP recovery among offspring bereaved by proband accidental death, sudden natural death, or suicide ($p > 0.05$).

Discussion

Results from this study suggest bereavement in youths is associated with poor cardiovascular recovery to acute social stress five years after parental death. Bereaved youths showed an overall slower recovery of SBP after a stress protocol than their non-bereaved peers, although there were no significant differences in systolic blood pressure reactivity across the

groups. Furthermore, race and sex moderated these effects. Within the bereaved group, poor SBP recovery to acute social stress was only significant in racial/ ethnic minority youths and marginally significant in males. Parentally bereaved youths of racial/ ethnic minority status were less able to recover from stress activation and return to baseline as effectively as non-bereaved offspring and parentally bereaved youths who were Caucasian. Similarly, boys who experienced parental bereavement demonstrated slower SBP recovery than did parentally bereaved girls, and non-bereaved youths overall. Exploratory analyses yielded no significant differences in blood pressure reactivity and recovery among offspring bereaved by parental accidental death, sudden natural death, or by suicide.

Several mechanisms have been proposed that relate cardiovascular recovery to acute stress with cardiovascular risk status¹⁷. Some argue that delayed recovery may be the result of chronic stress increasing the allostatic load to the cardiovascular system over a long period of time, as chronic stress may decrease the efficiency by which the parasympathetic nervous system can return to a homeostatic state after exposure to acute stress¹⁵. The theory of increased allostatic load states that the physiologic responses to external stressors, while adaptive in the short-run, may come at a cost if activated for long periods. This dysfunction may result in poor blood pressure recovery. Steptoe and Marmot (2006) argue that delayed systolic blood pressure recovery may be a marker for prolonged responses in hemostatic variables that have a direct influence on cardiovascular disease pathogenesis³⁰. Delayed recovery may be a mediator or marker of psychosocial effects on cardiovascular disease. Steptoe et al (2006) showed a correlation between poor blood pressure recovery to acute stress and increased carotid intima-media thickness³¹, another risk for cardiovascular disease. Halaris and colleagues (2013) suggest that mental stress leads to a sustained sympathetic overdrive which can result in diminished vagal tone³². Poor regulation of cardiovascular homeostasis may be an early interventional indicator for cardiovascular risk¹⁷.

It is possible that the stress of bereavement also leads to poor cardiovascular health. The psychological burden of parentally bereaved youths may promote maladaptive changes on stress systems and cardiovascular health well beyond the period of acute grief. The blunted SBP recovery to acute social stress demonstrated by bereaved offspring may suggest a disturbance in the homeostatic balance due to a maladaptive process: physiological dysfunction caused by prolonged psychosocial stress. In this study, the presence of psychiatric disorders in offspring or their caregivers before or after parental death did not account for the relationship between bereavement and cardiovascular function. Race and sex emerged as important moderators of the effect of parental bereavement on SBP recovery. Within bereaved offspring, incomplete SBP recovery was significant in ethnic/ racial minority youths and males as compared to Caucasian youths and females. Racial disparities in blood pressure and cardiovascular health are well established, with African Americans at increased risk for hypertension and other sub-clinical markers of cardiovascular disease³³. Slower SBP recovery to psychological stress tasks has been documented in African Americans adults with a family history of hypertension³⁴. Differences in the experience of chronic stress, including perceived racial discrimination, economic instability, and adverse childhood events, have been proposed and studied as contributors to these racial disparities in cardiovascular function^{35,36}. In addition, a recent study suggests racial disparities in life

expectancy equates to disparities in the experience of bereavement, with African Americans more likely to experience the death of family members and friends than white Americans across the lifespan³⁷. The long-term stress of cumulative bereavement and relationship loss may also contribute to early and emerging health disparities in ethnic / racial minorities. Similarly, results from this study correspond to a literature outlining sex differences in blood pressure and cardiovascular risk. Young and perimenopausal women have lower risk of hypertension than men³⁸. Longitudinal studies of blood pressure in children, adolescents, and young adults suggest that prehypertension is more likely to emerge in males between the ages of 8–35 than in females³⁹. Observed deficits in SBP recovery in parentally bereaved males may also suggest sex differences in coping with grief, stress and negative emotions, as well as accessing support in response to interpersonal loss. Adolescent boys and young adult men who have experienced parental bereavement may be less likely than bereaved girls and women to develop social support networks⁴⁰ or access mental health services to cope with psychological distress⁴¹. Although future studies are needed to replicate these findings, racial/ ethnic minority youths and boys may be particularly vulnerable to the emotional distress experienced with parental bereavement and may evidence dysregulation in their cardiovascular response to stress.

The results from this study must be considered in light of the study's strengths and limitations. This is one of the few controlled longitudinal studies of bereaved youths with detailed data on the five-year-course of psychiatric disorder and adjustment post parental death and one of the few studies that can control for the potential confounds of psychiatric disorders in both offspring and caregivers on offspring blood pressure responses. However, there are some significant limitations. Blood pressure response was not assessed before proband death, preventing the examination of longitudinal changes in blood pressure subsequent to bereavement. Thus, we do not know when the differences emerged or whether these differences were present before bereavement. While we were able to adjust for the effects of psychiatric disorders and physical illnesses, we cannot determine whether changes in blood pressure predated psychopathology/physiology or vice versa. Next, the long duration between bereavement and examination of blood pressure allows for many possible intervening variables that were not investigated in the current study, such as parenting, changes in family relationships, and social adversities subsequent to parental death. Another limitation in this study is the low incident of the various psychiatric disorders in both the bereaved and non-bereaved offspring that may have contributed to our nonsignificant findings for the effects of depression, anxiety, PTSD, alcohol/ substance use disorders, ADHD and behavior disorders on blood pressure reactivity and recovery. As bereaved offspring evidenced higher incidence of depression and PTSD than did non-bereaved offspring, these disorder may have indirectly affected differences in recovery from the social stress task. A larger sample size is needed to determine whether psychiatric disorders in parentally bereaved offspring contribute to differences in BP reactivity and recovery to acute stress. Similarly, there was a low rate of racial and ethnic minority offspring in both the bereaved (14%) and non-bereaved (13%) groups indicating that the results from this study should be interpreted cautiously as they may be due to the small sample of minority youths in this study.

Finally, discussion of our findings must be cautious as the difference in SBP recovery detected between bereaved and non-bereaved offspring in this study was small (approximately 3–5 mmHg points) and within the normative range for blood pressure. The small differences within the non-hypertensive range of SBP recovery scores for bereaved and non-bereaved offspring are not surprising given the age and health of our sample of youths, and that blood pressure recovery to psychological rather than physical challenges typically produce smaller effects on blood pressure recovery²⁰. However, these differences still may serve as an early marker of cardiovascular risk. Studies in normotensive adults with poor BP recovery were predictive of future development of hypertension^{21,22,42}, and small change scores of BP recovery in healthy adults were still found to be modest predictors of longitudinal increases in blood pressure²².

Compared to non-bereaved youths, parentally bereaved youths exhibit a decreased ability to return to baseline levels of SBP after acute social stress, with this effect heightened in ethnic/ racial minority youths experiencing bereavement and in bereaved males. Incomplete SBP recovery may be an indicator for poor homeostatic regulation in bereaved youths, and may be associated with adverse health effects in the future. There is a current push to look into specific, altered factors that may help elucidate the pathophysiology of psychiatric illnesses and poor health outcomes or serve as markers of cardiovascular risk. Future projects would aim to form the connection between bereavement and blood pressure recovery as well as blood pressure recovery and cardiovascular disease utilizing prospective, longitudinal studies and objective measures of cardiovascular function, such as intima-thickness and left ventricular size. We need to understand the connection between bereavement, cardiovascular identifiers, and cardiovascular outcomes in order to better target intervention and prevention efforts. Longitudinal studies are necessary to examine the progression of blood pressure changes, as well as biological and physical markers (i.e. inflammatory markers, carotid intima thickness, heart morphology) of cardiovascular risk, in bereaved youths. Therapeutic interventions that focus on stress management, maintaining a healthy body mass index (BMI) and exercise routine, and reducing risky behaviors related to poor health and mortality may be particularly important for bereaved youths. These findings support the further study of the health consequences of parental bereavement in youths.

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Dr. Pham, Dr. Melham, and Ms. Porta report no conflicts of interest. Dr. Dietz will receive royalties from Oxford University Press. Dr. Brent receives royalties from Guilford Press, has or will receive royalties from the electronic self-rated version of the C-SSRS from eResearch Technology, Inc., is on the editorial board of UpToDate, and is a reviewer for Healthwise. Drs. Dietz, Melhem and Brent have received research support from the National Institute of Mental Health. This work was supported by NIMH grant R01-MH65638 (David A. Brent, Principal Investigator).

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Highlights

- Compared to non-bereaved youths, parentally bereaved youths exhibit a decreased ability to return to baseline levels of SBP after acute social stress with bereaved ethnic/ racial minority youths and bereaved males evidencing poor blood pressure recovery.
- Incomplete SBP recovery may be an indicator for poor homeostatic regulation in bereaved youths, and may be associated with adverse health effects in the future.

Fig. 1.
Systolic blood pressure in mmHg of bereaved offspring and non-bereaved offspring across time points of acute stress task.

Fig. 2. Interaction between bereavement status and race on systolic blood pressure recovery to acute social stress.

Note: The y-axis interval is the change score in systolic blood pressure from late resting state (35-minute) and baseline (0 minute) during the TSST (calculated by subtracting baseline from late resting state systolic blood pressure), with positive/ higher values representing less recovery.

Fig. 3.

Interaction between bereavement status and sex on systolic blood pressure recovery to acute social stress.

Note: The y-axis interval is the change score in systolic blood pressure from late resting state (35-minute) and baseline (0 minute) during the TSST (calculated by subtracting baseline from late resting state systolic blood pressure), with positive/ higher values representing less recovery.

Table 1

Psychiatric Characteristics of Bereaved and Non-bereaved Offspring and their Caregivers (34–62 months after time of proband death).

	Bereaved Offspring (<i>N</i> = 99)	Non-bereaved Offspring (<i>N</i> = 87)	Test	df	p
Offspring Psychiatric Status					
Depression, N (% Yes)	19 (19.2%)	6 (6.9%)	$\chi^2 = 6.0$	1	0.01
Anxiety, N (% Yes)	18 (18.2%)	9 (10.3%)	$\chi^2 = 2.3$	1	0.13
Alcohol/Substance Disorder, N (% Yes)	13 (13.1%)	6 (6.9%)	$\chi^2 = 2.0$	1	0.16
PTSD, N (% Yes)	6 (6.1%)	0 (0.0%)	FET	-	0.03
ADHD, N (% Yes)	18 (18.2%)	13 (14.9%)	$\chi^2 = 0.3$	1	0.55
Behavior Disorders, N (% Yes)	4 (4.0%)	2 (2.3%)	FET	-	0.69
Any Disorder, N (% Yes)	50 (50.5%)	28 (32.2%)	$\chi^2 = 6.4$	1	0.01
Any Disorder by Type					
No Disorder, N (% Yes)	49 (49.5%)	59 (67.8%)	$\chi^2 = 8.7$	3	0.03
Internalizing, N (% Yes)	16 (16.2%)	14 (16.1%)			
Externalizing, N (% Yes)	23 (23.2%)	9 (10.3%)			
Both, N (% Yes)	11 (11.1%)	5 (5.8%)			
Caregiver Psychiatric Status (<i>n</i> = 104)					
Depression, N (% Yes)	12 (20.0%)	4 (9.1%)	$\chi^2 = 2.3$	1	0.13
Anxiety, N (% Yes)	10 (16.7%)	4 (9.1%)	$\chi^2 = 1.3$	1	0.26
Alcohol/Substance Disorder, N (% Yes)	6 (10.0%)	2 (4.6%)	FET	-	0.46
PTSD, N (% Yes)	9 (15.0%)	0 (0.0%)	FET	-	0.01
Any Disorder, N (% Yes)	24 (40.0%)	9 (20.5%)	$\chi^2 = 4.5$	1	0.03
Any Disorder by Type*					
No Disorder, N (% Yes)	36 (60.0%)	35 (79.6%)	FET	-	0.21
Internalizing, N (% Yes)	3 (5.0%)	1 (2.3%)			
Externalizing, N (% Yes)	18 (30.0%)	7 (15.9%)			
Both, N (% Yes)	3 (5.0%)	1 (2.3%)			

Note: Missing data for 6 participants (and their caregivers) who completed the TSST but did not complete diagnostic interview for follow-up; imputed dataset was used for planned analyses.

PTSD: Post-Traumatic Stress Disorder. ADHD: Attention Deficit Hyperactivity Disorder. FET: Fisher's exact test.

* Post-hoc differences: No disorder vs. Externalizing, $p = 0.008$.

Table 2

Demographic and Health Characteristics of Bereaved and Non-bereaved Offspring.

	Bereaved Offspring (<i>N</i> = 100)	Non-bereaved Offspring (<i>N</i> = 92)	Test	df	p
Age in years, Mean (SD)	16.9 (3.1)	17.8 (4.1)	$t = -1.6$	186	0.10
Sex, N (% Female)	47 (47.0%)	45 (48.9%)	$\chi^2 = 0.1$	1	0.79
Race, N (% Minority Status)	14 (14.0%)	12 (13.0%)	$\chi^2 = 0.04$	1	0.85
Abuse History, N (% Yes)	6 (6.0%)	0 (0.0%)	FET	-	0.03
Offspring Status on day of TSST					
Eating 2 Hours Prior, N (% Yes)	73 (76.0%)	87 (94.6%)	$\chi^2 = 12.7$	1	< 0.001
Caffeine 2 Hours Prior N (% Yes)	36 (38.3%)	24 (26.1%)	$\chi^2 = 3.2$	1	0.08
Smoking, N (% Yes)	16 (17.8%)	8 (8.8%)	$\chi^2 = 3.2$	1	0.08
Medications, N (% Yes)	37 (39.4%)	27 (29.7%)	$\chi^2 = 1.9$	1	0.17

Note: Missing demographic data for 6 participants who completed the TSST but did not complete diagnostic interview for follow-up. We were able to obtain complete information for sex and race from the previous timepoint. Imputed dataset was used for planned analyses.

Table 3

Offspring and Caregiver psychiatric status predicting SBP recovery.

Characteristic	Coeff. (95% CI)	t	P > t
Offspring Psychiatric History (prior to proband death)			
Depression	0.60 (−1.8, 3.0)	0.5	0.63
Anxiety	−1.05 (−3.9, 2.6)	−0.7	0.51
Alcohol/Substance Abuse	1.04 (−1.7, 3.8)	0.8	0.43
ADHD	−0.92 (−3.5, 1.7)	−0.7	0.49
Behavior Disorder	0.40 (−2.7, 3.5)	0.3	0.80
Any Disorder	0.24 (−1.6, 2.1)	0.3	0.80
Any Disorder by Type ^a			
Internalizing	−0.43 (−3.3, 2.5)	−0.3	0.77
Externalizing	0.46 (−2.0, 2.9)	0.4	0.71
Both	1.07 (−0.6, 2.7)	1.27	0.21
Offspring Psychiatric Disorders (0–33 months after proband death)			
Depression	0.46 (−1.7, 2.6)	0.4	0.68
Anxiety	−0.94 (−3.0, 1.1)	−0.9	0.37
PTSD	−0.81 (−2.8, 3.2)	−0.5	0.60
Alcohol/Substance Abuse	0.05 (−3.9, 4.0)	0.0	0.98
ADHD	−0.15 (−1.9, 1.6)	−0.2	0.86
Behavior Disorder	0.95 (−1.0, 3.0)	0.95	0.35
Any Disorder	−0.08 (−1.9, 1.7)	−0.1	0.93
Any Disorder by Type ^a			
Internalizing	−0.04 (−2.3, 2.2)	−0.0	0.98
Externalizing	0.28 (−2.1, 2.7)	0.2	0.82
Both	−0.76 (−3.3, 1.8)	−0.6	0.56
Offspring Psychiatric Disorder (34–62 months after proband death)			
Depression	0.60 (−1.6, 2.8)	0.5	0.59
Anxiety	−0.83 (−3.3, 1.7)	−0.7	0.51
PTSD	0.52 (−4.9, 6.0)	0.2	0.85
Alcohol/Substance Abuse	1.53 (−3.2, 6.2)	0.7	0.52
ADHD	−0.44 (−2.4, 1.5)	−0.5	0.65
Behavior Disorder	0.42 (−3.1, 4.0)	0.2	0.81
Any Disorder	−0.35 (−2.2, 1.5)	−0.4	0.71
Any Disorder by Type ^a			
Internalizing	−0.14 (−3.4, 3.1)	−0.1	0.93
Externalizing	−0.58 (−2.9, 1.8)	−0.5	0.62
Both	−0.33 (−3.2, 2.6)	−0.2	0.82
Caregiver Psychiatric History (prior to proband death)			
Depression	0.05 (−1.8, 1.9)	0.1	0.96
Anxiety	0.33 (−1.5, 2.1)	0.4	0.72

Characteristic	Coeff. (95% CI)	t	P > t
Alcohol/Substance Abuse	-1.62 (-3.6, 0.4)	-1.6	0.11
PTSD	1.52 (-1.3, 4.3)	1.1	0.29
Any Disorder	-0.22 (-2.4, 2.0)	-0.2	0.84
Any Disorder by Type ^a			
Internalizing	-2.46 (-6.1, 1.2)	-1.3	0.18
Externalizing	0.64 (-1.6, 2.9)	0.6	0.58
Both	-0.61 (-3.4, 2.1)	-0.4	0.66
Caregiver Psychiatric Disorders (0–33 months after proband death)			
Depression	0.36 (-2.1, 2.8)	0.3	0.77
Anxiety	-0.63 (-3.0, 1.8)	-0.5	0.60
Alcohol/Substance Abuse	-1.94 (-4.7, 0.8)	-1.4	0.16
PTSD	-1.20 (-5.0, 2.6)	-0.7	0.52
Any Disorder	-0.76 (-3.1, 1.6)	-0.6	0.53
Any Disorder by Type ^a			
Internalizing	-1.87 (-8.0, 4.2)	-0.6	0.55
Externalizing	-0.48 (-2.9, 2.0)	-0.4	0.70
Both	-1.18 (-5.9, 3.6)	-0.5	0.61
Caregiver Psychiatric Disorder (34–62 months after proband death)			
Depression	-0.24 (-2.7, 2.3)	-0.2	0.85
Anxiety	-0.52 (-3.1, 2.0)	-0.4	0.68
Alcohol/Substance Abuse	-1.87 (-5.5, 1.7)	-1.1	0.29
PTSD	0.30 (-2.7, 3.3)	0.2	0.84
Any Disorder	-0.59 (-2.6, 1.4)	-0.6	0.55
Any Disorder by Type ^a			
Internalizing	1.89 (-3.2, 7.0)	0.8	0.44
Externalizing	-0.84 (-3.1, 1.4)	-0.7	0.46
Both	-1.06 (-5.2, 3.1)	-0.5	0.60

Note: All analyses included Bereavement Status in models. ADHD = attention deficit hyperactivity disorder, PTSD = posttraumatic stress disorder.

^aAny Disorder by Type = No Disorder (0), Internalizing [1], Externalizing [2], Both Internalizing & Externalizing [3]. No disorder (0) is the referent group in reported analyses.

Table 4

Linear regression models for SBP recovery with and without other predictors.

	Unadjusted Model			Adjusted Model		
	Coefficient (95% CI)	t	P > t	Coefficient (95% CI)	t	P > t
Bereavement Status	2.0 (0.36, 3.6)	2.4	0.02	8.4 (4.7, 12.1)	8.4	< 0.001
Age	0.2 (−0.03, 0.4)	1.7	0.09	0.2 (−0.07, 0.4)	1.4	0.18
Sex	−1.0 (−2.4, 0.50)	−1.3	0.19	0.44 (−1.7, 2.6)	0.4	0.69
Kaee	−0.1 (−2.3, 2.1)	−0.1	0.90	−2.9 (−5.2, −0.7)	−2.6	0.01
SBP (0 min)	−0.5 (−0.6, −0.3)	−7.2	< 0.001	−0.5 (−0.6, −0.3)	−7.1	< 0.001
SBP (15 min)	0.3 (0.2, 0.3)	6.6	< 0.001	0.3 (0.2, 0.4)	6.6	< 0.001
Race × Bereavement Status	-	-	-	5.9 (2.2, 9.6)	3.1	0.002
Sex × Bereavement Status	-	-	-	−2.8 (−5.6, 0.1)	−1.9	0.06

Note: Bereavement Status (1 = bereaved, 0 = non-bereaved), Race (1 = Caucasian, 0 = racial/ethnic minority), Sex (1 = male, 0 = female), SBP = Systolic Blood Pressure.