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Autonomic activity and somatic symptoms in response to success vs. failure on a cognitive task: A comparison of chronic abdominal pain patients and well children☆

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Abstract

Objectives: To compare autonomic nervous system (ANS) activity and somatic symptoms in chronic abdominal pain (CAP) patients and well children during (a) resting baseline, (b) training in a cognitive task, and (c) random assignment to success vs. failure on the task. **Methods:** The ECG was continuously recorded with a dual lead system (Biopac) in 45 CAP patients and 22 well children, ages 9–16 years (mean age=12.3). Heart rate variability (HRV) was analyzed during the 5-min resting baseline, training, and success/failure on the task. Performance expectations were assessed before the task. Gastrointestinal (GI) and non-GI somatic symptoms were assessed before and after the task. **Results:** Compared to well children, CAP patients reported lower expectations for their task performance and higher GI symptoms (P's<.05). During success, CAP patients exhibited significant increases in both sympathetic (P<.05) and parasympathetic (P<.05) activity, whereas well children exhibited no change in ANS activity. During failure, CAP patients exhibited significant increases in somatic symptoms (<.05) but no change in ANS activity. **Conclusions:** The lower performance expectations of CAP patients compared to well children may have influenced their experience of success and contributed to differences in their autonomic activity.

Keywords: Chronic abdominal pain; Heart rate variability; Coactivation; Autonomic nervous system; Stress

Introduction

Chronic abdominal pain (CAP) is a common pediatric problem that often occurs without evidence of organic disease [1,2]. Medical evaluations show that the majority of CAP patients meet diagnostic criteria for a functional gastrointestinal (GI) disorder [3–5]. Psychological evaluations link CAP to emotional distress, primarily anxiety [6,7]. For many children, somatic and emotional symptoms associated with pediatric CAP continue into adolescence and young adulthood [1,8–10].

Psychological stress is widely believed to precipitate or exacerbate abdominal pain and other somatic symptoms associated with CAP. Several studies have shown that CAP patients more frequently experience major stressful life events than children without CAP [11–13]. In addition, a

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diary study found that, in comparison to well children, CAP patients reported significantly more hassles (i.e., minor stressors) during school hours [14]; moreover, the within-subject correlation between school day hassles and somatic symptoms was significantly higher for CAP patients than for well children. These findings suggest that school may be an important source of recurring acute stress for CAP patients. Studies that expose CAP patients to acute stress under controlled laboratory conditions are needed to further our understanding of the behavioral and physiological impact of stress on CAP patients.

Stress can be defined as a real or perceived threat to homeostasis that triggers adaptive responses including behavior as well as neuromuscular, endocrine, immune, autonomic, and visceral functions [15,16]. Dorn et al. [17] conducted one of the few laboratory studies of CAP patients' physiological responses to stressors. The laboratory stressors in their study—public speaking and mental arithmetic—were similar to those children experience at school. Their physiological measures included heart rate, blood pressure, and salivary cortisol. Results indicated that both CAP patients and patients with anxiety disorders had higher levels of systolic blood pressure following the laboratory stressors, although the comparison to well children did not achieve statistical significance. The authors recommended that future research with larger samples of CAP patients examine autonomic nervous system (ANS) activity during acute stress. Another study [18] found no ANS differences between CAP patients and well children during rest and also recommended study of ANS activity in CAP patients during acute stress. The ANS provides essential communication between the central nervous system and the GI tract [19,20]. Thus, ANS activity is particularly relevant to understanding mechanisms linking psychological stress to symptoms in CAP patients.

Heart rate variability (HRV)—the beat-to-beat alterations in heart rate—serves as a noninvasive, indirect measure of ANS activity [21,22]. HRV is sensitive to acute stress [23-25]. Spectral analysis of the electrocardiogram (ECG) partitions the total variance in HRV into rhythms that occur at different frequencies. The high-frequency (HF) component of HRV is mediated by parasympathetic nervous system activity and serves as an index of vagal tone. Its measurement is proposed as a method to assess an individual's vulnerability to stress [26]. Low vagal tone (low HF) reflects lack of ANS flexibility and has been associated with a variety of poor health outcomes [27,28]. The low-frequency (LF) component of HRV has been used as an index of sympathetic influences on the heart, but this perspective has been challenged [29,30] and the autonomic correlates of LF remain uncertain. By assessing ANS influences on cardiovascular activity, spectral analysis provides a "window" onto the interaction of sympathetic and parasympathetic tone and gives more detailed information about ANS activity than heart rate itself.

The present laboratory study investigated ANS activity and somatic symptoms in CAP patients and healthy children at rest and during a task similar to a classroom assignment. Using electrocardiogram (ECG), we assessed participants' ANS activity while they learned a novel cognitive task and subsequently performed the task. Participants were randomly assigned, without their awareness, to succeed or fail on the task. Thus, we manipulated children's exposure to a stressor—task failure—and evaluated the impact of the stressor by assessing changes in ANS activity and somatic symptoms from pre- to postperformance following randomization to success vs. failure conditions.

Other investigators have observed vagal withdrawal (i.e., decreases in HF) in response to laboratory stressors such as mental arithmetic [31]. Therefore, in this study we hypothesized that CAP patients would exhibit decreased HF (parasympathetic) activity, i.e., vagal withdrawal, and a reciprocal increase in LF activity in response to task failure. We expected that these changes in autonomic activity would be significantly greater in CAP patients than well children because of CAP patients' greater vulnerability to stress. Immediately prior to beginning the task, we assessed children's performance expectations, i.e., how well they expected to perform on the task compared to other children their age. Because CAP is associated with somatization [32,33] and school stress has been linked to both GI and non-GI symptoms in CAP patients [14], we also assessed GI symptoms and non-GI somatic symptoms before and after task performance. We hypothesized that CAP patients would experience greater increases in GI and non-GI somatic symptoms than well children in response to failure on the task.

Materials and methods

Study sample

The study population consisted of 45 consecutive new patients referred for evaluation of CAP at the pediatric GI clinic of the Children's Hospital at Vanderbilt University and 22 well children recruited from participants in a health survey conducted in the local public schools.

Patients were eligible for participation if they met the following criteria: (a) primary presenting complaint of at least three episodes of abdominal pain interfering with activities during the last 3 months; (b) no chronic illness (e.g., Crohn's disease, pancreatitis, diabetes, epilepsy); (c) not on tricyclic antidepressant or beta-blocker medications; (d) child and parent able to communicate in English; and (e) child between the ages of 9 and 16 years. The same eligibility criteria (b–e) were applied to well children; those well children who reported more than two episodes of abdominal pain in the past 2 weeks were excluded.

The majority (92%) of both CAP patients and well children were Caucasian. Forty-six percent of participants came from two-sibling and 32% from three-sibling families. Neither family size nor the child's birth order differed