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Original Article

Increased Pediatric Functional Neurological Symptom Disorders After the Boston Marathon Bombings: A Case Series

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ABSTRACT

BACKGROUND: Functional neurological symptom disorders are frequently the basis for acute neurological consultation. In children, they are often precipitated by high-frequency everyday stressors. The extent to which a severe traumatic experience may also precipitate functional neurological abnormalities is unknown. **METHODS:** For the 2-week period after the Boston Marathon bombings, we prospectively collected data on patients whose presentation suggested a functional neurological symptom disorder. We assessed clinical and demographic variables, duration of symptoms, extent of educational impact, and degree of connection to the Marathon bombing. We contacted all patients at 6 months after presentation to determine the outcome and accuracy of the diagnosis. **RESULTS:** In a parallel study, we reported a baseline of 2.6 functional neurological presentations per week in our emergency room. In the week after the Marathon bombings, this frequency tripled. Ninety-one percent of presentations were delayed by 1 week, with onset around the first school day after a city-wide lockdown. Seventy-three percent had a history of a prior psychiatric diagnosis. At the 6 months follow-up, no functional neurological symptom disorder diagnoses were overturned and no new organic diagnosis was made. **CONCLUSIONS:** Pediatric functional neurological symptom disorder may be precipitated by both casual and high-intensity stressors. The 3.4-fold increase in incidence after the Boston Marathon bombings and city-wide lockdown demonstrates the marked effect that a community-wide tragedy can have on the mental health of children. Care providers must be aware of functional neurological symptom disorders after stressful community events in vulnerable patient populations, particularly those with prior psychiatric diagnoses.

Keywords: functional neurological disorder, somatoform disorder, conversion disorder, terrorism

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Introduction

Functional neurological symptom disorder (also known as somatoform or conversion disorder) is a common diagnosis in primary care,[1] neurology clinics,[2] and in the inpatient setting.[3] Often these diagnoses are precipitated by relatively common stressors, such as academic pressure or family strain,[4,5] although elicitable triggers may not be identified and are no longer required in current diagnostic criteria.[6] Nevertheless, intense and ubiquitously felt stressors, such as acts of terrorism, can also increase the frequency of functional neurological symptom disorder and other somatic complaints.[7,8] These features can last for years, with marked disability and increased health care utilization.[9] Early recognition and treatment of functional neurological symptom disorder in children lead to resolution or substantial improvement in 80-90%.[4,10] Therefore, it is crucial to recognize and treat these patients early in the course of their illness.

On April 15, 2013, two bombs were detonated at the finish line of the Boston Marathon, killing three people and

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injuring 264.[11] While media coverage of the bombings was extensive, in the immediate aftermath, most children saw little disruption in their daily lives—school and work schedules returned to normal on April 16. However, 4 days after the attacks, officials requested a lockdown of Boston and surrounding cities to facilitate the search for the remaining suspect. Businesses and schools closed, families were instructed to stay inside with doors and windows locked, and armored vehicles patrolled the streets. During this 24-hour period, media coverage was difficult to avoid.

In a recent quality improvement project, we studied patients who presented to our pediatric emergency room with functional neurological disorders.[12] These prior patients (presenting 6-36 months before the bombings) allowed us to determine the frequency, characteristics, and outcomes of functional neurological abnormalities in our pediatric population. The Boston Marathon bombings allowed us to determine the impact of a shared high-intensity stressor on our pediatric population and to study whether high-intensity and casual stressors have distinct impacts on functional neurological symptom disorders in children.

Methods

We adapted the protocol of our previous study[12] with the addition of measures to assess the specific impact of the Marathon bombings. Our Institutional Review Board approved this protocol as a quality improvement project and did not require patient consent for chart review or follow-up contact.

Beginning on the day of the Boston Marathon bombings (April 15, 2013), we prospectively identified patients whose differential diagnosis included a functional neurological symptom disorder. We excluded patients with primarily somatic complaints and pain (e.g., headaches) because these diagnoses are difficult to separate from organic disorders in the emergency room setting. Pediatric neurology residents (post-graduate year 3-5) performed a full clinical history and examination on each patient. Data collected included age, gender, nature of abnormalities, date of onset, pre-existing medical and psychiatric diagnoses, and evident stressors (physical and/or sexual abuse, academic difficulties, bullying, extrafamilial relationships, family stressors, contact with the bombing, and school closure).

Follow-up information was gathered by combined chart review and phone interview. All subjects agreed to participate. The diagnosis of functional neurological symptom disorder was confirmed by attending neurologists after admission (five patients), outpatient follow-up with a senior neurologist or psychiatrist (five patients), or by an attending ophthalmologist (one patient). Follow-up by chart review and telephone calls occurred 4-6 months after presentation, with the exception of two patients who were reached 10 months after presentation. Three authors (D.B.P., M.E.B-L., and R.M.G.) conducted follow-up calls with parents in all cases but one, in which case information was gathered from the 19-year-old patient directly. Follow-up data were collected through structured telephonic interview as described elsewhere[12] with the additional inquiry into (1) whether the patient's school was closed during the lockdown and (2) whether the parent felt the bombings or lockdown was a stressor for their child.

Daily incidence was calculated for functional neurological symptom onset and for emergency room presentation—both measures produced similar results. We compared baseline and post-event incidence of functional neurological symptom disorders using a zero-inflated Poisson regression model. The high number of zero values (no patients on a given day) required this variation on the more-common Poisson regression. This model allowed us to estimate the incidence of functional neurological disorder on any given day for periods before and after the city-wide lockdown on Friday, April 19.

Results

For the 2 weeks after the Boston Marathon bombings (Tuesday, April 16, to Tuesday, April 30), 11 patients presented to our pediatric emergency room with findings suggestive of functional neurological symptom disorder (Table). Symptom onset for the majority (eight of 11 patients) was delayed to the second week after the bombings (Figure). We found a 3.4-fold increase from the baseline frequency of presentations in our emergency room[12] (baseline incidence, 0.46; 95% confidence intervals, 0.11-0.82; post-bombings incidence, 1.6; 95% confidence intervals, 0.31-2.9; $P = 0.048$).

Attending neurologists and/or psychiatrists confirmed that functional neurological symptom disorder was the sole explanatory diagnosis in 10 of 11 patients. The final patient (one of 11) had functional abnormalities superimposed on a possible medication side effect. The diagnostic accuracy of this initial suspicion (91%) is comparable with that previously demonstrated in childhood functional neurological symptom disorder.[12]

TABLE.
Demographic Information for Patients Diagnosed With a Functional Neurological Disorder

Age, yr	Gender	Presentation	Psychiatric Comorbidity	Neurological Comorbidity	Stressors	Symptom Duration (days)
7	F	Sensory	Somatoform	No	None	30
10	F	Weakness/gait	No	BRE	None	1
10	F	Sensory	No	No	Academic, bullying, bombing	Intermittent
12	M	Weakness/gait	Anxiety	No	None	14
12	M	Mixed	Anxiety, depression	No	Academic, family	60
12	F	Weakness/gait	Anxiety	Neuroinflammatory	Academic, family	>150
15	M	Sensory	Anxiety	Abdominal migraines	Academic, bombing	10
15	F	Motor/sensory	Psychosis	Epilepsy	Bullying	7
15	F	Mixed	Anxiety	No	Nonspecific	42
17	F	Mixed	Anxiety	Yes	Academic	60
19	F	Sensory	No	Pseudotumor cerebri	None	14

Abbreviations:
BRE = Benign rolandic epilepsy
F = Female
M = Male
Stressors and symptom duration were assessed by parental recall at follow-up.

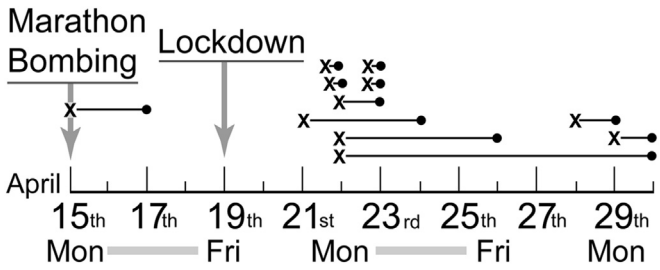

FIGURE
Timeline of functional neurological symptom onset and presentation. Each X indicates the day of symptom onset. Each circle indicates the day of presentation to our emergency room. Eight of 11 patients had symptom onset centered on the first day of school after the city-wide lockdown (April 22, ±1 day), a threefold increase in incidence ($P = 0.048$).

One girl had a prior diagnosis of a multifocal demyelinating disorder, and on casual assessment, her functional abnormalities might have been attributed to that earlier diagnosis. However, physical examination and neuroimaging studies were not consistent with recrudescence of her organic disorder. During the 6 months of follow-up, she had fluctuating signs of both functional and organic abnormalities and required serial magnetic resonance images to differentiate between diagnoses. This patient's symptoms continued beyond the 6-month follow-up interval, so the number of symptomatic days during the 6-month follow-up period was used as a proxy for duration.

Follow-up by review of electronic records and by telephone contact at 6 months after presentation confirmed the functional diagnosis in 11 of 11 patients. No patients developed a new diagnosis that could adequately explain their functional abnormalities. Eight of 11 (73%) patients had a pre-existing psychiatric comorbidity, and six of 11 (55%) carried a premorbid neurological diagnosis (Table). Nine of 11 patients (82%) were female, with a mean age of 12.9 years (range, 7-19 years). Average symptom duration was 25 days (range, 1-60 days). Patients missed between 1 day and several months of school in a bimodal distribution, with a lower mean of 2.3 days (six patients) and upper mean of 62.4 days (five patients). The latter group's mean was influenced by one individual who missed greater than 5 months of school related to both functional and organic neurological disorders. After excluding that outlier, the upper mean duration was 40.5 days (four patients). None of the patients had direct contact with the bombing, none were related to each other, and none attended the same school. Most parents (eight of 11, 73%) did not recognize the bombings as a specific stressor. Only three of 11 students (27%) had a school closure on the Friday after the bombings, and one additional student had a "shelter in place" drill. Other reported stressors included academic (five of 11 patients), bullying (two of 11 patients), nonspecific (two of 11 patients), and family (two of 11 patients). No apparent stressor was reported in five of 11 patients (45%).

Discussion

Nationwide surveys immediately after the September 11 attacks found that 44% of American adults and 35% of children experienced "substantial stress,"[13] in spite of their not living in areas that suffered attacks and having no direct contact with victims of the attacks. Likewise, in a survey of 4675 households in 2 weeks after the Boston Marathon bombings, high levels of acute stress were equally likely in Boston-area residents and residents of either New York City or a nationwide sample.[14] Such ubiquitously felt stresses have led to increases in psychiatric and functional neurological presentations after large-scale traumatic events, including the September 11 attacks in New York City,[15,16] the Oklahoma City bombing,[17] and attacks on Israeli civilians.[18] We found a similar pattern in children after the bombings at the Boston Marathon, with a threefold increase in cases presenting to our pediatric emergency room in the week after the bombings.

The demographics of functional neurological symptom disorder patients after this acute shared stressor were similar to our prior study: mean age of 12.9 years (14.8 at baseline); 81% female (67% at baseline).[12] Neurological comorbidities were equally frequent between acute and baseline populations (both around 50%). One intriguing difference in our acute shared stressor population is the doubled incidence of a prior psychiatric diagnosis: 73% post-bombings versus 30% at baseline. Psychiatric comorbidities in patients presenting with functional abnormalities are common. Koszlowska et al.[1] reported that 42% of their series of 194 children had a comorbid psychiatric diagnosis. It is likely that functional neurological complaints after acts of terrorism are the greatest in the most vulnerable patients.[15] This doubling in the incidence of prior psychiatric features suggests that acute severe stressors may elicit functional neurological symptom disorders in pediatric populations distinct from those susceptible to casual ubiquitous stressors.

We initially hypothesized that the direct impact of the bombings would induce an increase in functional neurological symptom disorder presentations. However, there was no direct link between our patients and the Boston Marathon bombings or their aftermath: no patients or families were injured or present at the Marathon; a minority of our patients (four of 11) experienced school closure or terror-preparedness drills; only three of 11 parents or patients endorsed that the events surrounding the Marathon bombings were a specific stressor. Likewise, in our patients, the timing of symptom onset and presentation correlated only weakly with the bombings and most strongly with the first school day after the city-wide lockdown (Figure). It is possible that pediatric functional abnormalities require a latency period between stressor and onset; this hypothesis conflicts with our prior experience, and we found no previous studies arguing for such a delay. Another potential explanation is that functional abnormalities actually began shortly after the bombings, but that fear of further attacks and firm instructions to "shelter in place" led families to delay presentation to our hospital. However, patients and families were unambiguous in their estimation of symptom onset—the peak of functional symptom onset was 1 week after the bombings.

We hypothesize that the threefold increase in functional neurological symptom disorder presentations was produced by a shared intense stressor that reached every Greater Boston community and that surrounded the manhunt and lockdown to a greater extent than the

bombings themselves: the swell of media coverage. This has been reported with prior shared traumatic events. In adolescents, total media exposure correlated with both posttraumatic stress disorder and anxiety disorder after the September 11 attacks; media exposure had a stronger correlation with findings than direct exposure to the attacks or having an involved family member.[19] Likewise, after the Boston Marathon bombings, high levels of media exposure were stronger predictors of acute stress than being present at the Marathon or having a family member injured.[14]

Our study has several limitations. First, although our review at 6 months (in 11 of 11 patients) revealed no new diagnoses of organic neurological disorders, it is possible that such alternate diagnoses might arise at a later time point. However, as the rate of misdiagnosis in functional disorders is only 0.4% (based on 1030 adults monitored for 18 months),[20] such diagnostic revision appears unlikely. Second, our method of ascertainment specifically excluded patients with non-neurological somatic abnormalities (e.g., headache, functional abdominal pain) and those with purely psychiatric abnormalities (e.g., anxiety, psychosis). Therefore, although our results are informative to the clinical practice of neurologists, our methods lead to an underestimation of the full psychological impact of the Boston Marathon bombings. Third, it is impossible to derive a causal relationship from this small sample, collected during a time of generalized fear and uncertainty. Indeed, a definitive assessment of trauma's effects on childhood functional abnormalities may prove difficult because large-scale stressors are generally unpredictable. Our report and others[19] have relied on fortuitous accidents, with concurrent data collection in the affected population. One potential approach to this methodologic challenge might focus on semipredictable natural events, such as large-scale hurricanes, with pre-existing infrastructure geared to health assessment and intervention. The challenges and cost of such an experimental approach underscore the difficulty in assessing the psychological impact of large-scale trauma.

Conclusions

That functional neurological abnormalities in children are increased after terrorism is well known.[18] The threefold increase in presentations after the Boston Marathon bombings and lockdown supports the dramatic effect that a community-wide tragedy can have on the mental health of children. Emergency preparedness efforts must recognize that functional presentations are likely to increase after shared traumatic events. Indeed, in similar settings to that after the Boston Marathon bombings (survivors of missile attacks in Israel), 43% of individuals presenting for acute care were "psychological casualties."[21] As functional neurological symptom disorder presentations in children may be delayed (as in this study, by 1-2 weeks), acute care providers must be trained to recognize this "second wave" of trauma victims. Functional neurological symptom disorders are highly disabling[22,23] and lead to substantial loss of educational and workplace productivity.[24,25] Early recognition and treatment are among the strongest predictors of recovery.[4,10] Disaster management plans that proactively address functional abnormalities after large-scale traumatic events will improve the outcome of children with functional neurological symptom disorder.

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The heads of children sometimes grow enormously large, the sutures give way, and the membranes of the brain are pushed up with the water within, and make a soft tumor rising above the edges of the sutures. This disorder happens to weakly children, and has been growing upon them for above a month. They daily become more and more stupid, with a pulse not above seventy-two. They can hardly be got to take anything for the last week, even out of a spoon, and seem to have no sense, and hardly utter any sound, and have frequent little convulsions.

Upon opening a child who died in this manner, half a pint of water was found in the ventricles. I have no experience of the use of any other means than purging and blistering, and these have not succeeded. The subjects of the hydrocephalus are chiefly children of both sexes, from the first to the eighth year of their life.

William Heberden
Commentaries on the History and Cure of Disease, 1802