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Frequency of primary neck pain in mild traumatic brain injury/ concussion patients.

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Abstract

Objectives: To determine (1) the frequency of neck pain overall and relative to other symptoms in patients presenting to a level I trauma center emergency department (ED) with mild traumatic brain injury (mTBI) and (2) the predictors of primary neck pain in this population.

Design: Cohort study

Setting: Level I trauma center ED

Participants: 95 patients presenting to the ED with symptoms of mTBI having been exposed to an event that could have caused a mTBI.

Interventions: Not applicable

Main outcome measures: Frequency of self-reported neck pain as measured by Sport Concussion Assessment Tool—3 (SCAT3) symptom questionnaire at <3, 8, 15, and 45 days post-injury. Primary neck pain defined in two ways (1) neck pain rated as equal or greater in severity than all other SCAT3 symptoms and (2) neck pain worse than all other symptoms.

Results: The frequency of any reported neck pain was 68.4%, 50.6%, 49%, and 41.9% within 72 hours and at 8, 15, and 45 days, respectively. Frequency of primary neck pain (equal or worse/worse definitions) was 35.8%/17.9%, 34.9%/14.5%, 37%/14.8% and 39.2%/10.8% across the four follow-up assessments. Participants who sustained their injuries in motor vehicle collisions had a higher rate of primary neck pain than those with other mechanisms of injury.

Conclusions: A sizable percentage of patients who present to level I trauma center EDs with mTBI report neck pain, which is commonly rated as similar to or worse than other mTBI-related symptoms. Primary neck pain is more common after motor vehicle collisions than with other mechanisms of injury. These findings support consensus statements identifying cervical injury as an important potential concurrent diagnosis in patients with mTBI.

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Preliminary results of this study were presented at a Medical College of Wisconsin spine research day August 10 of 2018. This was attended by Medical College of Wisconsin faculty and community providers.

Keywords

Mild traumatic brain injury; Concussion; Neck pain; Emergency Department

The United States saw 2.8 million emergency department (ED) visits, hospitalizations, and deaths related to traumatic brain injury (TBI) in 2010 over 80% of which are categorized as mild traumatic brain injury (mTBI) per acute injury statistics[1]. Consensus and position statements regarding sport-related concussion (a form of mTBI) recognize the possibility for comorbid cervical spine injury and make clinical recommendations for this possibility [2, 3]

Given this level of consensus regarding the possibility of comorbid cervical spine injury in patients with mTBI, it is interesting to note the lack of formal research dedicated to detailing the frequency, course of recovery or validation of treatments in this population.

To the authors' knowledge there has only been one small study using physical exam of the cervical spine to assess the frequency of cervical spine injury and concussion in hockey players, which found 100% of concussed subjects had whiplash findings on exam [4]. In a sample of patients involved in motor vehicle collisions (MVC) involving a strike to the head, 90% reported neck pain at the time of injury and 25% reported neck pain at twelve-month follow-up. [5, 6]. These findings align with other work suggesting that, like mTBI, cervical injuries are likely to occur during MVCs [7, 8]. Regarding cervical spine symptoms affecting course of recovery, a recent study found that the absence of neck pain was a positive predictor of complete recovery following mTBI [9].

Recent systematic reviews on treatment/rehabilitation following sport-related concussion recommend examination of the cervical spine in patients with continued symptoms; empirical support for this recommendation is based primarily on one randomized controlled trial (RCT) [10, 11]. In particular, the RCT studied the addition of cervical spine manual therapy, cervical spine rehabilitation, and vestibular rehabilitation to patients with prolonged concussion symptoms following sport related concussions and found that this decreased the time for clearance to return to activity in comparison to controls [12]. Additionally, we are aware of three relevant case series, which collectively described the successful treatment of prolonged concussion symptoms, in patients with both sport-related and non-sport-related concussions, with treatment of the cervical spine consisting of manual therapy, exercise and vestibular rehabilitation [13-15].

The objective of this study was to estimate the frequency and predictors of primary neck pain in a population of patients presenting to a level I trauma center ED with uncomplicated mTBI (i.e., mTBI with no evidence of intracranial injury on clinical computed tomography [CT] scans of the head). We performed secondary analysis of data from a recent prospective study in which participants with recent mTBI provided ratings of mTBI and related symptoms (e.g., neck pain) at several post-injury time points [16]. In addition to reporting the overall frequency of reported neck pain in this population, we further delineated neck pain based on the severity of neck pain in comparison to other symptoms. Other variables including cause of injury, race, age, sex, witnessed loss of consciousness (LOC), and involvement in litigation were assessed to see if they were predictive of primary neck pain.

We hypothesized that primary neck pain would be a commonly reported symptom in the civilian ED mTBI population and that it would be more commonly reported in patients injured in MVCs than patients injured in falls.

Methods

Participants

The sample was derived from participants in Project Head to Head I, which prospectively enrolled a convenience sample of ED patients treated between September 2012 and May 2014 at an academic medical center that serves the emergent needs of the local community as well as being the region's only level I trauma center. Participants completed informed consent before their first evaluation and were compensated \$210 for their time and effort in completing all assessments. Testing procedures were approved by the Institutional Review Board at the Medical College of Wisconsin.

The study design, screening/enrollment flow chart, and recruitment procedures have been described in prior publications from this study[16, 17]. Briefly, we monitored each patient being treated in the ED and attempted to approach any patient who appeared to meet inclusion and exclusion criteria and to have been exposed to an event that could cause an mTBI (i.e., motor vehicle-traffic crashes, falls, assaults, or struck by/against an object events; [7]). An attempt was made to enroll consecutive admissions to the ED. However research staff was not in the ED twenty four hours per day. Of the 98 participants who completed informed consent and were enrolled into the mTBI group, one did not complete any assessment procedures after consenting to participate and two were withdrawn after the first assessment when it was discovered they met exclusionary criteria (neurologic disorder and positive head CT), yielding a final sample for analysis of 95 participants with mTBI. A sample of trauma control participants without mTBI were also enrolled in the study but were not included in the current secondary data analysis project as the focus of this project was to identify the frequency of primary neck pain in mTBI patients.

Inclusion and Exclusion Criteria

Our definition of mTBI was based on that of the study sponsor, the U.S. Department of Defense: "mTBI is defined as an injury to the brain resulting from an external force and/or acceleration/deceleration mechanism from an event such as a blast, fall, direct impact, or motor vehicle accident which causes an alteration in mental status typically resulting in the temporally related onset of symptoms such as headache, nausea, vomiting, dizziness/ balance problems, fatigue, insomnia/sleep disturbances, drowsiness, sensitivity to light/ noise, blurred vision, difficulty remembering, and/or difficulty concentrating"[18].

Inclusion criteria for participation were age (18–45 years; the age range of interest to the study sponsor), loss of consciousness less than 30 min, posttraumatic amnesia less than 24 hours, no acute intracranial findings on brain imaging (if available), proficient in English, and able to present for the initial assessment within 72 hr of injury. Subjects were excluded if they had an injury that precluded participation in the study protocol (e.g., hand injury that prevented use of a computer mouse), current diagnosis of a psychotic disorder, history or

clinical suspicion of other conditions (e.g., epilepsy, stroke, dementia) known to cause cognitive dysfunction, and history of moderate or severe TBI.

Assessment Protocol

The study protocol involved completion of post-injury examinations conducted within 72 hours of injury and at 8 (± 1), 15 (± 2), and 45 (± 5) days post-injury. Mean (SD) time from injury to follow-up was 39.03 (21.62) hr, 7.94 (1.16) days, 14.63 (1.54) days, and 43.94 (3.93) days for the 72-hr and 8-, 15-, and 45-day time points, respectively. Tests were individually proctored by a research assistant in a quiet setting, nearly always with only one participant being examined at a time. Participants were either first assessed immediately after being medically discharged from the ED or they made an appointment to return another time. The assessment began with a one-on-one interview of contact information, demographics, and health history information followed by a neuropsychological assessment battery comprising two computerized neurocognitive assessments [16], the Sport Concussion Assessment Tool 3 (SCAT3) [3], and the Wechsler Test of Adult Reading (WTAR). Follow-up assessments began with an interview about subjects' recoveries followed by the same neuropsychological assessment battery, with the exception of WTAR. To reduce the burden on participants to come to our office for assessment, day 8 follow-up appointments were completed via phone and only obtained recovery and SCAT3 symptom ratings (see below).

The testing protocol consisted of a variety of assessments, which are described in the detail in a previously published paper on this dataset [16]. Of primary relevance in this study, SCAT3 symptom checklist was collected at each follow-up assessment. The SCAT3 symptom checklist is a 22-item self-report checklist of post-concussive symptoms including neck pain (each rated from 0-none to 6-severe, with the resulting symptom severity scores ranging from 0 to 132) [3]. Higher scores reflect greater symptom burden. The recovery interview administered at each assessment also asked patients to report whether or not they felt clinically recovered from their mTBIs and, if recovered, to estimate the duration of their symptoms.

Statistical Analyses

Statistical analyses were largely descriptive in nature and focused on characterizing the frequency of primary neck pain over time in the sample. For reporting the overall frequency of endorsement of neck pain, we considered any rating of 1 (mild) to 6 (severe) to reflect symptom endorsement. We defined *primary neck pain* in two ways based on participants' responses to the SCAT3 symptom checklist: (1) neck pain rated as worse than all other 21 SCAT3 symptoms (worse than definition) and (2) neck pain rated as worse than or equal to the most highly rated of the 21 other SCAT3 symptoms (equal or worse than definition).

Second, we explored the degree to which the occurrence of primary neck pain, using either definition, was associated with demographic and injury variables. We used generalized estimating equations (GEE) with a logit link function to accommodate the binary outcome of primary neck pain alongside its repeated measurements across time (<72 hours, day 8, day 15, day 45). Predictors were identified through a combination of theoretical interest and

sufficient sample size (>10) to expect reasonable power to detect significant effects. These included: age, race (black vs. white), sex, cause of injury (motor vehicle crash vs. fall vs. other), LOC, and self-reported involvement in injury-related litigation. Infrequently reported causes of injury (assault, struck by/against) were aggregated into an “other” category for analysis. Race groups with limited endorsement were not analyzed. Each predictor was entered in a separate model alongside Time and the predictor $\times$ Time interaction, with non-significant interactions dropped from the final models reported. Repeated measure interactions were also checked however none were significant and these were dropped from the model. An unstructured working correlation matrix was used, although sensitivity analyses demonstrated that the findings were not sensitive to the correlation matrix structure used. Alpha was set to .05. Analyses were performed using IBM SPSS Statistics version 24 [19].

Results

Sample Characteristics

The demographic makeup and acute injury characteristics of the sample are presented in Table 1. Eight participants self-reported a history of psychiatric disorder of these, six of whom reported having a mood disorder and two an anxiety disorder.

The frequency of self-reported acute injury characteristics supportive of the presence of mTBI were 36.8% loss of consciousness, 15.8% posttraumatic amnesia (beyond any window of unconsciousness), and 6.3% retrograde amnesia. (Additionally, by virtue of our inclusion criteria, all participants endorsed experiencing altered mental status at the time of injury.) The percentage of the sample that completed day 8, 15 and 45 follow-up assessments was 83 (87.4%), 81 (85.3)% and 74 (77.9%), respectively. Participants who did versus did not complete follow-up were not significantly different at any time point in age, gender, race, WTAR standard score, insurance type, cause of injury, or acute (< 72-hr) SCAT3 symptom severity.

The percentage of all subjects who reported subjective recovery from mTBI symptoms by 1 week, 1 month, and 45 days post injury was 21.6%, 50.0%, and 54.9%, respectively. Approximately one third (35.2%) of the sample was still symptomatic at the final 45 day visit, and 9.9% of subjects were symptomatic at an earlier visit but did not complete later visits[20].

Frequency of Neck Pain

Table 2 details the percentages of any reported neck pain at each time point. Neck pain was endorsed with a frequency of 68.4%, 50.6%, 49%, and 41.9% at < 72 hours, 8 days, 15 days and 45 days respectively. Of the total 22 symptoms collected on the SCAT 3, neck pain was ranked as the 5th, 9th, 9th and 3rd most common symptoms at < 72 hours, 8 days, 15 days and 45 days respectively.

Frequency of Primary Neck Pain

Figure 1 details the frequency of primary neck pain based on both operational definitions. When defining primary neck pain as neck pain equal to or worse than other symptoms, the percentage of participants reporting primary neck pain was 35.8%, 34.9%, 37% and 39.2% at < 72 hours, 8 days, 15 days, and 45 days post injury, respectively. Using the more restrictive worse than definition brought the percentage of participants with primary neck pain to 17.9%, 14.5%, 14.8% and 10.8% across the four time points.

Predictors of Primary Neck Pain

Primary neck pain, using the worse than definition, was significantly positively associated with Cause of Injury ($p = .022$) such that individuals injured in an MVC had higher odds of reporting primary neck pain across time than those with Other causes ($OR = 5.24$, $p = .023$) and Falls ($OR = 2.52$, $p = .069$), whereas odds of primary neck pain was not significantly different for Other causes versus Falls ($OR = .48$, $p = .383$). The overall mean prevalence of primary neck pain (and 95% confidence intervals) by cause of injury (19% MVC; 9% Fall, 4% Other) is depicted in Figure 2. Other demographic and injury variables were not significantly associated with this primary neck pain outcome in GEE models: sex ($p = .425$), age ($p = .867$), race ($p = .639$), LOC ($p = .803$), and litigation ($p = .367$). Associations between predictors and the equal or worse than definition were nonsignificant for all predictors: sex ($p = .439$), age ($p = .469$), race (.844), cause of injury (.695), LOC ($p = .201$), and litigation ($p = .542$).

Discussion

To our knowledge this is the first study to detail the frequency of reported primary neck pain in a prospective sample of ED patients with mTBI. Primary neck pain rates remained relatively stable from within 72 hours of mTBI to 45 days post-injury. Over one third of mTBI patients (35.8-39.2%) report neck pain amongst their most severe symptoms within 72 hours of injury and persistent at 45 days post injury. 10.8-17.9 percent of patients reported neck pain as their most severe symptom through the first several weeks after mTBI. Irrespective of other symptoms, about two thirds (68.4%) of mTBI patients experienced neck pain within 72 hours of injury and nearly half (41.9%) had some degree of persistent neck pain at 45 days post injury. This overall frequency of neck pain is similar to but somewhat less than prior reports of patients with mTBI having been involved in a MVC in which they struck their head, which found 90% reporting neck pain at the time of injury and 50% reporting neck pain the six-week time point in the same sample[5, 6]. The somewhat higher rates of neck pain found in these other studies could be explained by the inclusion criteria requiring a motor vehicle/traffic crash as the cause of injury and also requiring the patient to have struck their head. That we found that motor vehicle crashes were associated with more primary neck pain than falls supports this hypothesis.

Motor vehicle accidents are known to cause acceleration deceleration at the head and neck. The published magnitudes of impact accelerations to the head known to cause concussion well exceed the lowest published magnitudes of acceleration known to cause a whiplash injury[15]. Given this, it is feasible that MVC may cause comorbid mTBI/concussion and

cervical spine injury. The cervical spine, when injured, is known to cause symptoms very similar to mTBI such as headache, fatigue, concentration problems and others [21]. From a clinical standpoint, this can make identifying which clinical entity is responsible for continued or prolonged symptoms very challenging.

A previous analysis of this dataset showed that involvement in litigation was associated with increased overall reported symptom severity[20]. Interestingly, reporting of primary neck pain was not associated with involvement in litigation during the studied period. This finding, alongside our finding of an expectable association between cause of injury and frequency of neck pain, support the validity of our approach to defining primary neck pain from self-report symptom checklist data.

Our study builds on previous studies, which have reported neck pain as being common in patients with mTBI symptoms [5, 6]. Given the frequency of reported primary neck pain in our sample, we feel that this supports the statements in consensus/position statements recommending evaluation of the cervical spine in patients reporting cervical spine symptoms associated with a mTBI. Further studies should prospectively assess the rate of cervical spine injury in patients with mTBI symptoms with appropriate physical exam of the cervical spine as well as evaluation for mTBI.

Study Limitations

The study has multiple limitations. Subjects were evaluated in a laboratory setting within 72 hours of injury; reports of neck pain may not generalize to the acute ED setting. There was loss to follow-up (16% at 45 days post-injury) which contributed to smaller sample sizes for some data points. Given that this study was done only at one institution we may not be able to generalize these findings to populations different from those similar to our urban level I trauma center population. Given the study design and how data were collected, there is no way to account for any effect that ongoing treatment that the participants received for their symptoms such as medical treatment, including medications and other therapeutic options such as physical therapy, or chiropractic care may have had on reporting of neck pain. As there was no physical examination of the participants in this study and concussion related symptoms are very common in the non-injured adult population, we cannot truly determine how common cervical spine/soft tissue injuries were in the sample. Additional limitations include a lack of control group and follow-up only to 45 days.

Conclusions

In summary, we found that a sizeable percentage of adult patients presenting to a level I trauma center ED with mTBI also reported neck pain, which was often as severe or worse than other mTBI-related symptoms. Having sustained one's injury in a motor vehicle accident (vs. a fall) was associated with a higher rate of primary neck pain. These findings provide empirically support for clinical consensus statements identifying cervical injury as an important potential concurrent diagnosis in patients with mTBI. Additional study is needed to confirm these findings with objective physical examinations and to identify the treatment implications of having concurrent cervical injury alongside mTBI.

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Abbreviations:

ED	Emergency Department
mTBI	Mild traumatic brain injury
MVC	Motor vehicle collisions
TBI	Traumatic brain injury
RCT	Randomized controlled trial
LOC	Loss of consciousness
CT	Computed tomography
SCAT3	Sport Concussion Assessment Tool—3
WTAR	Wechsler Test of Adult Reading
GEE	Generalized estimating equations

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Highlights

- A significant number of adult patients with mTBI also report neck pain
- Neck pain was often as severe or worse than other mTBI symptoms
- Motor vehicle collision was predictive of neck pain

Figure 1:
Frequency (and 95% confidence interval) of primary neck pain by time and definition.

Figure 2.

Overall frequency (and 95% confidence interval) of primary neck pain by cause of injury. Data derived from a generalized estimating equations model of primary neck pain (defined as neck pain worse than other symptoms) incorporating time as a repeated measures variable.

Table 1.Sample characteristics (*N* = 95)

	<i>M (SD) or N (%)</i>
Gender (female)	38 (40.0%)
Age	29.2 (7.6)
Race	
Black	49 (51.6%)
White	38 (40.0%)
Other/unknown	8 (8.4%)
Psychiatric diagnosis	8 (8.4%)
WTAR standard score	93.5 (17.3)
Health insurance type	
Commercial	19 (20.0%)
Government	45 (47.4%)
None	30 (31.6%)
Other/unknown	1 (1.1%)
Prior history of mTBI	33 (34.7%)
Cause of injury	
Motor vehicle-traffic	57 (60.0%)
Fall	24 (25.3%)
Assault	4 (4.2%)
Struck by/against	10 (10.5%)
Litigation related to injury	25 (28.1%)
Worker's compensation injury	15 (15.7%)

mTBI = mild traumatic brain injury; WTAR = Wechsler Test of Adult Reading

Table 2.

Percentage of patients reporting symptoms at each time point.

	Percentage of patients with mTBI reporting each symptom over time			
	< 72 hours	8 days	15 days	45 days
Headache	81.1	71.1	59.3	37.8
Pressure in head	80.0	55.4	50.6	37.0
Neck pain	68.4	50.6	49.0	41.9
Nausea	32.6	28.9	21.0	15.1
Dizziness	51.6	34.9	28.4	23.0
Blurred vision	37.9	25.3	30.9	24.3
Balance problems	41.1	33.7	42.0	32.4
Sensitivity to light	58.9	47.0	40.7	27.0
Sensitivity to noise	37.9	31.3	27.2	18.9
Feeling slowed down	67.4	56.6	51.9	33.8
Feeling like in a "fog"	55.8	41.0	35.8	17.6
Don't feel right	72.6	51.8	54.3	31.5
Difficulty concentrating	68.4	60.2	56.8	41.7
Difficulty remembering	61.1	55.4	58.0	41.1
Fatigue	73.7	62.7	61.7	54.8
Confusion	40.0	30.1	28.4	19.2
Drowsiness	58.9	53.0	51.9	48.6
Trouble falling asleep	41.3	43.4	37.5	31.1
Emotional	46.3	45.8	39.5	27.0
Irritable	52.6	39.4	45.7	33.8
Sad	50.5	36.1	35.8	21.6
Nervous or anxious	47.9	30.1	31.2	29.7