



Characterization of the occult nature of frequently occurring pediatric motor vehicle crash injuries



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ABSTRACT

Background: Occult injuries are those likely to be missed on initial assessment by first responders and, though initially asymptomatic, they may present suddenly and lead to rapid patient decompensation. No scoring systems to quantify the occultness of pediatric injuries have been established. Such a scoring system will be useful in the creation of an Advanced Automotive Crash Notification (AACN) system that assists first responders in making triage decisions following a motor vehicle crash (MVC).

Study Design: The most frequent MVC injuries were determined for 0–4, 5–9, 10–14 and 15–18 year olds. For each age-specific injury, experts with pediatric trauma expertise were asked to rate the likelihood that the injury may be missed by first responders. An occult score (ranging from 0–1) was calculated by averaging and normalizing the responses of the experts polled.

Results: Evaluation of all injuries across all age groups demonstrated greater occult scores for the younger age groups compared to older age groups (mean occult score 0–4yo: 0.61 ± 0.23 , 5–9yo: 0.53 ± 0.25 , 10–14yo: 0.48 ± 0.23 , and 15–18yo: 0.42 ± 0.22 , $p < 0.01$). Body-region specific occult scores revealed that experts judged abdominal, spine and thoracic injuries to be more occult than injuries to other body regions.

Conclusions: The occult scores suggested that injuries are more difficult to detect in younger age groups, likely given their inability to express symptoms. An AACN algorithm that can predict the presence of clinically undetectable injuries at the scene can improve triage of children with these injuries to higher levels of care.

1. Introduction

Individual facets of injury after motor vehicle crashes (MVCs), such as mortality (Weaver et al., 2013; Doud et al., 2015; Kilgo et al., 2003, 2013; Meredith et al., 2002, 2003a, 2003b), time sensitivity (Schoell et al., 2015b; Doud et al., 2017a), predictability (Schoell et al., 2017, 2012, 2015a), and disability (Doud et al., 2017c), influence a patient's need for treatment at a trauma center (TC) rather than a non-TC (Stitzel et al., 2016). As such, these individual facets of injury should be identified and incorporated into triage decisions made at the time of the injury. Advanced Automatic Crash Notification (AACN) algorithms can provide an important adjunct to trauma triage decisions made by first responders at the scene. Such algorithms utilize a vehicle's telemetry data to predict the injuries sustained among occupants. Based on these injuries and the mortality, time sensitivity, predictability and disability

associated with the injuries, the AACN algorithm can provide first responders with a recommendation of which occupants may require treatment at a dedicated TC rather than a non-TC (Stitzel et al., 2016; Champion et al., 2003; Lahaussé et al., 2008; Clark and Cushing, 2002; Kononen et al., 2011). This recommendation would be used within the Centers for Disease Control and Prevention (CDC) field triage guidelines in Step 3 (vehicle telemetry data consistent with a high risk of injury) to supplement information that first responders collect on-scene (i.e. visual inspection, physiological measurements, anatomical indicators of injury) (Centers for Disease Control and Prevention, 2011). Thus, if a patient is negative for Step 1 and 2 in the guidelines, a high risk of injury indicated by an AACN algorithm could be used to inform transport to a trauma center (Lee et al., 2017).

AACN algorithms may be particularly useful in alerting first responders to the presence of unpredictable injuries (Schoell et al., 2017,

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2012, 2015a). Predictability quantifies the extent to which an injury may be occult, or missed by medical care providers upon initial assessment. This is particularly important when applied to first responders, as their initial assessment of the patient’s injuries dictates whether the patient is transported to a TC or not. Though occult injuries may have an initial silent period, they may suddenly become apparent and lead to rapid patient deterioration after the initial triage decision has already been made (Murray et al., 1997; Buduhan and McRitchie, 2000). Thus, prompt identification of potentially life-threatening occult injuries on the scene may allow for decreased under-triage of MVC occupants. Decreasing under-triage will reduce the prevalence of inter-facility transfers, thus reducing the time to definitive treatment and cost of care (Ross et al., 2012; Soundappan et al., 2007) and improving patient morbidity and mortality (Sampalis et al., 1997; Garwe et al., 2011).

In order to incorporate the facets of injury into triage decision-making, AACN algorithms require metrics defining each particular aspect. Prior work has focused on defining metrics to quantify the mortality (Doud et al., 2015), disability (Doud et al., 2017b), time sensitivity (Doud et al., 2017a), and transfer frequency (Doud et al., 2017c) of the most common injuries among pediatric occupants. Other work has focused on quantifying the occultness of common MVC-induced injuries in the adult population (Schoell et al., 2017) but no such study has attempted to do so among children, in whom the identification of injuries may be more challenging due to difficulties in communication of symptoms and other factors (Huelke, 1998). As such, the purpose of this paper is to develop a quantifiable score to define the relative occultness (or predictability) of the most common MVC-induced injuries among children for future incorporation into an AACN algorithm.

2. Materials and methods

Institutional Review Board approval was obtained for retrospective review of the National Automotive Sampling System - Crashworthiness Data System (NASS-CDS) and for administration of an electronic survey of expert opinion.

2.1. Selecting the injuries to survey: Top 95% most frequent motor vehicle crash injuries

NASS-CDS years 2000–2011 were utilized to determine the most common injuries among pediatric occupants in MVCs. The purpose of the NASS-CDS analysis was to select the injuries to include in an electronic survey of expert opinion on the occultness of common pediatric MVC injuries. NASS-CDS collects data on a representative, random sample of thousands of minor, serious and fatal tow-away crashes in the United States. Weighting factors are applied to provide a population-based estimate of the incidence of particular injuries associated with

MVCs in the United States (National Highway Traffic Safety Administration, 2011). Requirements for NASS-CDS crash investigations changed in 2009 such that many variables after this time were not collected for model year vehicles greater than 10 years old. Therefore, cases with such missing data were excluded from our analysis. To account for potential overly-influential weighting factors in NASS-CDS, we employed the technique described by Samaha et al. (2013). Thus, vehicles were stratified by vehicle type (passenger car, van or truck) and curb weight. Any NASS-CDS weighting factors above the 99th percentile in each stratified group were trimmed to this percentile.

Pediatric MVC occupants 18 years of age or younger were analyzed and divided into four age classifications based upon injury patterns previously studied by this group (Doud et al., 2016) and coinciding with commonly-used CDC groupings (Borse et al., 2009). Thus, children were grouped into the following age categories: 0–4, 5–9, 10–14, and 15–18 years. In order to capture the most salient injuries, Abbreviated Injury Scale (AIS) 1 severity injuries were excluded since they are mostly minor abrasions and contusions. Within each age group, the weighted injury counts of each AIS 2+ injury were summed and the injuries were ranked in order of decreasing incidence. The most frequently occurring injuries comprising the top 95% of the cumulative weighted injury count were included on that age group’s “Top 95% Injury List.” Injuries on the Top 95% Injury Lists from all four age groups were included as questions in a survey to collect ratings from experts on the occultness of injuries (described in the next section).

2.2. Survey of experts in pediatric care

The occult survey is electronic and was developed using Google Web Toolkit v2.5.0-RC1. The survey was deployed via personal email requests (containing a link to the survey) to pediatric surgeons, pediatric orthopaedic surgeons and pediatric emergency medicine physicians within the Wake Forest Baptist Health System. Additionally, we collected recommendations for experts to poll outside the Wake Forest Baptist Health System and based upon these recommendations, we sent personal emails with the survey link to these individuals. The survey was also deployed through the Childress Institute for Pediatric Trauma (CIPT) to medical practitioners with expertise in caring for children with traumatic injuries. This included physicians (MDs), nurse practitioners (NPs), physician assistants (PAs) and experienced emergency department registered nurses (RNs).

For each age-specific injury, participants were asked to assess the likelihood of the injury or symptoms related to the injury being missed upon initial assessment by first responders on a 5-point Likert scale (Fig. 1; Supplementary material). An occult score of 5, represented by the red buttons, indicates a highly occult injury – or highly likely to be missed. An occult score of 1, indicated by the green buttons, indicates a less occult, more obvious injury.

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Injury Description: Liver laceration moderate (OIS Grade III)

Occult: How likely would first responders be to miss symptoms related to this injury?

	0-4 Years	5-9 Years	10-14 Years	15-18 Years
Occult	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Not Occult	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Comments:

Fig. 1. Sample question from the Occult Survey.

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