Quality of Resuscitative Care Provided to an Infant with Abusive Head Trauma in Community Emergency Departments: An In Situ, Prospective Simulation-Based Study

Authors:

Riad Lutfi, MD[1]
Department of Pediatrics, Division of Pediatric Critical Care
Indiana University School of Medicine and Riley Hospital for Children at Indiana University Health
705 Riley Hospital Drive, Riley Phase 2 Room 4900
Indianapolis, Indiana 46202-5225
Email: rlutfi@iu.edu

Zachary J Berrens, MD[1]
Department of Pediatrics, Division of Pediatric Critical Care
Indiana University School of Medicine and Riley Hospital for Children at Indiana University Health
705 Riley Hospital Drive, Riley Phase 2 Room 4900
Indianapolis, Indiana 46202-5225
Email: zberrens@iu.edu

Laurie L Ackerman, MD[2]
Department of Neurosurgery,
Indiana University School of Medicine and Riley Hospital for Children at Indiana University Health
705 Riley Hospital Drive, Room 1601
Indianapolis, Indiana 46202-5225
Email: lackerma@iuhealth.org

Erin E Montgomery, RN[3]
LifeLine Critical Care Transport, Indiana University Health
Indianapolis, Indiana 46202-5225
Email: white20@iu.edu

Manahil Mustafa, MBBS[1]
Department of Pediatrics, Division of Pediatric Critical Care
Indiana University School of Medicine and Riley Hospital for Children at Indiana University Health
705 Riley Hospital Drive, Riley Phase 2 Room 4900
Indianapolis, Indiana 46202-5225
Email: mmmustaf@iu.edu

Michele L Kirby, RN[3]
LifeLine Critical Care Transport, Indiana University Health
Indianapolis, Indiana 46202-5225
Email: mlbaumga@iu.edu

Kellie J. Pearson, RRT[3]

This is the author's manuscript of the article published in final edited form as:
Lutfi, R., Berrens, Z. J., Ackerman, L. L., Montgomery, E. E., Mustafa, M., Kirby, M. L., ... & Abulebda, K. (2022). Quality of resuscitative care provided to an infant with abusive head trauma in community emergency departments: an in situ, prospective, simulation-based study. Pediatric Emergency Care, 38(1), e337-e342. https://doi.org/10.1097/PEC.0000000000002277

LifeLine Critical Care Transport, Indiana University Health
Indianapolis, Indiana 46202-5225
Email: kleeper@iuhealth.org

Samer Abu-Sultaneh, MD[1]
Department of Pediatrics, Division of Pediatric Critical Care
Indiana University School of Medicine and Riley Hospital for Children at Indiana University Health
705 Riley Hospital Drive, Riley Phase 2 Room 4900
Indianapolis, Indiana 46202-5225
Email: sultaneh@iu.edu

Kamal Abulebda, MD[1]
Department of Pediatrics, Division of Pediatric Critical Care
Indiana University School of Medicine and Riley Hospital for Children at Indiana University Health
705 Riley Hospital Drive, Riley Phase 2 Room 4900
Indianapolis, Indiana 46202-5225
Email: kabulebd@iu.edu

[1]Division of Pediatric Critical Care Medicine, Department of Pediatrics, Indiana University School of Medicine and Riley Hospital for Children at Indiana University Health, Indianapolis, Indiana

[2]Department of Neurosurgery, Indiana University School of Medicine and Riley Hospital for Children at Indiana University Health, Indianapolis, Indiana

[3]LifeLine Critical Care Transport, Indiana University Health, Indianapolis, Indiana

Corresponding Author:
Riad Lutfi, MD, FAAP
Department of Pediatrics, Division of Pediatric Critical Care
Indiana University School of Medicine and Riley Hospital for Children at Indiana University Health
705 Riley Hospital Drive, Riley Phase 2 Room 4900
Indianapolis, Indiana 46202-5225
Phone: 317- 944-1405
Fax: 317-944-7267
Email: rlutfi@iu.edu

Declarations

Ethics approval and consent to participate

This study was administratively reviewed by the Institutional Review Board of Indiana University and determined to be not human subjects research.

Number 1509259968

Not Human Subjects

Consent for publication

Not applicable

Availability of data and material

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests

Funding

Indiana university health values fund for education: VFE-332-Lufti

Authors' contributions

Drs. RL, SA and KA were the leaders of this project and were involved in the conception and design of the project, reviewed the available pertinent literature, data collection, drafted of the initial manuscript, and gave final approval of the manuscript.

All authors were involved in the conception and design of the project, met regularly with the project leader to review preliminary data, performed critical revisions of the manuscript, and granted final approval of the manuscript.

Acknowledgements

We would like to thank the members of pediatric critical care division at Riley Hospital for Children at IU health and Indiana University Health Lifeline for their support and help in this project.

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Abstract

Objectives: Abusive head trauma (AHT) is a very common and serious form of physical abuse, and a major cause of mortality and morbidity for young children. Early Recognition and supportive care of children with AHT is a common challenge in community emergency department (CEDs). We hypothesized that standardized, in situ simulation can be used to measure and compare the quality of resuscitative measures provided to children with AHT in a diverse set of CEDs.

Methods: This prospective, simulation-based study measured teams' performance across CEDs. The primary outcome was overall adherence to AHT using a 15-item performance assessment checklist based on the number of tasks performed correctly on the checklist.

Results: Fifty three multi-professional teams from 18 CEDs participated in the study. Out of 270 participants, 20.7% were physicians, 65.2% registered nurses, and 14.1% were other providers. Out of all tasks, assessment of airway/breathing was the most successfully conducted task by 53/53 teams (100%). Although 43/53 teams (81%) verbalized the suspicion for AHT, only 21/53 teams (39.6%) used hyperosmolar agent, 4/53 teams (7.5%) applied cervical spine collar stabilization, and 6/53 teams (11.3%) raised the head of the bed. No significant difference in adherence to the checklist was found in the CEDs with an inpatient pediatric service or these with designated adult

trauma centers compared to CEDs without. CEDs closer to the main academic center outperformed CEDs these that are further away.

Conclusion: This study used in situ simulation to describe quality of resuscitative care provided to an infant presenting with AHT across a diverse set of CEDs, revealing variability in the initial recognition and stabilizing efforts and provided and targets for improvement. Future interventions focusing on reducing these gaps could improve the performance of CED providers and lead to improved patient outcomes.

Introduction

Child maltreatment is a considerable social and public health problem in the United States. Reports from the Department of Human and Health Services showed that 674,000 (9.1 victims per 1,000 children in the population) were identified as victims of child abuse and neglect with a nationally estimated 1,720 children died from abuse or neglect in 2017 [1]. This equates to a rate of 2.32 children per 100,000 children in the general population or an average of nearly five children dying every day from abuse or neglect [1]. Physical abuse represents 18.3% of all children maltreatment [2-4]. Abusive head trauma (AHT) in particular is a very common and the most serious form of physical abuse. AHT is a major cause of severe traumatic brain injury (TBI) in young children. It accounts for 80% of death resulting from child maltreatment injuries, making it the leading cause of

traumatic death for children younger than 1 year of age [3,5,6]. Additionally, two-thirds of children who survive AHT have significant neurologic consequences.

AHT is difficult to diagnose and is often missed due to misleading history, subtle nonspecific presentation, and lack of consistent signs of injury [7]. Children with AHT initially present at a diverse set of emergency departments where frontline providers must recognize and provide immediate treatment [8,9]. The majority of these children (>90%) seek care in community emergency departments (CEDs) that are not solely prepared to care for children [10]. Several studies show that physical abuse is more commonly missed at CEDs, and that fewer children are diagnosed with an AHT at CEDs in comparison to pediatric EDs due to misdiagnosis and other challenges innate to working in CEDs [9,11]. This is aligned with national reports showing CEDs are generally less prepared than pediatric centers and have limited access to resources, guidelines, and pediatric services and specialists due to a limited national specialist workforce [12,13,10,14]. Although data reveals disparities in the quality of care and outcomes of pediatric trauma patients presenting to CEDs in comparison to pediatric EDs, there is limited data describing the quality of care and management provided to patients with AHT presenting to CEDs. Research in pediatric AHT has mainly focused on deficiencies in CEDs recognition of AHT and reluctance of providers to report suspicious injuries. Given the significant morbidity and high fatality in pediatric patients with AHT compared to non-abusive brain injury, it is important to accurately describe current practices among CEDs providers regarding acute supportive care of AHT and to identify opportunities for improvement [15].

Research describing the recognition of AHT among children in CEDs is limited by an underestimated incidence of AHTs, cost and logistic difficulties. Additionally, the lack of clear consensus regarding goals of management and treatment of AHT contributes to the lack of standardized guidelines once AHT is diagnosed in the CED [16]. Therefore, we leveraged the use of in situ simulation as an investigative methodology to measure the quality of care to children with AHT in CED settings. In situ simulation provides a robust tool for the measurement of the processes of patient care and adherence to standards of care [17,18]. In situ simulation allows the research team to evaluate the quality of care delivered by multi-disciplinary healthcare teams using their own equipment and clinical resources [19]. Simulation has developed into a valuable tool to measure clinical performance and discover safety threats and system issues in high-risk clinical settings [20,21].

The objectives of this study were to 1) evaluate the quality of resuscitative care in CEDs caring for an infant presenting with a severe AHT in simulated setting and to 2) assess changes in providers self-reported comfort in managing pediatric patients with AHT presenting to their emergency department after pediatric AHT simulation.

Materials and Methods:

Study Design, Setting and Population:

This is a prospective simulation-based study designed to measure the performance of multi-professional teams providing stabilization efforts in a simulated 3-month old infant

presenting with severe AHT. The Institutional Review Board at Indiana University School of Medicine approved this study.

The study team research coordinator contacted sites through established relationships at each CED. All site visits were scheduled in coordination with each hospital's CED medical director and/or manager. The study was conducted between January 2018 and February 2019 across 18 CEDs with varying patient volumes and locations throughout the state of Indiana to provide a diverse representation of CEDs. Staff was recruited to participate in the simulation sessions by the site manager or medical director who served as a pediatric champion for their site. The CED participant teams were composed of registered nurses (RN), respiratory therapists (RT), emergency medicine physicians, and physician assistants. Pharmacists and emergency medical services were also included if available, since they are normally part of the resuscitation team. Team size was limited to 4 to 6 participants per simulation scenario to reflect the actual clinical setting. All participants were protected from clinical duties during the simulation sessions. To encourage participation, continuing medical education credits were offered to the participants free of charge.

CED demographics such as annual pediatric volume, distance to academic medical center (AMC), and the availability of a pediatric inpatient service were documented. CED’s pediatric volume was categorized based on Emergency Medical Services for Children's definitions for pediatric patient visits per year (low (<1800), medium (1800–4999), and

medium to high (5000–9999)).

A collaborative education team of pediatric intensivists, pediatric emergency physicians, two pediatric critical care transport nurses and a pediatric respiratory therapist from the main AMC in the state of Indiana named “Pediatric Community Outreach Mobile Education PCOME” conducted the study. All members of the educator team had undergone training in simulation and reflective debriefing.

Simulations:

Each CED visit started with a presentation to introduce the educator team, describe the agenda for the day, and provided the participants with the rules and expectations regarding the simulation sessions.

All CED teams participated in a standardized in situ simulation for a 3-month infant patient with a severe AHT presenting to their ED. Simulation sessions took place in the actual CED rooms using each site’s actual equipment (e.g. infusion pumps), supplies (e.g. syringes) resources (ex: cognitive aids), and policies/guidelines.

Before each simulation session, participants were oriented to the functionality of the high fidelity simulator (SimNewB® designed by Laerdal, New York, USA). The team was introduced to the embedded participant that was used as a parent. The case was started with a brief scenario that included a patient history and chief complaint. Laboratory data were provided on request on pre-printed laminated cards, including standard point-of-care testing (e.g., venous blood gas, dextrose, electrolytes, radiologic imaging) (supplementary file 1, 2).

Each scenario ran for 20 minutes and was followed by a 40-minute post-simulation reflective debriefing. Facilitator-guided post-event debriefing using three phases structure (reaction, analysis, summary) was used to ensure the relevant issues and learning objectives identified during the scenario were addressed. Debriefings were structured to focus on opportunities for improvement resuscitative care of the multi-professional team and to identify knowledge deficits and latent safety threats. We also distributed a pediatric AHT flowchart to each site that incorporates guidelines and recommendations for AHT evaluation and management (Figure. 1) [22].

Outcome Measures:

The primary outcome of this study was the quality of stabilization efforts provided to a pediatric patient presenting with AHT as measured by adherence to critical action checklist. Content validity evidence of the checklist was provided through adaptation of established guidelines and a consensus-based approach by a multidisciplinary expert panel of pediatric critical care, pediatric emergency medicine, and pediatric neurosurgery team members. The checklist piloted within our institution prior to use in this study. To further validate the checklist, the checklist was also piloted at four CED sites not included in our study and changes based on learnings from these sites were made as prior to starting this study.

During the simulation sessions, team performance was scored in real-time by two separate facilitators documenting the number of checklist items performed correctly.

After the simulation was complete, the facilitators discussed differences in their respective scoring to reach a consensus score. This two approach increased the likelihood that if the team was performing two checklist items simultaneously, that one of the facilitators would document item completion. A case performance score was calculated using equal weighting for all subcomponents and dividing by the total number of possible elements to derive the composite adherence score (CAS) on a scale of 0 to 100.

CED providers' self-reported confidence/comfort level managing pediatric patients with abusive head trauma was collected after each simulation session. After each simulation session, participants completed a survey assessing their confidence/comfort regarding the management of AHT in their CED. The participant self-assessment followed a 1 to 5 Likert scale (1 = no confidence/understanding and 5 = complete confidence/ understanding).

Statistical Analysis:

Basic descriptive statistics were calculated as frequencies (percentages) for categorical variables and medians (inter-quartile ranges) for continuous variables. Associations between hospital characteristics and CAS scores were analyzed using Wilcoxon rank-sum tests for categorical variables and Spearman rank-sum correlation analyses for continuous variables, due to non-linear distribution of CAS scores. Analyses were performed using SAS v9.4 (SAS Institute, Cary, NC).

Results

Participating Hospitals and Team Characteristics

Fifty-three multi-professional teams from 18 CED sites located within 100 miles from the main pediatric AMC were enrolled in the project between January 2018 and February 2019. None of the participating CEDs had a separate pediatric ED. Eight of the 18 CEDs are certified adult trauma hospitals: one CED was level 1, two CEDs were level 2, and five CEDs were level 3. A total of 270 participants were involved in the simulations, of which 20.7 % were physicians, 65.2 % were nurses, 9.3 % were respiratory therapists, and 4.8 % were other staff (paramedics, pharmacists, or students). Detailed team characteristics and CED site demographics are shown in Table 1.

Simulation Performance Outcomes

Out of all tasks, assessment of airway/breathing was the most successfully conducted task by 53/53 teams (100%) followed by placing an IV/IO access by 52/53 teams (98%). Assessment of circulation, neurological exam and full body exposure were conducted by 53%, 55% and 47% of teams, respectively. Although 43/53 teams (81%) verbalized the suspicion for AHT and 49/53 teams (94.5%) verbalized the need for head CT, only 21/53 teams (39.6%) used hyperosmolar agent, 4/53 teams (7.5%) applied cervical spine collar stabilization, and 6/53 teams (11.3%) applied neuroprotective measures. The median CAS for all teams was 60.8%.None of the teams were adherent to all AHT checklist stabilization tasks. (Table. 2).

Effects of hospital CEDs characteristics on teams' performance

No significant difference in the composite adherence score (CAS) was found between CEDs with an inpatient pediatric service and those without onsite pediatric units or CEDs with and without adult trauma center designation. Teams from low to medium pediatric volume CED had significantly higher CAS than teams from medium to high volume CEDs (CAS 67% vs 53%, p=0.0168, Table 3). Teams from CED sites closer to the main AMC had higher CAS score compared to CEDs that are further from the AMC (p=0.002) (Table 3).

Course Evaluation Outcome

Two hundred sixty-two participants completed post-simulation surveys (8 participants left the session early because of clinical duty). The vast majority of participants (95%) found the simulation session increased their comfort in the recognition and management of AHT pediatric patients. Ninety-eight percent of participants indicated that they would alter their current practice of AHT management based on the education received during the simulation session (Table 4).

Discussion

This study demonstrated gaps in the quality of resuscitative care provided to an infant presenting with an abusive head trauma across a diverse spectrum of CEDs in a simulated setting. In this study, our simulation-based assessment revealed variability in the initial recognition of an infant presenting with AHT to CEDs and the quality of resuscitative efforts provided by CED teams. Additionally, it demonstrated differences in quality of

stabilization efforts among CEDs teams based on their pediatric patient volume or distance from the academic medical center. This is the first study that uses simulation-based methodology to measure the quality of resuscitative care of a pediatric patient with AHT within the actual care setting.

In the US, less than 10% of injured children are initially cared for at a children's hospital or pediatric trauma center. They more commonly present to the nearest CED for initial work up and stabilization at facilities where pediatric emergency care is a low-frequency event [15]. Outcome disparities between CEDs and pediatric trauma centers for pediatric trauma patients persist, likely secondary to limited resources, distance to appropriate pediatric trauma centers, and a lack of pediatric surgeons and/or specialists available at the CED [23-25]. Recent studies targeting collaborative improvement programs to enhance the quality of care provided to pediatric trauma patients in CEDs have been successful [26,27].

Children with AHT are at higher risk for poor outcomes given the younger age, higher incidence of seizure, inconsistent recognition, and lack of pediatric specialists readily available [28]. However, very limited work had done to evaluate and improve CEDs teams providing acute resuscitative care to pediatric patients with AHT through implementing targeted educational interventions [29] [30]

Our study revealed several important findings. While 100% of teams performed initial airway assessment, only half of the teams assessed circulation, neurological status and performed full body exposure. These items represent important steps in the primary

survey of a pediatric trauma patient [31]. This could be explained by the lack of recognition of a potential trauma given the initial presentation as a "lethargic infant". Hunt et al reported similar deficiencies in the stabilization of children presenting to CEDs in simulated setting making this a potential target for future intervention including team training and providers' competency [32].

Although 81% of teams verbalized their concerns regarding a potential AHT during the simulated scenarios, only 7% of CEDs providers applied an appropriate cervical collar. Similarly, only 11% of teams elevated the head of bed at 20-30 degrees, and 39% of teams appropriately used hyperosmolar agent in respond to vital sings changes correlating with increased intracranial pressure. During debriefings, one of the barriers to use cervical collar is the lack of availability of appropriate sizes for an infant patient. It was also noted that most teams failed to apply neuroprotective measures due to the lack of familiarity with the pediatric best practices and the low exposures to these injuries in their CED setting. This could be attributed to the lack of consensus regarding treatment goals in the context of AHT and the difficulty in applying TBI literature guidelines to population with AHT [16]. This is an important finding and clinically relevant since TBI management guidelines in children focuses on preventing secondary brain injury to improve outcomes given that TBI secondary to AHT is a major cause of death and disability and is considered a "silent epidemic"[33, 34].

Despite previous reports that higher pediatric volume CEDs showed better adherence to best practices and established guidelines of care than lower volume CEDs [35], our study

showed different findings. This is potentially due to the small sample size and /or to a lack of pediatric trauma-specific guidelines in the CEDs where we conducted our study. Interestingly, in our cohort CEDs closer to the AMC had higher composite adherence scores than more distant CEDs. These finding are consistent with a previous study showing improved quality of resuscitative care in CEDs that are more proximal to the AMC, and this could be explained by the fact that more proximal CEDs have more frequent interaction with the pediatric trauma center and easier access to pediatric specialists and resources [36].

Our simulation-based initiative was well received by CEDs providers. Ninety-nine of participating providers reported increased comfort in the recognition of AHT. Furthermore, 98% self-reported increased comfort in management of a pediatric patient presenting with AHT to their ED. This is likely due to the immediate post simulation debriefing conducted after each scenario that allowed all team members to reflect on their own performance and provided opportunities to implement suggestions for continuing learning to improve future individual and team performance. Samples of the participants' reflective comments were "Very informative without making you feel bad for not knowing all the answers. We need more of these", "No one was intimidating but gave great constructive criticism" Additionally, the AHT flowcharts we distributed during the debriefings provided a cognitive gain among providers (figure 1).

Our study has several limitations. We measured the quality of resuscitative care in simulated setting using a checklist that has not been validated using a known validation

framework. Despite a growing body of literature on AHT as a distinct form of TBI, there remains a dearth of evidence AHT acute targeted therapies making it difficult to extrapolate accidental TBI guidelines to AHT population. To mitigate that, relevant items in the checklist were derived from best practices and guidelines and were reviewed by a multidisciplinary expert group of critical care physicians, pediatric emergency physicians, a pediatric trauma surgeon and a pediatric neurosurgeon at our institution. It was also pilot tested prior to its implementation in the study. Study results may be limited by the relatively close geography of the participant sites to the AMC, and the results may not be generalizable to CEDs that are further from the AMC. Finally, it is difficult to ensure that simulated scenarios are sufficiently realistic, and it is challenging to demonstrate that learning from simulation sessions will translate into improved care in patient care.

Conclusions

Using in situ, high fidelity simulation our study revealed high variability in quality of resuscitative care provided to children with abusive head trauma across a diverse set of community emergency departments. We identified several deficiencies in the initial stabilization of children presenting with AHT that serve as a basis for the development of future educational interventions targeted at providers in CEDs. Future research should investigate whether interventions focused on these deficiencies can improve the quality of care provided in simulated and potentially clinical setting, and ultimately, improve the outcomes of children with AHT presenting to CEDs.

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Tables

Table 1. Characteristics of Participating Teams and Community Emergency Departments

Team characteristics	
Number of teams	53
Number of Participants	270
Number of MDs, number (%)	56 (20.7%)
Number of RNs, number (%)	176 (65.2%)
Number of RTs, number (%)	25 (9.3%)
Number of Others, number (%)	13 (4.8%)
CED characteristics	
Number of CEDs	18
CED pediatric volume	
Low	2 (11.2%)
Medium	8 (44.4%)
Medium to high	8 (44.4%)
Affiliation with AMC	5 (27.8%)
Distance from the AMC (miles)	46 (19,60)
Presence of inpatient pediatric unit	12 (66.7%)

Certified Adult Trauma Hospitals	8 (44%)
Data presented as number (%) or median (25th, 75th interquartile range) MD: Physician; RN: nurse; RT: respiratory therapist; CED: community emergency department; AMC: academic medical center; ICU: intensive care unit.	

Table 2. Abusive Head Trauma Management Adherence Checklist.

#	Item	N (%)
1	Assesses airway/breathing In first 5 min	53 (100%)
2	Assesses circulation In first 5 min	28 (52.8%)
3	Assesses neurological status In first 5 min	29 (54.7%)
4	Performs full body exposure	25 (47.2%)
5	Places IV/IO	52 (98.1%)
6	Orders relevant labs (basic metabolic panel or point-of-care blood gas)	40 (75.5%)
7	Verbalizes concerns for AHT	43 (81.1%)
8	Verbalizes concerns of increased ICP	35 (66.0%)

9	Applies C-collar stabilization	4 (7.5%)
10	Verbalizes the need of head CT	49 (92.5%)
11	Applies neuroprotective measures: HOB elevated 20-30 degrees	6 (11.3%)
12	Uses appropriate hyperosmolar agent: 3% HTS: 5-10 ml/kg Mannitol: 0.25-1 gm/kg	21 (39.6%)
13	Considers patient intubated prior to transport	35 (66%)
14	Notifies child protective service/Social worker	32 (60.4%)
15	Arranges for tertiary center transport	31 (58.5%)
	Complete Adherence Score (CAS)	60.8%

Table 3. Effects of Hospital Characteristics on Composite Adherence Scores

Variable	**CAS**	***p*-value**
Availability of inpatient pediatric services ● Yes ● No	 0.60 (0.47 – 0.73) 0.63 (0.60 – 0.73)	 .2361
Distance from the AMC	-0.4129	.0021
Affiliation with the AMC o Yes o No	 0.53 (0.40 – 0.67) 0.63 (0.53 – 0.73)	 .0662
CED pediatric patient volume ● Low and medium ● Medium to high	 0.67 (0.60 – 0.73) 0.53 (0.40 – 0.67)	 .0168
Designated adult trauma center o Yes o No	 0.53 (0.53 – 0.63) 0.60 (0.53 – 0.73)	 .5295
Data presented as median (25th, 75th interquartile range), with Wilcoxon p-values, for categorical variables and Spearman correlation coefficients for continuous variables.		

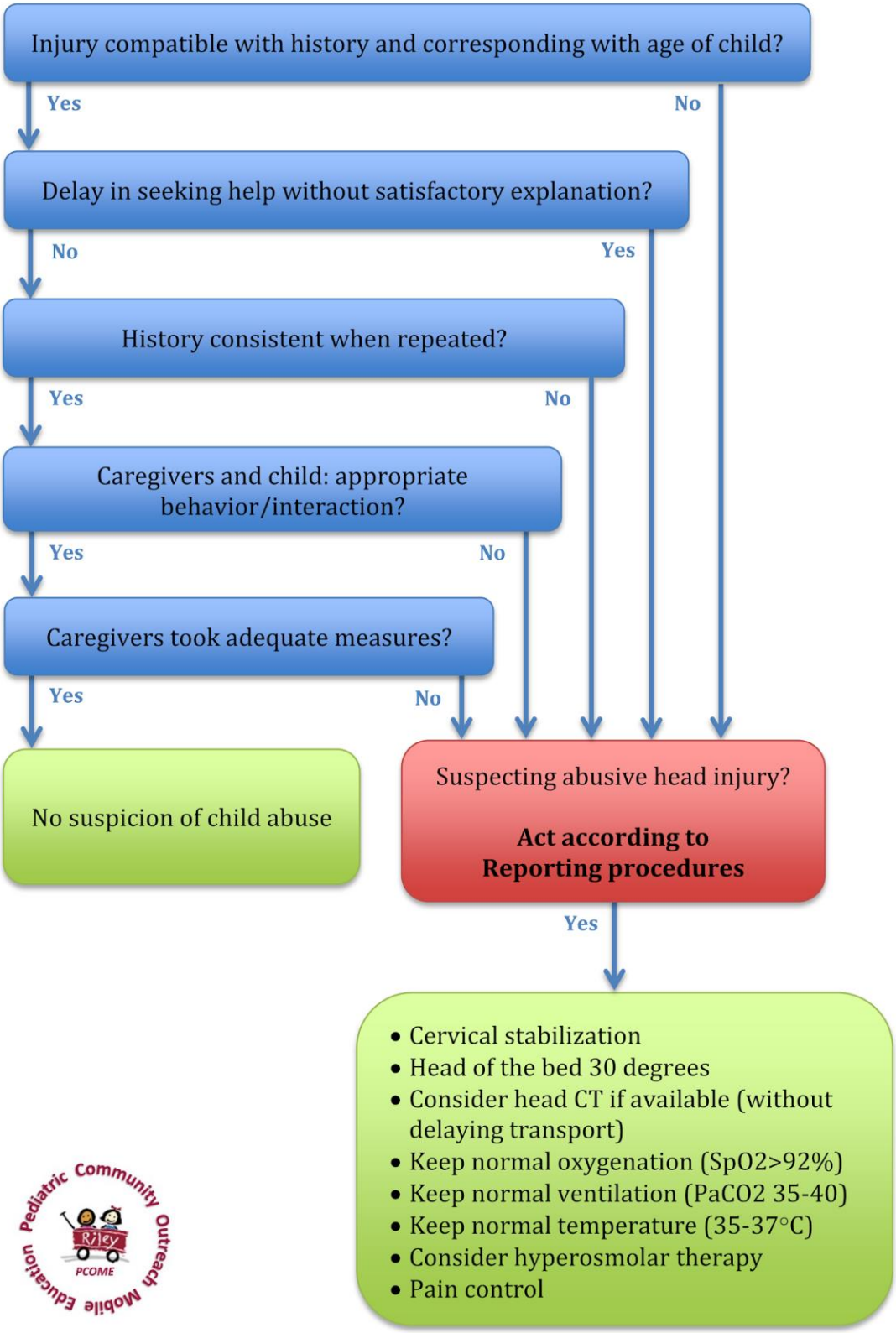
CAS: composite adherence score; AMC: academic medical center

Table 4: Participant's Evaluation of the Simulation Session

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1. I am more comfortable with identifying AHT and associated symptoms	0	0	2 (1%)	106 (40%)	154 (59%)
2. I am more comfortable with the management of an AHT patient	0	0	4 (2%)	111 (42%)	147 (56%)
3. I'm likely to alter my current management of a pediatric patient with AHT	0	0	4 (2%)	116 (44%)	142 (54%)
Surveys filled by 262 participants AHT: abusive head trauma					

Figure

Figure 1: Abusive Head Trauma Assessment and Management Flowsheet



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