

## Recognition and Initial Treatment of Suspected Intracranial Hypertension by Primary Care Pediatricians: An Advanced Simulation Observational Study

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### Abstract

**Background and objectives:** Acute intracranial hypertension (ICH) is a life-threatening event. Any pediatrician should be able to perform its diagnosis, stabilization and initial treatment. Training by means of advanced simulation can improve the pediatrician's abilities in the management of acute ICH, as well as decreasing errors and increasing patient safety. Our objective was to assess the ability of primary care pediatricians to deal with a simulated case of acute ICH and to detect the aspects that would need to be improved.

**Material and Methods:** We systematically reviewed ICH simulated scenarios during advanced simulation courses designed for pediatricians in Spain. The assessment was based on a previously defined sequence of tasks (technical and non-technical), from diagnosis to initial treatment, stabilization and preparation for transport.

**Results:** A total of 27 scenarios from 21 courses, with the participation of 95 pediatricians were assessed. Suspicion of acute ICH was correctly done in 85% of scenarios after a median time of 7.5 minutes. Osmolar therapy was started in 78% and bag-mask hyperventilation was done in 63%. The patient's head was elevated in 41% and sedatives were administered in 11%. Median time to ask for a brain imaging was 8.5 minutes and to contact neurosurgery was 12 minutes. The evaluation of non-technical skills showed that in 12 of 27 scenarios this aspect was poor.

**Conclusions:** Primary care pediatricians are able to identify an acute ICH, but need to improve their treatment skills. Systematic analysis of professional's performance during a simulated scenario permits to detect both strengths and weakness; these evidences should be used to improve training programs.

**Keywords:** Acute intracranial hypertension; Simulation; Training; Children

### Introduction

Acute intracranial hypertension (ICH) is not frequently seen in the out-of-hospital environment. However, a variety of diseases like brain tumors, brain trauma, non-traumatic intra cerebral hemorrhage, ischemic stroke, hydrocephalus and idiopathic ICH may cause acute ICH, a fact that emphasizes the need for adequate recognition and management of such events by Pediatricians [1,2].

Primary Care Pediatricians (PCP) use to be familiar with a wide range of children's health-related problems, but rarely face emergency situations. Little is known about the PCP's actual skills to adequately manage acute critical events; some evidences obtained in simulated scenarios indicate that they have diagnostic abilities but lack some practical skills [3,4]. Continued medical education programs should consider the actual learning and training needs of professionals and update courses accordingly.

Although the PCP's role in the initial stabilization of a child with acute ICH has not been clearly defined, it is generally accepted that such management requires a classic ABCD approach and the treatment goal would be to maintain an adequate cerebral blood flow and oxygenation. Elevation of head 30°, sedation and analgesia, osmolar therapy with hypertonic saline or mannitol, and moderate hyperventilation (PaCO<sub>2</sub> goal of 30-35 mmHg) are treatment options [5,6], as well as immediate transport to a neurosurgical facility.

Advanced simulation has been used in prior studies as an assessment tool for health professionals in a variety of medical environments including pediatric clinical practice [3,4,7]. Studies indicate that simulation may be a valuable training tool but also it may be used to assess the potential skills of professionals and to recognize strengths and weakness that should be considered to re-design training programs [7-10].

Our objective was to assess the ability of PCP to deal with a simulated case of acute ICH in order to detect the training aspects that would need to be improved.

## Material and Methods

A retrospective and descriptive study was performed in simulated scenarios of acute ICH. Scenarios were carried out in a multi-site program of Advanced Pediatric Simulation Courses supported by the Spanish Society of Primary Care Pediatrics and included in its continued medical education (post-graduate) activities. The scenarios were designed and ran by an ad hoc instructor's team. These courses were performed with the Simbaby® (Laerdal, Stavanger, Norway) advanced infant simulator.

Ninety-five Pediatrics specialists, who worked as PCP in Spain, have participated in these courses.

In Spanish healthcare system, PCP is responsible of children's health evaluations and medical assistance at out-of-hospital (Primary Care) level. PCP may work under the Public Health System or at private clinics or facilities. Currently, their training is made by means of a 4-years national pediatric residency program at teaching hospitals, including training periods at accredited primary care facilities. During their working life, PCP assist children (from newborn to adolescence) with a wide range of diseases and clinical complaints (nutritional problems, infections, common respiratory and gastro-enteric disorders, etc.) and devote significant time to preventive activities [11]. Although most of children cared by PCP have problems without immediate risk for life, they also need to be prepared to manage some rare but high-risk cases.

In each course subjects were grouped in teams of 3 to 4, one of them acting as leader and the other as collaborators. Realistic environment was also simulated with the representation of a primary care emergency room.

One instructor according to team performance drove scenario development without interfering with their actions. Each scenario was video recorded by means of Laerdal Simulation system and used as a support during the debriefing.

At the beginning of each course, participants gave their written consent for scenario recordings and use of data for publication.

Briefly, the ICH case report was: a 2-year-old girl, with personal history of constipation, who experiments acute headache after hard stool defecation. One hour after putting the child to sleep the parents find her less reactive. She is taken to the Primary Care facility where she comes unconscious, without reaction to stimuli (Glasgow coma scale score of 3), presents anisocoria and arterial hypertension with bradycardia. Despite the slow and irregular breathing, the remaining physical examination is normal. The final diagnosis of this patient was an intracerebral hemorrhage secondary to an unknown vascular malformation.

The participants were permitted to require additional information about the patient, specifically level of responsiveness, mental status, color, perfusion and temperature, or to talk to the parents if needed.

The scenario ended at minute 20, regardless of its evolution.

## Simulation system

Pediatric advanced simulator SimBaby® (Laerdal, Stavanger, Norway) was used. The simulator and computer interface automatically records certain events (i.e. pulse palpation) while other are registered by the operator (i.e. osmolar therapy). The operator can

set and manipulate in real time parameters such as heart rate, blood pressure, oxygen saturation, heart tones and various other vital signs. Pupil's size, however, can't be manipulated so it is the same along the scenario (e.g. anisocoria) regardless of clinical evolution.

## Evaluation of the ICH scenario

One of the authors (MF) performed systematic scenario video review [12,13]. A task list was elaborated by consensus between authors based on current recommendations on ICH initial management [14-17]. Only videos in which no operator interference did occur were considered valid for analysis.

The primary goal of evaluation was achievement of ABCD approach, acute ICH suspicion and initial stabilization and treatment. Decisions to obtain a brain imaging and transfer to neurosurgery facility were secondary goals.

For each scenario, three non-technical skills were evaluated including leadership, team coordination and level of organization according to a subjective score from one (minimum score) to three (maximum score). Evaluation criteria were: a) leadership: problem solving, confidence and assertiveness; b) team coordination: efficiency, method, clarity; c) level of organization: communication, cooperation and accuracy. Global non-technical skills score was obtained from the sum of the three variables and range from 3 (minimum or badly performed) to 9 (maximum or best performance).

A descriptive analysis was performed. The results are expressed as N / Total (%) and median (range).

## Results

From the 36 scenarios initially collected, corresponding to 21 courses, 27 were included in the analysis (5 were excluded due to technical issues and 4 due to instructor's technical interference in case development). Ninety-five pediatricians (56 female and 39 male), with a mean age of 33.7 years (range 28-62 years), have participated. The average of years worked by the participants was 11 years (range 1-32).

Results about technical skills are resumed in (Table 1). The most frequently observed errors are listed in (Table 2).

With the proposed case and scenario, most of the participants correctly identified acute ICH after a median time of 7.5 minutes. In 15% of scenarios diagnosis was not reached. All teams did an initial assessment with the ABC approach. They administered oxygen (median time: 1 minute; range: 0.4 to 3 minutes) and performed tracheal intubation (median time: 4.3 minutes; range: 1.5 to 17.9 minutes). The interface used for oxygen administration was face mask with reservoir in 85% and bag-mask with reservoir in 15%.

Ninety three percent of teams identified anisocoria; median time to pupil evaluation was 3.7 min, and 60% performed frequent pupil re-evaluation along the scenario. Osmolar therapy was administered in 78% of cases, with median time to initiation of 8 minutes. Mannitol was the preferred therapy. Moderate hyperventilation to treat ICH was used in 63% scenarios. Of these, only in 53% use of capnography was considered to monitor ventilation therapy.

In 85% of scenarios, the proposed goal (initial stabilization, decision to obtain brain imaging and transfer to neurosurgery) was achieved.

Technical Tasks	N (%)	Time (median, range)
<b>Airway</b>		
Opening airway	27/27 (100%)	
Oropharyngeal airway incubation (initially)	9/27 (33%)	1.7 ( 0.5 - 2.9)
<b>Breathing</b>		
Hyperventilation	17/27 (63%)	
Goal directed EtCO2	9/17 (53%)	
<b>Circulation</b>		
Evaluation	27/27 (100%)	
Identifies arterial hypertension and bradychardia	23/27 (85%)	5.8 ( 1.9 – 14.6)
<b>Vascular accesses</b>		
1 peripheral line	9/27 (33%)	
1 peripheral lines	12/27 (44%)	
Intraosseus line	1/27 (4%)	
Intraosseus line + 1 peripheral line	5/27 (19%)	
Fluids bolus	5/27 (19%)	
<b>Disability</b>		
Correct evaluation (Glasgow coma scale score)	25/27 (93%)	
Identifies anisocoria	25/27 (93%)	3.7 (0.3 – 12)
Requests toxics in blood	14/27 (52%)	
Evaluation of the head 30 degrees	11/27 (41%)	
Sedation and analgesia	3/27 (11%)	
Osmolar therapy	21/27 (78%)	8 (1.2 – 18)
Mannitol	19/21 (90%)	
Hypertonic saline	12/21 (57%)	
Hypertonic saline as first choice	8/21 (38%)	
Considers brain imaging	23/27 (85%)	8.5 (2.9 – 16.1)
Contact with neurosurgery team and transfer	23/27 (85%)	12 (4 – 18.9)

**Table 1:** Technical skills that were completed correctly

Evaluation and diagnosis	n (%)
Do not detect anisocoria	2 (7%)
Do not detect hypertension	4 (15%)
Do not reach diagnosis	4 (15%)
Do not consider brain imaging	4 (15%)
<b>Stabilization and treatment</b>	

Tries to lower arterial hypertension	1 (4%)
Do not consider transfer in 15 minutes	18 (67%)
Chest compressions	7 (26%)
Drugs	
Adrenaline	7 (26%)
Atropine	6 (22%)
Naloxone	3 (11%)
Dexamethasone	3 (11%)

**Table 2:** Errors most frequently observed (N = 27)

## Discussion

Despite the fact that primary care pediatricians usually assist children with a variety of diseases, most of them without immediate risk for life, they also need to be prepared to manage some rare but high-risk cases. Acute ICH is one example of such non-frequent but critical situation where early and adequate management is essential to outcome. Pediatricians must have knowledge about the symptoms, signs, causes and treatment of acute ICH and, additionally, they should have the skills to manage patients early and safely.

Advanced medical simulation emerged as a powerful tool to facilitate medical training in non-frequent critical situations without compromising patient safety. It also allows to the medical professional (individually or as a clinical team) to identify weak points and to use error as a teaching strengthening. On the other hand, standardized scenario analysis can help to characterize the current knowledge and skills of subjects (in our case primary care pediatricians), so that curriculum update targets can be addressed [12,13].

Our study is one of the first that has systematically analyzed how pediatricians would attend to a seriously ill infant with acute consciousness disturbance due to ICH. Our results suggest that pediatric teams are well trained to diagnose acute ICH and are familiar, at least in theory, with its treatment but when to apply that knowledge to the advanced mannequin, deficiencies and mistakes did occur.

Pediatricians demonstrated ability to manage the airway. All teams performed opening the airway and administration of supplementary oxygen, as standard procedure in the initial stabilization of the patient, within the first minute. As well, all teams decided, due to mental status, to intubate the child after a median time of 4.3 minutes.

Early vascular access is imperative in emergencies like acute ICH [15]. Forty four percent of our team decided to obtain two peripheral vascular accesses, and 22% opted by intraosseous access. The remaining 33% only obtained one peripheral line. This suggest us that our primary care pediatricians need to improve their skills on emergency vascular access, namely intraosseous, a very effective and feasible access, indicated when peripheral venous access is not obtained soon.

In 7 scenarios (26%) the inadequate ICH management led to extreme bradycardia which was interpreted as cardiac arrest by the participants; this wrong assumption, remarkable by the fact that the patient had arterial hypertension and easily palpable peripheral pulses,

led to chest compressions and adrenaline administration. Other erroneous assumptions led to administration of atropine by 22% of teams, naloxone by 11% and dexamethasone by other 11%.

In general, neurological evaluation during the scenario was poor and represents one of the most important aspects to be improved. Although 25 (93%) of teams identified anisocoria, only 15 (60%) repeated pupil evaluation during the scenario; also, the median time to first pupils assessment (near to 4 minutes) may be considered suboptimal for a child with severe neurological impairment and very low Glasgow coma scale score.

Management of acute ICH in a case like this must be quick and aggressive [15,16]. However, in our scenario maneuvers performed by teams to control acute ICH were not. Only 41% elevated head 30 degrees, sedation and analgesia was administered in 11% and moderate hyperventilation was tried in only 63%. Despite current recommendations, capnography as ventilation monitoring tool was considered only by 53% of those who used hyperventilation [17,18]. On the other hand, osmolar therapy was used by 78% of teams after a median time of 8 minutes. The preferred osmolar drug was mannitol (90%) versus hypertonic saline (57%). Although both options may be acceptable, as no clear recommendations for treatment in acute ICH have been released, the hemodynamic status of the patient should be taken in consideration [16]. Discussion at the bedside about which osmolar drug to use was very common and perhaps responsible for loss of some precious time to the patient. During the debriefing the preference for mannitol was not clearly explained by teams.

The requisition of toxics in blood was performed in 14 (52%) of cases as a systematic initial assessment of the comatous patient and in no scenario was asked after the identification of the structural origin of coma.

In respect to non-technical skills, leadership and team coordination need practice like any technical aspect in the emergency room. The leader role is very important to the participant's performance and scenario outcome. Low level of coordination score was obtained in the same scenarios whose leadership and team coordination were also poor. Almost 45% of the scenarios were classified with the lowest non-technical skills score, despite 15% obtained the maximum score. This might be explained because pediatric teams were composed by members of the same category, with the same level of differentiation and coming from different working areas, factors that may have hindered the leader role, but also by the fact that primary care

pediatricians are not adequately trained in aspects like crisis resource management and teamwork.

Given the virtual absence of studies on this topic, it is difficult to compare our results with others. As far as we know, none study has been published regarding the evaluation of an ICH scenario, but only the evaluation of supraventricular tachycardia scenarios [19].

At the light of our assessment we consider that further studies are needed to know the role of advanced simulation as initial and continued medical education strategy with special focus on serious rare but possible events. Ideally, the effects of training on the care of children should be evaluated by means of pre and post-training outcomes but due to the scarcity and uncontrollable nature of events, effects were evaluated by means of standardized registries like in case of those made in cardiopulmonary arrest and resuscitation [20].

### Limitations

Our study has some limitations that should be considered to contextualize the results and designing future studies. The study was retrospective and analyzed sample was limited to PCP, a specific group of pediatricians working out-of-hospital; therefore, the results cannot be extrapolated to other hospital pediatricians that should be more familiarized with this kind of neurologic complication.

Furthermore, we recognize that realism and difficulty in representation of physical findings in the high fidelity simulator may hinder patient assessment and subsequent management decisions in real life cases; so, these results cannot be directly extrapolated to clinical practice [21,22].

### Conclusions

In conclusion, primary care pediatricians are able to identify an acute ICH but need to improve their training to treat it properly. Training by means of advanced simulation can improve the pediatrician's abilities in the management of acute ICH. Furthermore, errors and delays encountered during scenario simulation detect pitfalls and grey areas where reinforcement in training may be needed.

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