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Review

Modern Paediatric Emergency Department: Potential Improvements in Light of New Evidence

Roman Kula^{1,2}, Stanislav Popela^{3,4}, Jozef Klučka^{1,5}, Daniela Charwátová⁶, Jana Djakow^{1,5,7,*} and Petr Štourač^{1,5}

¹ Department of Paediatric Anaesthesiology and Intensive Care Medicine, University Hospital Brno and Faculty of Medicine, Masaryk University, Kamenice 5, 625 00 Brno, Czech Republic;

Kula.Roman@fnbrno.cz (R.K.); Klucka.Jozef@fnbrno.cz (J.K.) and Stourac.Petr@fnbrno.cz (P.Š.)

² Department of Physiology, Faculty of Medicine, Masaryk University, Kamenice 5, 625 00 Brno, Czech Republic.

³ Emergency Department, University Hospital Olomouc and Faculty of Medicine, Palacký University, I.P. Pavlova 185/6, 779 00 Olomouc, Czech Republic; stanislav.popela@seznam.cz (S.P.)

⁴ Emergency Medical Service of the South Moravian Region, Kamenice 798, 625 00 Brno, Czech Republic.

⁵ Department of Simulation Medicine, Faculty of Medicine, Masaryk University, Kamenice 5, 625 00 Brno, Czech Republic.

⁶ Department of Surgery, Vyškov Hospital, Purkyňova 235/36, 682 01 Vyškov, Czech Republic; d.charwatova@gmail.com (D.Ch.)

⁷ Paediatric Intensive Care Unit, NH Hospital Inc., 268 01 Horovice, Czech Republic.

* Correspondence: jana.djakow@gmail.com; Tel.: +420-53223-4692

Abstract: The increasing attendance of paediatric emergency departments becomes a serious health issue. To reduce an elevated burden of medical errors, inevitably caused by high level of stress exerted on emergency physicians, we propose potential areas for improvement in regular paediatric emergency departments. In effort to guarantee demanded quality of care to all incoming patients, the workflow in paediatric emergency departments should be sufficiently optimized. The key component remains implementing one of the validated paediatric triage systems upon patient's arrival at emergency department and fast-tracking patients with low level of risk according to the triage system. To ensure the patient's safety, emergency physicians should follow issued guidelines. Cognitive aids, such as well-designed checklists, posters or flow charts, generally improve physicians' adherence to guidelines and should be therefore available in every paediatric emergency department. To sharpen diagnostic accuracy, the use of ultrasound in paediatric emergency department, according to ultrasound protocols, should be targeted to answer specific clinical questions. Combining all mentioned improvements might reduce number of errors linked with overcrowding. The review serves not only as a blueprint for modernizing paediatric emergency departments, but also as a bin of useful literature which can be suitable in the paediatric emergency field.

Keywords: emergency; triage; guidelines; checklist; ultrasound

1. Introduction

Recently published papers have outlined the increasing overcrowding in both adult [1] and paediatric [2] emergency departments. High level of stress exerted on emergency physicians, together with an environment full of multitasking and interruption, inevitably lead to elevated rate of task errors [3]. In the light of patient's safety, more attention is now focused on the methods guaranteeing an equal quality of care to all incoming patients, implementing structural thinking to buy a physician's mental space for important decisions and giving more accuracy to discriminate patient's diagnosis.

The present review thus brings possible improvements in the three above-mentioned domains. The aim is to make the improvements easily incorporable into daily clinical routine. We have also highlighted the crucial publications which served us to compile the ideological framework for the proposed improvements.

2. How to optimize workflow in Paediatric Emergency Departments?

Crowding in paediatric emergency departments remain an important public health concern. To estimate a level of overcrowding, investigators traditionally measure retrospective indicators, such as waiting time, *i.e.* the time interval between arrival at the emergency department and examination by a physician, length of stay, *i.e.* the total time spent in the emergency department, left without being examined, *i.e.* the proportion of patients leaving the emergency department without being seen by a physician and patient satisfaction. Beside these unidimensional indicators, two multi-dimensional scores (PEDOCS [4] and SOTU-PED [5]) were designed to obtain data from real-time paediatric emergency department operations and inform staff and administrators if crowding occurs. Both scores were critically evaluated in the recently published review [6] and found to be comparably accurate. In PEDOCS, score is calculated according to the equation 1 and the scale ranges from 0 to 200 (0, not busy; 40, busy; 80, extremely busy but not overcrowded; 120, overcrowded; 160, severely overcrowded; 200, dangerously overcrowded).

$$\text{PEDOCS} = 33.3 * 0.11 + 0.07 * (\text{patients in the waiting room}) + 0.04 * (\text{total registered patients}) \quad (1)$$

SOTU-PED is a linear model, defined by the equation 2, to predict global hourly crowding perception on a 10-level Likert scale. Perception of overcrowding among healthcare professionals occurred within the value greater than 5 and corresponded with SOTU-PED of 2 and higher.

$$\text{SOTU-PED} = 0.764 + 0.49 \text{ Census-H24 (number of admissions in the past 24 hours)} + 0.496 \text{ Occ-Rate (occupancy rate)} + 0.302 \text{ 1-year infant (number of patients)} \quad (2)$$

Although overcrowding in paediatric emergency departments has no impact on hospital admission within 7 days or mortality within 14 days after discharge [7], it may negatively influence quality of care (*e.g.*: delays in antibiotic administration for febrile neonates, analgesia for sickle cell crises and timely treatment of asthma [8–10]). Moreover, children coming to crowded paediatric emergency departments also have higher likelihood of being admitted [7,11]. It therefore remains essential to understand the causes of overcrowding. For this purpose, the *input-throughput-output model* of patient flow in emergency department might help to find gaps for improvement [12].

The most promising way to reduce burden of paediatric patients on the *input* side remains diverting non-urgent patients at triage (*i.e.* level 4 and 5 in all routinely used triage systems) to nearby alternative locations [12–14]. These units, so-called *fast tracks*, are urgent care centers or retail clinics, usually staffed by experienced practitioners or physician assistants, respectively. Beside its application in *fast tracks*, triage systems generally facilitate the prioritization of patients by assigning them to one of predefined levels (usually five in total) of urgency with the dedicated maximum possible waiting time. Triage systems with published evidence of widespread adoption and available paediatric version include the Australasian Triage Scale (ATS), Canadian Triage and Acuity Scale (CTAS), Emergency Severity Index (ESI), Manchester Triage Scale (MTS) and South African Triage Scale (SATS). These triage systems are comparable (Table 1) and share standardized format: deploy a 5-level classification scheme and set targets for timeliness to physician contact per triage level. They were developed through group consensus and universally rely on some level of subjective judgment by trained triage providers to execute [15]. None of the above triage systems emerges as superior and similar performance trends and weaknesses are common to all systems [15,16].

Table 1. Triage system characteristics. Table is adopted from Hinson et al. [15].

Triage system	CTAS	ESI	MTS	ATS	SATS
Stated objective	Provide patients with timely care	Prioritize patients by immediacy of care needs and resource	Rapidly assess a patient and assign a priority based on clinical need	Ensure patients are treated in order of clinical urgency and allocate patients to the most appropriate treatment area	Prioritize patients based on medical urgency in contexts where there is a mismatch between demand and capacity
Recommended time to physician contact, min	1: immediate 2: ≤ 15 3: ≤ 30 4: ≤ 60 5: ≤ 120	1: immediate 2: ≤ 15 3: none 4: none 5: none	Red: immediate Orange: ≤ 10 Yellow: ≤ 60 Green: ≤ 120 Blue: ≤ 240	1: immediate 2: ≤ 15 3: ≤ 30 4: ≤ 60 5: ≤ 120	Red: immediate Orange: ≤ 10 Yellow: ≤ 60 Green: ≤ 120 Blue: ≤ 240
Discriminators					
Clinical	Yes	No	Yes	Yes	Yes
Vital signs	Yes	Yes	Yes	Yes	Yes
Pain score	Yes (10-point)	Yes (visual scale)	Yes (3-point)	No	Yes (4-point)
Resource use	No	Yes	No	No	No
Paediatrics	Separate version	Separate vital sign differentiators	Considered within algorithm	Considered within algorithm	Separate flowchart

Triage systems usually rely on an experienced triage nurse to undertake triage [17]. Employing primary healthcare professionals (*i.e.* family physicians/general practitioners, nurse practitioners and nurses with increased authority) may be useful extension of triage team [18]. Discussion about replacing a triage nurse by a physician has no evidence to suggest that physicians are any better or more cost effective at triage than experienced nurses [17,19]. Triage systems may work more smoothly when combined with artificial intelligence. Based on the previously collected data, artificial intelligence learns to predict value of any targeted parameter with certain level of accuracy. For example, timeliness to physician contact per triage level could be accompanied by prediction of real waiting time based on the ongoing level of crowding [20]. This information is essential to make more responsive and proactive actions (*i.e.*, asking the doctor-on-call to be on duty or deploying doctors from other departments) if long waiting time is anticipated. Artificial intelligence may even match patients to triage levels even more accurately than emergency specialists themselves [21]. Further possibilities for implementation of artificial intelligence in the field of emergency medicine was systematically reviewed by Boonstra and Laven [22].

Worster et al. highlighted the importance of triage education since they showed that after 3 hours of triage training, general nurses were able to match experienced nurses in the use of the triage system [23]. The majority of the attainable possibilities for paediatric triage education was recently summarized in the integrative review [24]. Among wide variety of strategies, such as standardized educational programs, patient simulations followed by structured debriefing, computerized paediatric scenarios or lectures, the patients simulations are the most reliable not only in gaining but also in sustaining triage skills [25–27]. It was shown that participants of the most well-represented Emergency Triage Assessment and Treatment course, which includes both didactic and hand-on approaches, experienced a decline in triage skills over time [28].

An alternative to triage system is the 'see and treat' model, available in UK since 2004 [29]. The aim of the model is to assess and treat patients with minor complaints as soon as they arrive. It works on the principle that the first clinician to see the patient can assess, treat and discharge that patient. Appropriate clinical staff are dedicated to 'see and treat' and they see patients as they arrive. Because each patient only takes a short amount of time to treat, queues do not build up. At the same time, another team of clinicians deal with more serious cases as they arrive. Since its introduction, the 'see and treat' model has been broadly used in the UK [30] and is probably responsible for the largest overall reduction in waiting times. The clinicians of the first contact with minor illness are physicians or, more often, nurses. As was proved by Sakr et al. [31], nurses with at least 4 years' experience of working in emergency department can provide care for patients with minor injuries that is equal or in some ways better than that provided by junior doctors. This finding highlights the importance of taking nurses as reliable partners throughout providing paediatric emergency care. It is also necessary to habilitate nurses with adequate training program and procedural competencies. The trained nurse can, for example, successfully place peripheral intravenous catheters under ultrasound control if intravenous access is recognized to be difficult to secure[32].

Pandemic of COVID-19 has brought a strong involvement of virtual meetings to everyday life. With regards to available on-line technologies, Reid et al. [33] conducted a prospective cohort study examining the feasibility, utilization rate and satisfaction of virtual care as an adjunct to in-person emergency care. The authors adapted a secure encrypted video platform (Zoom for Healthcare™). Prior to meeting an emergency physician on-line, patient went through on-line checklist (Figure 1) to determine if virtual care is appropriate for the patient. If the patient was experiencing any of the listed high-acuity complaints (Figure 1), family was directed to present for in-person meeting. The authors found that virtual care could be a safe alternative to traditional paediatric emergency department, with ability to reduce the burden of in-person visits. Teleconsultations had been already known from the past as a helpful tool to facilitate emergency paediatric care [34,35]. Nevertheless, this is the first study on virtual emergency care with the pre-assessment in the form of on-line checklist being successfully employed.

If you/your child answers 'yes' to any of the following questions, you should be seen in-person at the Emergency Department today. Please do not request a virtual visit if:

- You/your child have a fever AND any ONE of the following:
 - Are less than 3 months old
 - Have an immune system problem
 - Have a complex health problem
 - Are very difficult to wake up even when the fever is treated
- You/your child have continuous wheeze, difficulty talking or feeling very short of breath
- You/your child have vomiting or diarrhea AND any ONE of the following:
 - Are less than 3 months old
 - Have repeated vomiting (more than 3 times) and unable to keep liquids down
 - The vomit or diarrhea contains blood
 - Have concern about dehydration with no pee in more than 8 hours
- You/your child have an injury AND any ONE of the following:
 - A head injury where there was a loss of consciousness (passing out), confusion or repeated vomiting (more than 3 times)
 - A cut that may need stitches
 - A burn with blisters that are larger than a Loonie
 - An injury with difficulty moving the arm/leg and swelling
 - An eye injury
 - An injury causing chest or stomach pain
- You/your child have a fever with a rash that looks like tiny or expanding bruises
- You/your child have had an intentional or unintentional ingestion of a medication or substance

If you/your child do not have any of the symptoms listed above, you/your child may be able to be seen through CHEO Emergency Department Virtual Care.

Figure 1. Screening checklist to determine if virtual care is appropriate for the paediatric patient. Adopted from Reid et al. [33]. The checklist is done on-line, prior to meeting an emergency physician. If the patient experiences none of the stated high-acuity complaints, the required care and follow-up can be provided virtually.

The causes of overcrowding in *throughput-output* parts of the model differ among emergency departments. Compared to adult emergency departments where overcrowding is caused by delay in transfer of admitted patients, overcrowding in paediatric emergency departments appears to be driven by considerable volume of visits and operational inefficiencies [36,37]. However, the causes can be changeable and workflow model of the patient journey is probably the most helpful tool in identifying bottlenecks in patient flow [38]. In the cited example, the authors presumed that overcrowding might be partially linked to long waits for the results of ordered tests. The optimized

workflow model allowed the authors to clarify that the delay on this level of operation was rather caused by missing alert when results were available. Such operational inefficiency might be nowadays effectively solved, for example by the computerized whiteboard system described by Aronsky et al. [39]. The whiteboard system consists of a large, touch-sensitive monitor which displays an overview of all admitted patients and ongoing operations in the emergency department. The delay in transfer of admitted patients, if identified as a possible factor for overcrowding, could be easily overcome by implementing artificial intelligence to predict hospital admission at the time of triage and thus liberate a bed for a coming patient in advance [40–42]. Any change toward eliminating the causes of overcrowding might be tested before its institution by a decision support system. Based on discrete-event simulation model, it allows to predict an impact of the intended change on the studied indicators of overcrowding [43].

In the end, the successful application of lean thinking, *i.e.* focusing on value-adding steps and eliminating non-value-adding steps in every part of the *input-throughput-output conceptual model*, was demonstrated [44,45] and can, by nature, serve as overall philosophy on how to increase the efficiency of paediatric emergency departments.

3. How to optimize the use of structural approach?

During an emergency, time and cognitive resources are limited. When under stress, clinicians are less able to recall remembered lists and are more likely to become fixated on certain course of action and reluctant to change it, despite the evidence that indicates a need for change [46,47]. In such environment, it becomes easier to follow a structured guidance. For simplicity, the presented look of the guidance may take form of posters, flowcharts, checklists, or even mnemonics, globally named as cognitive aids. Cognitive aids target all three key domains associated with the timely recognition and effective management of ongoing issue: they improve communication [48,49], teamwork and leadership [49–51] and the safety culture [51–53]. Unsurprisingly, the use of cognitive aids leads to a significant reduction in error rates [54].

Due to the listed evidence, many emergency departments have adopted the globally issued guidelines or at least use them to establish their own recommendations. However, guideline use is less than ideal as shown by population-based studies from several countries [55–57]. Considering such findings, more attention should be given during the process of guidelines development, notably on designing their applicability. Evaluations of guidelines showed that they were high in quality for scope and purpose, stakeholder involvement, rigor of development and clarity of presentation, but consistently lacking in applicability [58–62]. It goes together with the results of the recent cross-sectional survey from China where the authors identified guidelines accessibility at the point of care and training of medical staff to better embrace guidelines as two key challenges on the way of successful guidelines implementation [63].

If a local health authorities intend to prepare new guideline, an extensive literature review on subject of guideline development and implementation from Kredo et al. [64] might render useful input. The course of new guideline development is also depicted in Figure 2. Once a gap in available guidelines is detected, there are well-credentialed guideline development manuals, written by the World Health Organization [65], the Scottish Intercollegiate Guidelines Network [66], the National Institute for Health and Care Excellence [67] and the Australian National Health and Medical Research Council [68]. For simplicity, Schünemann et al. itemized all potentially relevant steps on the way of guideline development into the 18-points checklist [69]. Before the initiation of guideline development, available data in the intended area of study need to be gathered and graded according to their quality. Two main approaches have emerged to support systematic and comprehensive evidence synthesis: Grading of Recommendations Assessment, Development and Evaluation (GRADE) [70] and the Australian NHMRC approach, Formulating Recommendations Matrix (FORM) [71]. By the end of guideline development, the implementability of a developed guideline, *i.e.*: a set of characteristics that predict ease of (and obstacles to) guideline implementation, should be assessed by GuideLine Implementability Appraisal [72]. Regarding guideline presentation, physicians clearly evinced preference for the multilayered presentation format rather than a

traditional narrative format [73]. Multilayered format displays recommendations upfront with supporting information as collapsible boxes provided by clicking on the recommendation itself. The strength of the recommendation is communicated by use of text and color coding, and a header describes the population for which the recommendation applies. An 'user-friendly' multilayer software tool for guideline presentation was issued by DECIDE consortium [74] and is available on <http://www.decide-collaboration.eu/>. Rather than preparing new guideline, the local health authorities more often face up to excess of guidelines on the same subject. The main role of the local health authorities then remains to choose the most appropriate guideline to be applied in the local health setting (Figure 2). To facilitate the selection, the Appraisal of Guideline ResEarch and Evaluation (The AGREE II) instrument [75,76] tool might be employed. The AGREE II instrument is a tool that assesses the methodological rigor and transparency in which the guideline has been developed. It comprises six domains with a total of 23 items, each scored 1–7 (Strongly Disagree through to Strongly Agree) and can be applied by any health care providers in effort to identify strong and weak sides of any guideline. The successful application of AGREE II can be demonstrated on comparing seven international guidelines focused on management of fever in children [77]. After having conducted review of literature, the authors selected two appraisers who underwent the online training tools recommended by the AGREE collaboration before conducting appraisals. On completing the 23 items, the appraisers provided the overall assessment of each guideline, and decided which guideline was recommendable, with or without modifications, and which was not recommendable. The selected recommendations were then extracted and summarized in comparative tables focusing on possible gaps and common messages. Thus, any local health authority, furnished with AGREE II instrument, might effectively evaluate the quality of international guidelines, and make synthesis from the most suitable recommendations. New, simplified tool, the iCAHE quality checklist, was recently developed as an alternative to the AGREE II tool [78].

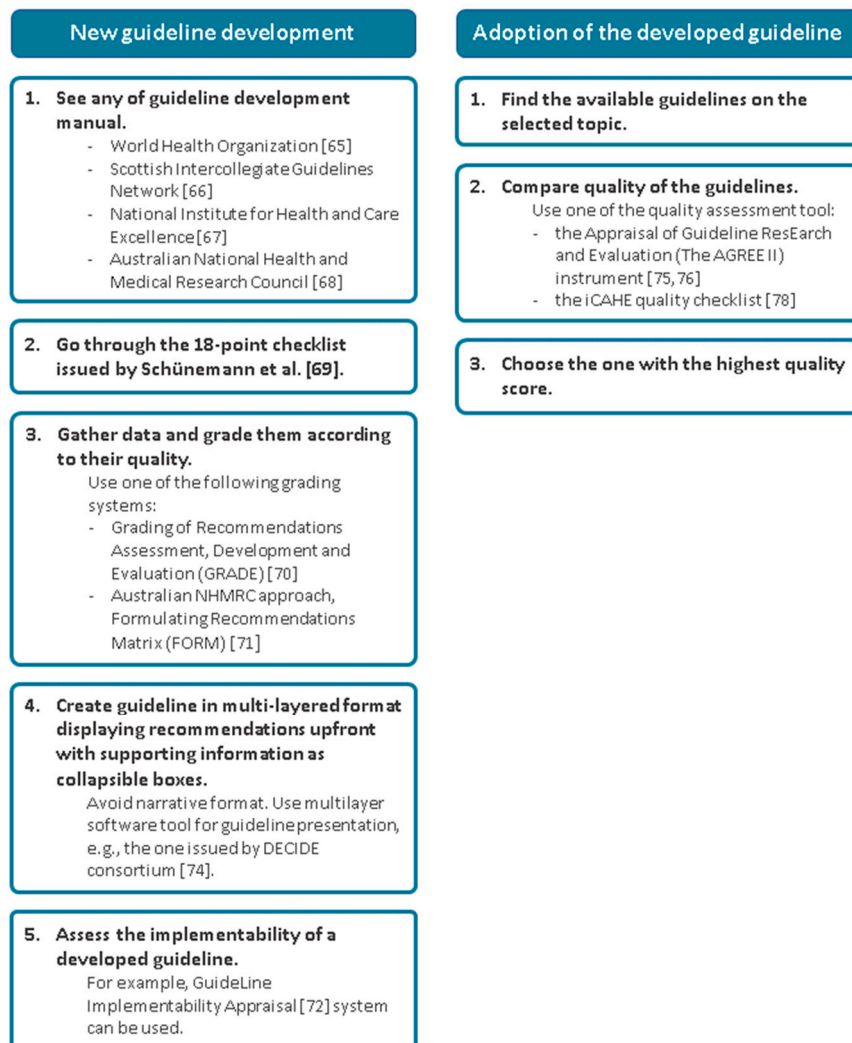


Figure 2. The possible step-by-step manual for the new guideline development or for the adoption of already developed guideline.

To foster guidelines implementation, cognitive aids should be involved since they improve adherence to guidelines [79,80]. The most frequent form of cognitive aids has become a checklist. However, despite its simplicity, instructiveness and proved positive impact on reducing mortality [81], its use may meet several obstacles, such as the operating theatre staff's reluctance to perform surgical safety checklist before every surgery [82]. The essential part thus remains right development and design of checklists to be effective and harmonious with the flow of emergency tasks. Burian et al. recently provided a comprehensive and evidence-based blueprint for the development or revision of medical checklists [83]. The traditional design of checklist is a form of step-by-step guide, most probably adopted from the field of aviation. However, Burian and his colleagues observed that that physicians often do not respond to critical events in such a linear manner. Instead, many of them first use existing knowledge and refer to a checklist for additional ideas or specific information (e.g., drug dosages) only after starting treatment [84]. Thus, the design of paper critical event checklist, which is adjusted to enable responding to an event already in progress, contains different actions which are grouped into color-coded blocks. This allows users to jump directly to the needed block when accessing the checklist or to jump to Crisis Management actions at any time, even when in the middle of a different block (e.g., Treatment). Some of critical-event checklist for paediatric life-threatening events have been already designed and issued by Society for Pediatric Anesthesia and are freely available on its webpage (<https://www.pedsanesthesia.org/>).

As with any tool, training in the use of checklist will optimize its successful use [85]. For this purpose, the Society for Pediatric Anesthesia gleaned some principles on training in the use of critical-event checklists [86]. All users should be instructed on how a group of checklists is ordered (e.g., alphabetically), with the goal of enabling users to identify and reach the desired checklist quickly. Familiarizing users with layout, structure, and formatting of the checklists is also part of training. The other necessary parts of training are to specify exactly who is involved in performing the checklist, to make users understand the goal of checklist and expected actions for each event, to expose users to scenarios for which checklist are designed and to maintain proficiency by frequent reviewing.

With the ubiquity of handheld electronic devices such as smartphones and tablets, there is a strong temptation to translate paper-based cognitive aids into electronic ones [87]. It was proved that the provision of a cognitive aid on a mobile phone might render better outcomes [88,89]. Even a simple audio prompt was found to be useful for improving adherence to guidelines [90,91] or to surgical safety checklist [92], most likely because it eliminated the need to read most items when visual attention to other tasks was precious.

The most frequently used structural approach is the ABCDE one. Initially introduced by Safar et al. [93], the ABCDE training was later proved as an important tool for increases both short and long-term survival following cardiac arrest [94]. A cognitive aid tool for the ABCDE approach was recently developed and validated in the simulation study [95]. Even though the ABCDE approach is considered a hallmark of emergency medicine, there is limited knowledge on how often and how completely it is applied to emergency patients. Recent study done by Olgers et al. showed that the ABCDE approach was performed more often and sooner after admission of unstable patients with high triage level [96]. While triage level decreases, the ABCDE approach has been performed more sporadically, despite the medical staff being well-trained in this approach with high completeness score. The main reasons for omitting the ABCDE approach were that the patient seemed stable at a first glance (clinical impression), the reason for visiting the emergency department or the vital signs done by the nurse did not indicate instability. It might look safe enough to use the clinical impression initially and only then to decide if an ABCDE approach is needed. However, since the ABCDE approach itself can be performed within 10 minutes in most patients, its application seems convenient even in the stable patients.

The essential part of the structural approach in emergency department is to have a properly formed resuscitation team. The association between the establishment of the structured resuscitation team and the increased rate of return of spontaneous circulation during cardiopulmonary resuscitation is well-documented [97]. However, delay in identifying team roles still represents a substantial part of system errors in cardiopulmonary resuscitation [98]. Team can be formed from the members of emergency department for purpose of providing immediate cardiopulmonary resuscitation to admitted patients. It is therefore recommended that the members of emergency department should meet at the beginning of each shift for introductions and allocation of roles in the resuscitation team [99]. As suggested by Weng et al., the in-hospital resuscitation team should consist of 6 members: team leader, compressor, recorder, a member for intravenous access, for preparing medication and for keeping airway and ventilation [97].

4. How to rationalize the use of imaging methods?

Ultrasound can be of diagnostic help in multiple emergency settings. Abdolrazaghnejad et al. brought a comprehensive summary of the ultrasound protocols used in the emergency medicine and proved that the ultrasound decreases the time needed for diagnosis and treatment [100].

Point-of-care ultrasound (POCUS) has become a standard part of examination in emergency department. Several protocols are currently established including extended focused assessment with sonography in trauma (eFAST), Bedside Lung Ultrasound in Emergency (BLUE) and Rapid Assessment of Dyspnea with Ultrasound (RADiUS) for dyspnoea, Rapid Ultrasound in Shock (RUSH) for shock and Focused Echocardiography in Emergency Life support (FEEL) for cardiac arrest [101]. These protocols are mostly standardized for adult population, nevertheless, can be also

used in children, bearing in mind anatomical and physiological differences between adult and child patient.

On the other hand, some studies demonstrated either no benefit [102] or deterioration [103] in the outcome if ultrasound was added to the initial emergency management. The evidence brings us to conclusion that routine ultrasound uses in every patient (even with evident diagnosis or in state which is treatable without having the exact diagnosis) does not yield benefits. The use of ultrasound should thus be targeted to answer specific clinical questions (e.g., use of BLUE protocol in patient with clinical sight of respiratory failure to help us differentiate the presence of pulmonary oedema, pneumothorax or other). An overview of the emergent cases where ultrasound was thought to be able to improve outcome was recently done by Goldsmith et al. [104].

Regarding emergency ultrasound education, recommendation for ultrasound training was issued by the American College of Emergency Physicians [105] and also by Vieira et al. as consensus educational guidelines [106]. Blehar et al. determined a minimum of 50 examinations which any learner must perform to reach performance level comparable to expert sonographers, for both image acquisition and interpretation [107]. To experience sufficient number of examinations, simulations and multimedia resources might be involved [108]. Implementing ultrasound training into medical school curricula may also reduce educational burdens for emergency physicians [109,110].

Quantitative assessment of ultrasound image, provided automatically by artificial intelligence, remains nowadays a debatable topic [111]. It was shown that ultrasound examination, augmented by artificial intelligence, increased accuracy and efficiency for diagnosing pneumonia by lung ultrasound [112], interpreting echocardiogram [113] or detecting and predicting prognosis of cancer disease [114]. Ultrasound can be also used for diagnosis of long bone fractures. Very promising is POCUS diagnosis of paediatric forearm fractures with pooled sensitivity of 93.1% and specificity of 92.9% [115]. POCUS can also be used in control of close reduction of fractures in emergency unit as a quick and sensitive diagnostic method. Beside ultrasound, artificial intelligence can be useful for fracture diagnosis on radiographs particularly if specific type of specialist is not available [116].

Talking about imaging methods in paediatric emergency department, the right indication of head imaging in minor head trauma belongs to the tricky tasks for every paediatric emergency physician. Head injury in children is getting more common in last decade, fortunately with low incidence of severe cases requiring neurosurgical or other therapeutic intervention. However, it still represents one of most common causes of disability and death in young age [118]. After clinical examination, the standard diagnostic method for head trauma is computed tomography (CT) scan. With high incidence of minor head trauma, often repeated in the same patient, CT scan might be problematic because of unnecessary and high radiation exposure. In comparison with adults, children are more sensitive to radiation with longer life expectancy than adults. Moreover, if CT setting are not adjusted for children body, they can get unnecessarily higher dose of radiation with the increased risk of malignant disease as tumors or leukemia [119]. For a cumulative dose of 50 to 60 milligray to the head (equivalent of two to three CT scans), a threefold increase in the risk of brain tumors was reported.

Taking together, it is of high importance to have clinical decision rule to select high risk patients of severe head trauma. Three algorithms were validated for this purpose: Pediatric Emergency Care Applied Research Network (PECARN), Children's Head injury Algorithm for prediction of Clinically Important Events (CHALICE) and Canadian Assessment of Tomography for Childhood Head Injury (CATCH). According to prospective cohort studies [120,121], PECARN showed the highest sensitivity in comparison with two other decision rules. Schonfeld et al. proved that children in very low risk group for brain traumatic injury according to PECARN could safely avoid a CT scan with very low risk of significant head injury [122]. In general, all three decision rules are based on similar premises and are summarized in Figure 3.

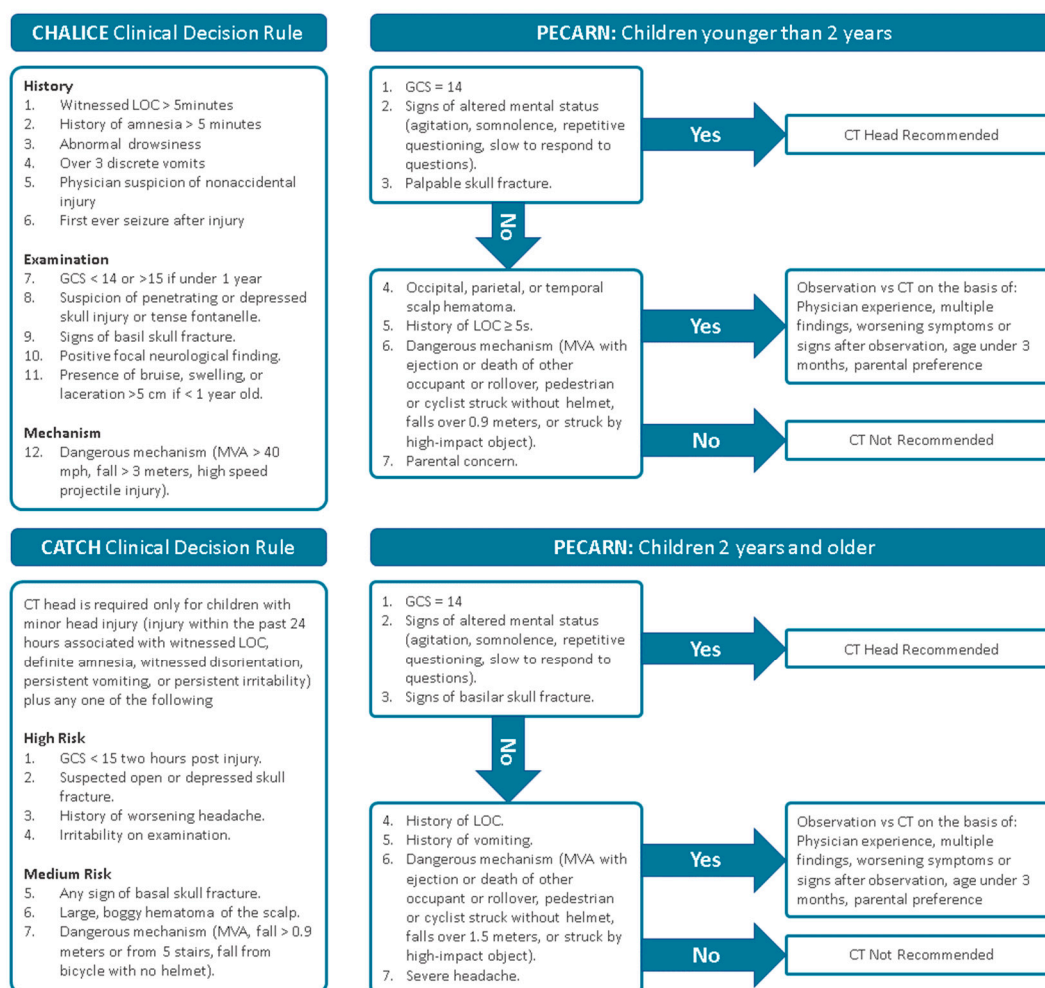


Figure 3. Summary of Clinical Decision Rules (CHALICE, CATCH and PECARN) to identify candidates with minor head trauma for head CT scan. Adopted from McGraw and Way [117]; LOS – loss of consciousness, MVA – motor vehicle accident, mph – miles per hour.

Another method using radiation to diagnose head trauma is X-ray. Still to these days it is more accessible and more often used in diagnostic algorithm of head trauma than any other imaging method. Even though it can identify a skull fracture not apparent by clinical examination, it gives us no information about intracranial changes. Up to 50% of intracranial trauma can be present without a skull fracture. For this reason, head X-ray is not recommended for diagnosis of any intracranial injury when CT is available [123].

Very promising method in detection of paediatric skull fractures is becoming ultrasound. According to some studies, bedside emergency ultrasound performs with 100% sensitivity and 95% specificity when compared to CT scan for the diagnosis of skull fractures [124]. This can significantly reduce excessive radiation exposure in children after minor head trauma. Thanks to simplicity of this examination, the emergency physician does not need to have a great experience to get the accurate image.

5. Conclusions

The increasing attendance of paediatric emergency departments evoked the necessity for care optimisation in effort to guarantee the patient's safety. Hereby we presented the compilation of several strategies whose single use in the emergency setting somehow led to outcome improvement. The idea of potentiating the benefits of the proposed improvements by their combination remains to be elucidated. The review serves not only as a blueprint for modernizing paediatric emergency

departments, but also as a pool of useful literature which can be suitable in the paediatric emergency field.

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