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An Overview On How to Reduce the Numbers of Unnecessary Head CT Scan of Traumatic Pediatric Patients

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Abstract

Context: The current review article considered the latest published papers on reducing unnecessary head computed tomography (CT) scans in pediatrics, so that a better basic structure can be made for further surveys.

Evidence acquisition: The papers were selected using Google scholar and Pubmed to search "reducing unnecessary head CT scan in pediatrics" with related keywords compatible with Mesh system in search strategy. Original articles and systematic reviews published after 2010 were included; but other types of manuscripts such letter to editor, editorial, case series, etc. were excluded. The eligible articles' title and abstract were assessed for relevance to our topic. The full-text of final selected papers were studied by the investigators. Furthermore, a critical appraisal was performed in an expert panel to summarize and make it applicable.

Results: The extracted manuscripts have addressed this issue with various strategies. To simplify discussion, the findings could be categorized as followed: observation period, focused history taking; protocol and guideline development; implementation of validated clinical prediction rules; and finally blood-based decision making by assessing neuro-biomarkers level.

Conclusion: Most of reviewed articles are focused on clinical findings so that we can find the very low risk or low risk category of the pediatrics with blunt head trauma. Some other also tried to ease the use of available clinical prediction rules in this regards. On the other hand, measurement of serum biomarkers level has been taken into account, but their widely application in practice is not well supported by evidence yet.

Keywords: Child; Decision Support Techniques; Head Injuries, Closed; Pediatrics; Tomography, X-Ray Computed; Unnecessary Procedures

1. Context

Trauma is definitely, if not the most, one of the most frequent reason for visiting emergency department (ED); and pediatric patients are consisting a significant part of ED traumatic patients, with special and different needs from adults. The physical examination in this age category is almost difficult, and results in lower threshold of decision making regarding use of radiology. Among the available radiologic modalities, head computed tomography (CT) scan is the modality that is frequently used, and studies have been performed to assess its interpretation accuracy by various physician (1, 2). It is regularly used as a high sensitive test to rule out the intracranial and skull injuries following traumatic events in pediatrics, with highly variated rate in various centers and countries (3-5). But, it seems that the rate of normal imaging is so high which lead to conducting researches in this era, so can reduce unnecessary head CT and excessive radiation exposure in this population. This topic has been taken into account, because of lots of known or even unknown side effects in near or far future (6, 7). The current review article, aimed to review the latest published papers on this subject, so that a basic structure can be made for better upcoming surveys.

2. Evidence acquisition

For conducting this simple review article, the papers were selected using Google scholar and Pubmed to search "reducing unnecessary head CT scan in traumatic pediatrics" with related keywords compatible with Mesh system in search strategy. The selected keywords were as bellow: "Tomography, X-Ray Computed", "Pediatrics", "Unnecessary Procedures" and "Head Injuries, Closed".

Those paper that performed a survey with the main aim of reducing the number of head CT in traumatic pediatrics were eligible. Just Original articles and systematic reviews, published after 2010 were included; but other types of manuscripts such letter to editor, editorial, case series, etc. were excluded. Papers in other language other than English were also excluded. By reviewing the articles, using Endnote software, duplicated findings were omitted.

The eligible articles' title and abstract were assessed for their relevance to our topic. The full-text of selected papers were studied by the investigators. Furthermore, a critical appraisal was performed in an expert panel to summarize and make it applicable.

Finally, the extracted subjects were categorized in subheadings and the article was written. Thereafter whole manuscript was reviewed, revised and approved by all the authors.

3. Results

Researchers from all around the world are trying to implement different strategies to reduce the number of unnecessary head CT scans in pediatric population. The findings have been categorized and are discussed in the following subheadings. There were some specific answers to the main question of this review article. The extracted manuscripts have addressed this issue with various strategies that were summarized below.

3.1. Observation and reassessment before decision making

Nigrovic et al in 2011 conducted a prospective multicenter observational study to evaluate the influence of an observation period prior to decision making regarding whether to perform head CT scan in pediatrics with minor blunt head trauma or not. They found out the mentioned strategy was associated with reduced number of head CT (8).

Most ED physicians in response to the worried parents, prefer to perform head CT scans in order to decide on disposition as soon as possible. Overcrowded EDs, and lack of proper and specific place for pediatric observation can also be effective on such preference. But it was reported that considering a period for observation and reassessment could be valuable for reducing unnecessary head CT in pediatrics (8).

3.2. History suggestive but not determinative

Palchak et al tried to find whether an isolated history of loss of consciousness (LOC) and/or amnesia is predictive of TBI in pediatrics affected by blunt head trauma. They concluded that such history, without other clinical findings, was not accompanied with neither pathologic findings in head CT nor with any TBI (9). In another study conducted by Palchak et al, history of post traumatic vomiting in a child is a considerable risk factor for TBI and in presence of such a history could not preclude the risk of TBI (10).

3.3. Guideline or protocol development

Astrand et al in 2016, published Scandinavian guideline for primary management of children affected by head trauma. The guideline divided the head trauma pediatric patients into minimal, mild and moderate, and also the mild group into 3 categories including high-, medium- and low-risk. Based on this guideline, we can refrain from performing head CT scan in children with minimal-risk, mild-low-risk and mild-moderate-risk (11).

Protocols were commonly used as local solution in response to the needs of specific center, especially the educational one, in which the in-charge physicians including residents were changed regularly. Although the protocols were prepared based on the evidence, they were modified by the

physicians of the related center. Guidelines are usually prepared by national or international scientific forums, and are constructed using high level of evidence from better literature review.

3.4. Implementation of clinical prediction rules

Osmond et al in 2010, derived a clinical decision rule for dealing with pediatrics affected by blunt head trauma. "Failure to reach score of 15 on the Glasgow coma scale (GCS) within two hours, suspicion of open skull fracture, worsening headache and irritability" were considered as high-risk factors that have 100.0% sensitivity for expecting the necessity of further investigation. "Large, boggy hematoma of the scalp, signs of basal skull fracture, dangerous mechanism of injury" were considered as medium-risk factors with 98.1% sensitivity for the prediction of TBI by head CT scan. This clinical prediction rule is known as "CATCH", abbreviation for "Canadian Assessment of Tomography for Childhood Head Injury" (12).

Jennings et al in 2017, evaluated the impact of implementing of a validated clinical prediction rule on decreasing the use of head CT scan in children. They reported that the rate of performing head CT scan decreased significantly from 29.2% to 17.4% when using this prediction rule (13).

Derivation of clinical prediction rules has attracted a lot of attention in recent years. In such surveys, following a prospective high power cohort study, the low risk or very low risk patients were defined, so excluded from further unnecessary diagnostic test. National Institute of Clinical Excellence (NICE) in 2004, The Royal College of Surgeons of England (RCS) in 2005, Children's Head Injury Algorithm for the Prediction of Important Clinical Events (CHALICE) in 2006, and Canadian Assessment of Tomography for Childhood Head Injury (CATCH) in 2010 derivate their guidelines for favorable management of pediatric population presenting ED due to head trauma (12, 14-16). However, when it comes to "reducing unnecessary head CT scan in pediatrics", the

PECAREN study was one of the valuable studies which derivate and validate an age-specific clinical prediction rule for pediatrics younger and also older than 2-year-old separately (17). "Normal mental status, no scalp hematoma except frontal, no loss of consciousness or loss of consciousness for less than 5 seconds, non-severe injury mechanism, no palpable skull fracture, and acting normally according to the parents" with NPV of 100% obviate the need for performing head CT in children younger than 2 years. As well, "normal mental status, no loss of consciousness, no vomiting, non-severe injury mechanism, no signs of basilar skull fracture, and no severe headache" with NPV of 99.95% obviate the need for performing head CT in children older than 2 years (17). It should be mentioned that the controversies are still present regarding the most valuable clinical prediction rules and research in this era is still on (18).

Ghizoni et al in 2013, performed a critical appraisal on the literatures and their final conclusion was in favor of accepting the Pediatric Emergency Care Applied Research Network (PECARN) guidelines, suggesting head CT scans for "children with GCS of 14, altered level of consciousness and palpable skull fracture, or when warranted by the physician experience, multiple findings or worsening symptoms" (19).

3.5. Gadgets for ease of use

Atabaki et al in 2017, published a paper and reported that despite introducing the validated evidence-based clinical prediction rules, the rate of unnecessary head CT had not decreased. So they designed an electronic health record (EHR) for easier application (20). Using computerized clinical decision support systems, web-based calculator, or mobile applications make the clinical prediction rules easier and more convenient to use (21, 22).

3.6. Blood-based decision making: neuro-biomarkers

Langness et al in 2017, published a paper regarding the role of plasma D-dimer level measurement to decrease unnecessary head CT scan in children affected by blunt head trauma. They reported that plasma D-dimer level less than 750 pg/μL could significantly preclude the number of unnecessary head CT scans (23).

Papa et al in 2017, investigated the possible role of serum ubiquitin C-terminal hydrolase (UCH-L1) level in predicting pathologic findings on head CT scan in children with mild and moderate TBI with GCS of 15. They reported that UCH-L1 cut-off level of 0.18 ng/mL has a sensitivity and negative predictive value (NPV) of 100%, but specificity of 47% (24).

Manzano et al in 2016, evaluated the possible role of serum S100B level in predicting the TBI in pediatrics population affected by mild blunt head trauma. They concluded that, with a 0.14 μg/L cut-off point, its measurement during the first 6 hours of traumatic event has a sensitivity of 95%, so would be valuable in terms of reducing unnecessary head CT (25).

Lastly, numerous researchers recommend that measurement of some biomarkers in blood sample could be considered as a reliable method to predict possible TBI (26). S100B protein is the one that has been assessed in major number of surveys to find its best cut-off point and also the best period for sampling and controversies are yet present. Considering the available resource, it seems that S100B has a high sensitivity but low specificity for predicting TBI in pediatrics (25, 27). UCH-L1, D-dimer, myelin basic protein (MBP), neuron-specific enolase (NSE), glial fibrillary acid protein (GFAP), interleukin-6 and interleukin-8 were also, to some extent, investigated in this regard, but still need further evaluation before application (23, 24, 28). Such biomarkers have been investigated lonely, and it may be logical to use paired or multiple biomarkers in this regard.

4. Conclusion

Most of reviewed articles are focused on clinical findings so that we can find the very low risk or low risk category of the pediatrics with blunt head trauma. Some other also tried to ease the use of available clinical prediction rules in this regards. On the other hand, measurement of serum biomarkers level has been taken into account, but their widely application in practice is not well supported by evidence yet.

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Authors' contribution

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Conflict of interest

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References

1. Talebian M-T, Kavandi E, Farahmand S, Shahlafar N, Arbab M, Seyedhosseini-Davarani S, et al. Comparing the brain CT scan interpretation of emergency medicine team with radiologists' report and its impact on patients' outcome. Emergency Radiology. 2015;22(3):261-8.
2. Dolatabadi AA, Baratloo A, Rouhipour A, Abdalvand A, Hatamabadi H, Forouzanfar M, et al. Interpretation of computed tomography of the head: emergency physicians versus radiologists. Trauma monthly. 2013;18(2):86-9.
3. Stanley RM, Hoyle JD, Jr., Dayan PS, Atabaki S, Lee L, Lillis K, et al. Emergency department practice variation in computed tomography use for children with minor blunt head trauma. The Journal of pediatrics. 2014;165(6):1201-6.e2.

4. Blackwell CD, Gorelick M, Holmes JF, Bandyopadhyay S, Kuppermann N. Pediatric head trauma: changes in use of computed tomography in emergency departments in the United States over time. Annals of emergency medicine. 2007;49(3):320-4.

5. Yoshida K, Krille L, Dreger S, Hoenig L, Merzenich H, Yasui K, et al. Pediatric computed tomography practice in Japanese university hospitals from 2008–2010: did it differ from German practice? Journal of radiation research. 2017;58(1):135-41.

6. Pearce MS, Salotti JA, Little MP, McHugh K, Lee C, Kim KP, et al. Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumours: a retrospective cohort study. Lancet (London, England). 2012;380(9840):499-505.

7. Brenner D, Elliston C, Hall E, Berdon W. Estimated risks of radiation-induced fatal cancer from pediatric CT. AJR American journal of roentgenology. 2001;176(2):289-96.

8. Nigrovic L, Schunk J, Foerster A, Cooper A, Miskin M, Atabaki S, et al. The Effect of Observation on Cranial Computed Tomography Utilization for Children After Blunt Head Trauma. Pediatrics. 2011;127(6):1067-73.

9. Palchak MJ, Holmes JF, Vance CW, Gelber RE, Schauer BA, Harrison MJ, et al. Does an Isolated History of Loss of Consciousness or Amnesia Predict Brain Injuries in Children After Blunt Head Trauma? Pediatrics. 2004;113(6):e507-e13.

10. Palchak MJ, Holmes JF, Vance CW, Gelber RE, Schauer BA, Harrison MJ, et al. A decision rule for identifying children at low risk for brain injuries after blunt head trauma. Annals of emergency medicine. 2003;42(4):492-506.

11. Astrand R, Rosenlund C, Undén J. Scandinavian guidelines for initial management of minor and moderate head trauma in children. BMC medicine. 2016;14(1):33.

12. Osmond MH, Klassen TP, Wells GA, Correll R, Jarvis A, Joubert G, et al. CATCH: a clinical decision rule for the use of computed tomography in children with minor head injury. CMAJ : Canadian Medical Association journal = journal de l'Association medicale canadienne. 2010;182(4):341-8.

13. Jennings R, Burtner J, Pellicer J, Nair D, Bradford M, Shaffer M, et al. Reducing Head CT Use for Children With Head Injuries in a Community Emergency Department. Pediatrics. 2017;139(4):e20161349.

14. Dunning J, Daly JP, Malhotra R, Stratford-Smith P, Lomas J, Lecky F, et al. The implications of NICE guidelines on the management of children presenting with head injury. Archives of disease in childhood. 2004;89(8):763-7.

15. Dunning J, Daly J, Lomas J, Lecky F, Batchelor J, Mackway-Jones K. Derivation of the children's head injury algorithm for the prediction of important clinical events decision rule for head injury in children. Archives of Disease in Childhood. 2006;91(11):885-91.

16. Dunning J, Daly J, Lomas J, Lecky F, Batchelor J, Mackway–Jones K. Children′s Head Injury Algorithm for the Prediction of Important Clinical Events Study Group (2006) Derivation of the children's head injury algorithm for the prediction of important clinical events decision rule for head injury in children. Arch Dis Child.91:885-91.

17. Kuppermann N, Holmes JF, Dayan PS, Hoyle JD, Atabaki SM, Holubkov R, et al. Identification of children at very low risk of clinically-important brain injuries after head trauma: a prospective cohort study. The Lancet. 2009;374(9696):1160-70.

18. Babl FE, Lyttle MD, Bressan S, Borland M, Phillips N, Kochar A, et al. A prospective observational study to assess the diagnostic accuracy of clinical decision rules for children presenting to emergency departments after head injuries (protocol): the Australasian Paediatric Head Injury Rules Study (APHIRST). BMC Pediatrics. 2014;14(1):148.

19. Ghizoni E, Fraga AdMA, Baracat ECE, Joaquim AF, Fraga GP, Rizoli S, et al. Indicações de tomografia de crânio em crianças com trauma cranioencefálico leve. Revista do Colégio Brasileiro de Cirurgiões. 2013;40:515-9.

20. Atabaki SM, Jacobs BR, Brown KM, Shahzeidi S, Heard-Garris NJ, Chamberlain MB, et al. Quality Improvement in Pediatric Head Trauma with PECARN Rules Implementation as Computerized Decision Support. Pediatric Quality & Safety. 2017;2(3):e019.

21. Dziadzko MA, Gajic O, Pickering BW, Herasevich V. Clinical calculators in hospital medicine: Availability, classification, and needs. Computer methods and programs in biomedicine. 2016;133:1-6.

22. Garg AX, Adhikari NK, McDonald H, Rosas-Arellano MP, Devereaux PJ, Beyene J, et al. Effects of computerized clinical decision support systems on practitioner performance and patient outcomes: a systematic review. Jama. 2005;293(10):1223-38.

23. Langness S, Ward E, Halbach J, Lizardo R, Davenport K, Bickler S, et al. Plasma D-dimer Safely Reduces Unnecessary CT Scans Obtained in the Evaluation of Pediatric Head Trauma. Journal of Pediatric Surgery. 2017:in press.

24. Papa L, Mittal M, Ramirez J, Silvestri S, Giordano P, Braga C, et al. Neuronal Biomarker Ubiquitin C-Terminal Hydrolase Detects Traumatic Intracranial Lesions on Computed Tomography in Children and Youth with Mild Traumatic Brain Injury. Journal of neurotrauma. 2017;34(13):2132-40.

25. Manzano S, Holzinger IB, Kellenberger CJ, Lacroix L, Klima-Lange D, Hersberger M, et al. Diagnostic performance of S100B protein serum measurement in detecting intracranial injury in children with mild head trauma. Emerg Med J. 2016;33(1):42-6.

26. Glushakova OY, Glushakov AV, Mannix R, Miller ER, Valadka AB, Hayes RL. Chapter 8 - The Use of Blood-Based Biomarkers to Improve the Design of Clinical Trials of Traumatic Brain Injury A2 - Skolnick, Brett E. In: Alves WM, editor. Handbook of Neuroemergency Clinical Trials (Second Edition): Academic Press; 2018. p. 139-66.

27. Bouvier D, Fournier M, Dauphin J-B, Amat F, Ughetto S, Labbé A, et al. Serum S100B determination in the management of pediatric mild traumatic brain injury. Clinical chemistry. 2012;58(7):1116-22.

28. Papa L, Ramia MM, Kelly JM, Burks SS, Pawlowicz A, Berger RP. Systematic review of clinical research on biomarkers for pediatric traumatic brain injury. Journal of neurotrauma. 2013;30(5):324-38.