Original Article

ISSN: 2675-3626

Evaluation of overuse of Head Computerized Tomography scan on traumatic brain injury pediatric patients

Victor Beneditti Guimarães[1], Gustavo Rogério Pinato[2], Erica Antunes Effgen[3], Tatiana Pissolati Sakomura[2], Gustavo Botelho Sampaio[2]

[1] Hospital Austa, São José do Rio Preto, São Paulo, Brazil

[2] Hospital da Criança e Maternidade, São José do Rio Preto, São Paulo, Brazil

[3] Hospital de Base, Faculdade de Medicina de São José do Rio Preto (FAMERP), São José do Rio Preto, São Paulo, Brazil

Erica Antunes Effgen, MD

e-mail: erica.effgen@gmail.com

Available at: http://www.archpedneurosurg.com.br/

Introduction: Traumatic brain injury (TBI) is a leading cause of morbidity and mortality among pediatric patients. Head Computerized Tomography (CT) scan has the undoubtedly benefit of diagnosing TBI lesions but is also associated with increased risk of cancer due to radiation.
Materials/Methods: This study was composed of 190 patients evaluated in the emergency setting of a pediatric Brazilian hospital from January 2019 to December 2021.
Results: The results of the study demonstrated an increased amount of CT scans in patients with mild TBI during this period. Besides, we noticed that many of these CT scans showed normal results or clinically insignificant findings such as subgaleal hematomas.
Conclusion: Knowing the risks related to radiation exposure at such a young age makes us question the validity of the hospital protocol we are following. Also, we believe that a future solution to this issue would be to implement radiation-free complimentary exams such as Magnetic Resonance Imaging (MRI) to our hospital protocol. Emphasizing the importance of justification of procedures and optimization of radiation doses are also crucial to prevent cancer development in pediatric patients.

Keywords: trauma, radiation, cancer, tomography, pediatrics

INTRODUCTION

Traumatic brain injury (TBI) is a leading cause of morbidity and mortality among pediatric patients [1]. Compared with adults, children have several anatomical differences that may predispose them to injury including thinner cranial bones, a larger head-to-torso ratio, an immature immune system, and differences in thermoregulation. After initial trauma evaluation, TBI investigation should contemplate a complete neurologic exam including a Glasgow Coma Score (GCS), pupil size, inspection of the head and spine, including the anterior fontanel, for gross deformity along with funduscopic and otoscopic evaluation. The pediatric GCS is modified according to verbal development and should be used for children under two years of age. Children over two years should be evaluated with the standard GCS measurement [2]. Studies suggest that there is an increased risk of cancer development from exposure to Computerized Tomography (CT) scans [3]. For example, Brenner et al., concluded that there could be a potential of 500 extra cases of fatal cancers from CT scans performed on children annually in the United States, based on estimates of the number of CT examinations performed and a single abdominal CT protocol [3]. These calculations suggest that there is approximately one fatal cancer for every 1000 CT scans performed in a young child [4]. It is worth emphasizing two points: it has been common practice in radiology to minimize all radiation exposure in patients and health care workers, as exemplified by the techniques of shielding for fluoroscopy and use of collimation (coning) for image acquisition. Second, there is no reason to expose children to more radiation than necessary, as emphasized by the familiar basic radiation safety principle of “as low as reasonably achievable” [5-6]. Therefore, considering the risks of radiation exposure in a young age, this study aims to evaluate the statistical data regarding head CT scan in a pediatric Brazilian hospital in the state of São Paulo from January 2019 to December 2021 in patients with TBI during this period.

Received: 26 november 2023
Accepted: 30 January 2024
Published: 21 February 2024

METHODS

The study was composed of 190 patients from 1 month to 14 years old evaluated from January 2019 to December 2021 in the emergency setting of a pediatric Brazilian hospital which is located in the city of São José do Rio Preto (in the state of São Paulo) and represents a tertiary health care reference center with several specialties, receiving referred patients from 102 cities (about 1.7 million inhabitants) and presenting both public (60% of the patients) and private (40% of the patients) health care system. In the emergency setting, the decision whether to perform a Head CT is considered according to the protocol of the Pediatric Emergency Care Applied Research Network (PECARN). Data was organized in an Excel planner and afterwards transferred to IBM-SPSS Statistics version 29 (IBM Corporation, NY, USA) for exploratory data analysis. The exploratory data analysis included descriptive, average, median, standard-deviation, minimum value and maximum value as numerical variables, and number and proportion as categoric values. For the analysis of behavior of continuous variables, we considered the descriptive statistics, histogram graphics, boxplot, and Shapiro-Wilk test [7-8]. The statistical analysis was made through IBM-SPSS Statistics version 29 software (IBM Corporation, NY, USA). Patient consent was not required for this study.

RESULTS

The descriptive analysis of the study was composed of 190 patients, in which 82 were women and 108 were men. The age ranged from 0.1 to 14 years of age with a median of 1 year of age (Table 1). The average of age was 3.19 years of age. The severity of traumatic brain injury was classified as mild, moderate and severe based on admission Glasgow Coma Scale. 184 patients (96.8%) had mild TBI, 4 (2.1%) had moderate and 2 (1.1%) had severe TBI. 168 patients (88.4%) performed a Head Computerized Tomography (CT) Scan and 22 (11.6%) of them did not. The indications of Head CT scan were based on the hospital protocol and included the following: height of the fall, location, mechanism of trauma, vomiting, neurological status, age and severity of the trauma. The main indication was height of the fall (30.5%) (Table 2).

Table 1. Descriptive analysis of demographic data from the 190 patients included in the study.

Age	Median (variation)	
Age, years	1,0 (0,1 – 14,0)	
Sex	**N**	**%**
Female	82	43,2
Male	108	56,8

Continuous variables are described as median (minimum – maximum); categoric variables are described as number and percentage.

Table 2. Severity of TBI and percentage of Head CT scans performed.

Severity of TBI	N	%
Mild	184	96.8
Moderate	4	2.1
Severe	2	1.1
Total	190	100.0
Head CT scan	**N**	**%**
No	22	11.6
Yes	168	88.4
Total	190	100
Indication of Head CT scan	**N**	**%**
Height	58	30,5
Location	39	20,5
Mechanism	29	15,3
Vomiting	21	11,1
Neurological status	20	10,5
Age	1	0,5
Moderate TBI	1	0,5
No indication	21	11,1
Total	190	100,0

The CT findings of the 168 patients that performed the exam included subgaleal hematoma (69%), midline shift (0.6%), subdural hematoma (14.3%), epidural hematoma (1.2%), fracture (21.4%). Three-quarters of these patients had one finding or less on CT scan and one-quarter had two or more findings. From the 168 patients that performed CT scan, 10 of them (6%) also performed an additional exam, such as a Head Ultrasound. 19 (10%) of the 190 patients of the study also had trauma in other locations other than TBI (table 3).

Table 3. Head CT findings from the 168 patients that performed the exam.

Finding	N	%
Subgaleal hematoma		
No	52	31,0
Yes	116	69,0
Midline shift		
No	167	99,4
Yes	1	0,6
Subdural hematoma		
No	144	85,7
Yes	24	14,3
Epidural hematoma		
No	166	98,8
Yes	2	1,2
Fracture		
No	132	78,6
Yes	36	21,4
Number of findings		
0	49	29,2
1	77	45,8
2	25	14,9

Received: 26 november 2023
Accepted: 30 January 2024
Published: 21 February 2024

3	16	9,5
4	1	0,6
Total	168	100,0

The observation period from the moment of trauma until hospital discharge was less than 12 hours in 83.7% of patients and more than 12 hours in 16.3% of them. The descriptive analysis showed that 162 (88%) of the 184 patients that were classified as having mild TBI performed a Head CT Scan, whereas all patients classified as having moderate or severe TBI performed this exam. From the 162 patients that had mild TBI, 111 (68.5%) of them had subgaleal hematomas, 23 (14.2%) of them had subdural hematomas, 1 (0.6%) of them had epidural hematoma and 34 (21%) of them had fractures. We encountered that from the 4 patients that had moderate TBI, 3 (75%) of them had subgaleal hematomas only and one of them had no findings on the exam. From the 2 patients that had severe TBI, one of them (50%) had midline shift, one (50%) had subdural hematoma, one had epidural hematoma (50%), and both of them (100%) had fractures. From the 162 patients classified as mild TBI, 8 of them (4.9%) also performed an additional exam besides Head CT scan, whereas one of the moderate TBI patients and one of the severe TBI patients also performed an extra exam. One out of the 184 patients classified as having mild TBI was a surgical candidate, while both severe TBI patients (100%) needed surgical treatment (table 4).

Table 4. Descriptive analysis of the Head CT findings from the 168 patients from the study that performed Head CT Scan, according to in-hospital observation period.

	Less than 12 hours N = 137	More than 12 hours N = 31
Finding	N (%)	N (%)
Subgaleal hematoma		
No	49 (35,8)	3 (9,7)
Yes	88 (64,2)	28 (90,3)
Midline shift		
No	137 (100,0)	30 (96,8)
Yes	0 (0,0)	1 (3,2)
Subdural hematoma		
No	137 (100,0)	7 (22,6)
Yes	0 (0,0)	24 (77,4)
Epidural hematoma		
No	137 (100,0)	29 (93,5)
Yes	0 (0,0)	2 (6,5)
Fracture		
No	121 (88,3)	11 (35,5)
Yes	16 (11,7)	20 (64,5)

Variables are described in number (percentage).

None of the moderate TBI patients were surgical candidates in our sample. The descriptive analysis also described a subgroup of patients with clinically irrelevant findings on CT scan, defined as patients with one finding at most, with the finding being subgaleal hematoma. This subgroup included 122 patients from the 168 that did Head CT scan. 49 patients (40.2%) had zero findings and 73 (59.8%) had only one clinically irrelevant finding (subgaleal hematoma). From this subgroup of patients, 118 (96.7%) were classified as having mild TBI and 4 (3.3%) as moderate TBI. From the 168 patients that performed Head CT scan, 137 of them (81.5%) were observed for less than 12 hours and 31 of them (18.4%) were observed for more than 12 hours inside the hospital. From the 137 patients that stayed inside the hospital for less than 12 hours, 88 of them (64.2%) had subgaleal hematomas, 16 of them (11.7%) had fractures and 33 of them (24%) had zero findings. From the 31 patients that that were observed for more than 12 hours, 28 of them (90.3%) had subgaleal hematomas, one (3.2%) had midline shift, 24 of them (77.4%) had subdural hematomas, 2 of them (6.5%) had epidural hematomas, and 14 (64.5%) had fractures.

DISCUSSION

CT scans among children and young adults has increased significantly since the 1990s [9-10] due to its undoubtedly benefits to provide diagnostic information. Despite ongoing efforts, evidence suggest that many CT examinations are done unnecessarily [11] and dose reductions are possible without compromising diagnostic accuracy [12].

EPI-CT, a large European cohort study, evaluated children and young adults that were exposed to ionizing radiation during CT examinations [13]. The first results of this study after a median follow-up of five to six years showed a strong dose-response relationship between brain radiation and dose and the relative risk of all brain cancers combined and glioma separately. The translation of risk estimates to the clinical setting suggests that for every ten thousand children who received one head CT examination, about one radiation-induced brain cancer is expected during the 5 to 15 years following the CT examination [14].

Reasons for unnecessary CT scans include lack of adherence to clinical guidelines, repeated scans, and CT preference over other imaging modalities [15]. There are still few evidence-based clinical guidelines for the management of pediatric mild TBI, in contrast to TBI in adults. The Centers for Disease Control and Prevention (CDC) guideline states that both head CT scans and brain MRI should not be routinely obtained in children with mild TBI, and risk factors for intracranial injury should be considered, such as age younger than 2 years, vomiting, loss of consciousness, severe mechanism of injury, severe or worsening headache,

http://www.archpedneurosurg.com.br/

Received: 26 nocember 2023
Accepted: 30 January 2024
Published: 21 February 2024

amnesia, nonfrontal scalp hematoma, Glasgow Coma Scale (GCS) less than 15, and clinical suspicion for skull fracture [17].

CDC guideline indicated that symptom scales which aid the diagnosis of mild TBI are useful and have the advantages of low cost and short time of application [17]; however, it is still necessary to be developed age-specific measures, in order to address younger children [19].

For instance, Grubenhoff et al. used the Standardized Assessment of Concussion (SAC) in a pediatric population and concluded that the graded symptom checklist was reliable for identifying mild TBI in children between 6 and 18 years old [18]. The application of the SAC took about 5 minutes and it comprises a grading system, which includes the evaluation of orientation, immediate memory, symptoms (headache, nausea, vomiting, dizziness, poor balance, blurred vision, sensitivity to light, sensitivity to noise, ringing in ears, poor concentration, memory problems, fatigue, sadness, irritability), post-traumatic or retrograde amnesia, concentration, and delayed recall [18].

In our study, in the emergency setting, the decision whether to perform a Head CT is considered according to the protocol of the Pediatric Emergency Care Applied Research Network (PECARN) [20]. For patients in all ages with a palpable skull fracture or altered mental status or Glasgow Coma Scale less than 15 points, a Head CT is recommended. For patients under 2 yeas old, loss of consciousness for 5 seconds or more, the presence of scalp hematoma, not acting normally according to the parents, or severe mechanism of injury (patient ejection, death of a passenger, run over by a motorized vehicle, falls of more than 0,9 m, or head struck by a high impact object) are the recommendations for undergoing a Head CT. For patients above 2 years old, the history of loss of cousciousness, vomiting, intense headache, or severe mechanism of injury are the recommendations for undergoing a Head CT.

The use of brain Magnetic Resonance Imaging (MRI) in TBI in pediatric population and its indications are not well stablished yet. Although it prevents the exposure to radiation, MRI has higher costs and it is not available and accessible among all the health care centers; in addition, it often requires sedation in pediatric patients [16, 17].

CONCLUSION

Our study evaluated the statistical data of pediatric patients with TBI submitted to the Head CT scan protocol of a Brazilian pediatric hospital in the state of São Paulo from January 2019 to December 2021. We reached the conclusion that our results demonstrated an increasing number of CT scans in patients with mild TBI during this period. Besides, we noticed that many of these CT scans showed normal results or clinically insignificant findings such as subgaleal hematomas. Knowing the risks related to radiation exposure at such a young age makes us question the validity of the hospital protocol we are following and question the possible lack of adherence to the protocol and clinical guidelines. Emphasizing the importance of justification of procedures and optimization of radiation doses is crucial in the context of cancer development in pediatric patients. We believe that a future solution to this issue would be to implement radiation-free complimentary exams such as MRI to our hospital protocol to aid the diagnosis of TBI in children; discouraging, however, its indiscriminate use and favoring rapid-sequence MRI in order to avoid sedation.

Limitation Declaration: As a cross-sectional study, it is not possible to stablish a causal inference or to determine the consequences of excessive CT scan performed in a young age in our patients in long term.

ACKNOWLEDGMENTS

We would like to acknowledge Fukuta Estatística e Metodologia Científica for doing the statistical analysis of the results showed in this study.

DISCLOSURES

Ethical approval

This study was performed in line with the principles of the Declaration of Helsinki. Since it is a case report in which the participant was not identified in any way, submission for ethical committee approval was not necessary.

Consent to participate

The patients gave consent to use their information and images for research purposes. *Consent for publication*

The patient gave consent to use his information and images for publication.

Conflict of interest

The authors declare no conflicts of interest with respect to the content, authorship, and/or publication of this article.

Funding

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors

Received: 26 november 2023
Accepted: 30 January 2024
Published: 21 February 2024

CONTRIBUTIONS

-**Victor Beneditti Guimarães**: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing

-**Gustavo Rogério Pinato**: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing

-**Erica Antunes Effgen**: Writing – review & editing

-Tatiana Pissolati Sakomura: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing

-Gustavo Botelho Sampaio: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing

-: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing

REFERENCES

1. Vane DW, Shackford SR. Epidemiology of rural traumatic death in children: a population-based study. J Trauma. 1995; 38: 867–70.
2. Paneitz DC, Ahmad S. Pediatric Trauma Update. Mo Med. 2018;115(5):438-42.
3. Rice HE, Frush DP, Farmer D, Waldhausen JH. Review of radiation risks from computed tomography: essentials for the pediatric surgeon. J Pediatr Surg. 2007;42(4):603-7.
4. Brenner D, Elliston C, Hall E, Berdon W. Estimated risks of radiation-induced fatal cancer from pediatric CT. AJR Am J Roentgenol. 2001;176(2):289-96.
5. Willis CE, Slovis TL. The ALARA concept in pediatric CR and DR: dose reduction in pediatric radiographic exams--a white paper conference. AJR Am J Roentgenol. 2005;184(2):373-4.
6. The ALARA (as low as reasonably achievable) concept in pediatric CT intelligent dose reduction. Multidisciplinary conference organized by the Society of Pediatric Radiology. August 18-19, 2001. Pediatr Radiol. 2002;32(4):217-313.
7. Conover WJ. Practical nonparametric statistics: Wiley; 1999.
8. Siegel S, Castellan NJ. Estatística não-Paramétrica Para Ciências do Comportamento: Artmed Editora.
9. Meulepas JM, Smets A, Nievelstein RAJ, et al. Trends and patterns of computed tomography scan use among children in The Netherlands: 1990-2012. Eur Radiol. 2017;27(6):2426-33.
10. Smith-Bindman R, Kwan ML, Marlow EC, et al. Trends in Use of Medical Imaging in US Health Care Systems and in Ontario, Canada, 2000-2016. Jama. 2019;322(9):843-56.
11. Hendee WR, Becker GJ, Borgstede JP, et al. Addressing overutilization in medical imaging. Radiology. 2010;257(1):240-5.
12. Smith-Bindman R, Wang Y, Chu P, et al. International variation in radiation dose for computed tomography examinations: prospective cohort study. Bmj. 2019;364:k4931.
13. Bernier MO, Baysson H, Pearce MS, et al. Cohort Profile: the EPI-CT study: a European pooled epidemiological study to quantify the risk of radiation-induced cancer from paediatric CT. Int J Epidemiol. 2019;48(2):379-81g.
14. Hauptmann M, Byrnes G, Cardis E, et al. Brain cancer after radiation exposure from CT examinations of children and young adults: results from the EPI-CT cohort study. Lancet Oncol. 2023;24(1):45-53.
15. Howe J, Fitzpatrick CM, Lakam DR, Gleisner A, Vane DW. Routine repeat brain computed tomography in all children with mild traumatic brain injury may result in unnecessary radiation exposure. J Trauma Acute Care Surg. 2014;76(2):292-5; discussion 5-6.
16. Ohana O, Soffer S, Zimlichman E, Klang E. Overuse of CT and MRI in paediatric emergency departments. Br J Radiol. 2018;91(1085):20170434.
17. Lumba-Brown A, Yeates KO, Sarmiento K, Breiding MJ, Haegerich TM, Gioia GA, Turner M, Benzel EC, Suskauer SJ, Giza CC, Joseph M, Broomand C, Weissman B, Gordon W, Wright DW, Moser RS, McAvoy K, Ewing-Cobbs L, Duhaime AC, Putukian M, Holshouser B, Paulk D, Wade SL, Herring SA, Halstead M, Keenan HT, Choe M, Christian CW, Guskiewicz K, Raksin PB, Gregory A, Mucha A, Taylor HG, Callahan JM, DeWitt J, Collins MW, Kirkwood MW, Ragheb J, Ellenbogen RG, Spinks TJ, Ganiats TG, Sabelhaus LJ, Altenhofen K, Hoffman R, Getchius T, Gronseth G, Donnell Z, O'Connor RE, Timmons SD. Centers for Disease Control and Prevention Guideline on the Diagnosis and Management of Mild Traumatic Brain Injury Among Children. JAMA Pediatr. 2018 Nov 1;172(11):e182853.
18. Grubenhoff JA, Kirkwood M, Gao D, Deakyne S, Wathen J. Evaluation of the standardized assessment of concussion in a pediatric emergency department. Pediatrics. 2010 Oct;126(4):688-95.

Received: 26 november 2023
Accepted: 30 January 2024
Published: 21 February 2024

19. Gioia GA, Schneider JC, Vaughan CG, Isquith PK. Which symptom assessments and approaches are uniquely appropriate for paediatric concussion? Br J Sports ed. 2009 May;43 Suppl 1:i13-22.
20. Kuppermann N, Holmes JF, Dayan PS, Hoyle JD Jr, Atabaki SM, Holubkov R, Nadel FM, Monroe D, Stanley RM, Borgialli DA, Badawy MK, Schunk JE, Quayle KS, Mahajan P, Lichenstein R, Lillis KA, Tunik MG, Jacobs ES, Callahan JM, Gorelick MH, Glass TF, Lee LK, Bachman MC, Cooper A, Powell EC, Gerardi MJ, Melville KA, Muizelaar JP, Wisner DH, Zuspan SJ, Dean JM, Wootton-Gorges SL; Pediatric Emergency Care Applied Research Network (PECARN). Identification of children at very low risk of clinically-important brain injuries after head trauma: a prospective cohort study. Lancet. 2009 Oct 3;374(9696):1160-70.

Received: 26 nocember 2023
Accepted: 30 January 2024
Published: 21 February 2024

ISSN: 2675-3626

1

2

3

4

5

6

7

, MD

e-mail:

Available at:
http://www.archpedneurosurg.com.br/

Keywords:

INTRODUCTION

METHODS

DISCLOSURES

Ethical approval

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the local Ethics Committee, number:

Consent to participate

The patients gave consent to use their information and images for research purposes. *Consent for publication*

The patient gave consent to use his information and images for publication.

Conflict of interest

The authors declare no conflicts of interest with respect to the content, authorship, and/or publication of this article.

Funding

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors

CONTRIBUTIONS

REFERENCES

Received:

Accepted:

«titulo»

21.