

Use of CT-scan in pediatric patients with thoraco-abdominal trauma: experience at a latin-american trauma facility

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ABSTRACT

Introduction. CT-scan is the method of choice for major trauma assessment. However, it significantly increases radiation exposure in the pediatric population. The objective of this study was to analyze differences in clinical outcomes according to the preoperative use of CT-scan.

Materials and methods. A retrospective observational study of pediatric patients admitted for trauma and requiring surgery was carried out. Patients were classified according to the previous use of CT-scan. ICU stay, re-admissions, and deaths were assessed.

Results. From 2011 to 2017, 737 patients under 18 years of age with external lesions were treated, 174 of whom required surgery. 48 patients (27.6%) underwent CT-scan prior to the procedure (Group 1), while the remaining 126 patients (72.4%) were directly scheduled for surgery (Group 2). Penetrating trauma occurred in 81% of patients, the proportion being significantly higher in Group 2 ($p=0.001$). Median age was 15 years (interquartile range: 12-17), with no differences between groups. No significant differences were found in terms of hemodynamic instability at admission between groups ($p=0.596$). At surgery, 3 out of 48 patients (6.3%) had no evident lesion. No significant differences were found in terms of re-admissions ($p=0.476$), mortality (0.994), and ICU stay (0.466).

Conclusion. The use of CT-scan as a diagnostic tool in pediatric trauma does not reduce mortality, ICU stay, or number of re-admissions. The use of tools such as ultrasound examination and simple X-ray should be protocolized to avoid unnecessary exposure to higher radiation doses. Prospective studies confirming this hypothesis are required.

KEY WORDS: CT-scan; Pediatrics; Injures and trauma; Radiation.

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USO DE LA TAC EN PACIENTES PEDIÁTRICOS CON TRAUMA TORACO-ABDOMINAL: EXPERIENCIA DE UN CENTRO DE TRAUMA LATINOAMERICANO

RESUMEN

Introducción. La tomografía axial computarizada (TAC) es el método de elección en la evaluación del trauma mayor, sin embargo, aumenta significativamente la exposición a radiación en la población pediátrica. El objetivo de este estudio es determinar diferencias en los desenlaces clínicos de acuerdo con el uso preoperatorio de la TAC.

Métodos. Estudio observacional retrospectivo. Se incluyeron pacientes pediátricos ingresados por trauma que necesitaron manejo quirúrgico, y se clasificaron de acuerdo con el uso previo de TAC. Se evaluó tiempo en Unidad de Cuidados Intensivos (UCI), readmisiones, y muerte.

Resultados. Durante 2011 a 2017, 737 pacientes menores de 18 años consultaron por lesiones de causa externa, 174 requirieron intervención quirúrgica. A 48 (27,6%) se les realizó TAC previo al manejo quirúrgico (Grupo 1); los restantes 126 pacientes (72,4%) fueron llevados directamente a cirugía (Grupo 2). El trauma penetrante se presentó en un 81% de los pacientes, siendo significativamente mayor en el grupo 2 ($p=0,001$). La mediana de edad fue 15 años (rango intercuartílico 12-17) sin diferencia entre los grupos. No hubo diferencias significativas en inestabilidad hemodinámica al ingreso entre los grupos ($p=0,596$). Al momento de la cirugía, tres de 48 pacientes (6,3%) no presentaron ninguna lesión evidente. No hubo diferencias significativas en las readmisiones ($p=0,476$), la mortalidad (0.994) y estancia en UCI (0.466).

Conclusión. El uso de TAC como herramienta diagnóstica en trauma pediátrico no disminuye la mortalidad, días de estancia en UCI, ni el número de readmisiones. Debe protocolizarse el uso de herramientas como la ecografía y radiografía simple para evitar exposición innecesaria a dosis más altas de radiación. Se requieren estudios prospectivos que confirmen esta hipótesis.

PALABRAS CLAVE: Tomografía computarizada de emisión; Pediatría; Heridas y traumatismos; Radiación.

INTRODUCTION

Trauma is the main cause of death in infants, children, and adolescents, which makes it one of the most important public health issues in this population^(1,2). Globally speaking, nearly 25% of trauma mortality is attributable to thoracic lesions^(3,4), and up to 80% of all thoracic trauma in children are caused by contusions⁽⁵⁾. In the US, car accidents are the most common form of trauma in pediatric patients, accounting for 42%, followed by falls, with 37%⁽⁶⁾, whereas penetrating lesions are less frequent and mostly found in patients over 10 years of age⁽⁷⁾. In Cali (Colombia), falls (56.3%) and crushing (12.1%) are the main reasons for pediatric trauma consultation, with an overall mortality of 1.2%, second to firearm injuries (12.9%)⁽³⁾.

Biomechanically speaking, in the pediatric population, trauma impact is distributed in a lower body mass, which translates into greater force received. In the case of the thorax, the proximity of vital organs causes multiple lesions and increases lethality⁽⁸⁾. Thoracic lesions account for 14% of pediatric deaths as a result of closed trauma⁽⁸⁾. When associated with other lesions, especially in the head, abdomen, and longer bones, mortality rate increases, which makes early identification at emergency rooms indispensable⁽⁹⁾.

Given its short duration, high quality information, availability, and ease of access, CT-scan is the imaging test of choice for major trauma assessment⁽¹⁰⁾. However, in children, the risk of developing cancer as a result of CT-scan associated radiation exposure is estimated to be as high as 1/500, with the risk of developing a fatal cancer being 1/2000^(11,12). Children undergoing CT-scan, and especially younger children, are exposed to higher effective radiation doses than adults, with abdominal, thoracic, and head CT-scan being the primary contributors to increased risk of cancer^(13,14).

According to Advanced Trauma and Life Support, contrarily to adult lesions, most thoracic lesions in children can be identified by means of thoracic X-ray. However, cross-sectional images, such as CT-scan, are rarely required in the case of thoracic contusions and should be reserved for those cases where findings cannot be explained by X-ray⁽¹⁵⁾.

As a result of health risks associated with the increasing use of CT-scan, various studies have been carried out in order to avoid excessive use in the pediatric population. In a cohort of 174 patients, 33% of whom underwent thoracic CT-scan, Herschel et al. found that CT-scan does not impact patient management, but does increase radiation exposure⁽¹²⁾.

Given the anatomical and physiological differences between polytraumatized children and adults, changes should be implemented in the diagnostic procedure in order to minimize delays in the decision-making process. One of these changes involves the use of CT-scan, which

causes greater radiation exposure in the pediatric population. Establishing how frequently CT-scan should be used will allow us to characterize findings and their relationship with the need for surgery and with mortality, which in turn will determine usefulness in this population. Therefore, this study aims to compare clinical outcomes from patients undergoing CT-scan prior to surgery with those from patients undergoing surgery right away.

MATERIALS AND METHODS

Cali is the capital of Colombian Valle del Cauca department and the third largest city in the nation. It is ranked as the 16th most dangerous city in the world, with a homicide rate of 53.2 per 100,000 inhabitants. In 2018, mortality rate in Cali as a result of external causes in children under 15 years of age was 53.6 deaths per 100,000 people⁽¹⁶⁾. Our study was carried out at a third-level, reference hospital for southwest Colombia, covering 10 million people approximately.

Study groups and variables collected

A retrospective, observational cohort study was carried out. All patients admitted at the emergency department with external cause lesions according to ICD-10 were included. Patients not undergoing surgery as a result of trauma were excluded. Data were collected from our healthcare facility's clinical records.

Exposure variables

Demographic variables, clinical characteristics, use of imaging tests, and hospital results, as well as information on trauma mechanism, were collected. Patients under study were divided into two groups – Group 1 was made up of patients undergoing CT-scan at admission (CT-scan group) prior to surgery, while Group 2 consisted of patients directly undergoing surgery (surgery group).

Hemodynamic instability was defined as the presence of tachycardia or bradycardia, low blood pressure, and Glasgow < 9 or need for transfusion at admission. Tachycardia was defined as a heart rate above 95 percentile according to age, bradycardia was defined as a heart rate under 5 percentile according to age, and low blood pressure was defined as systolic blood pressure with a z-score under -1.65 according to sex and age.

CT-scan was performed using a multi-detector Toshiba Aquilion One[®] device, which allows full body volumetric acquisitions to be achieved in 12.6 seconds with a 180cm extension.

Result variables

Final result variable was death. Other variables such as ICU stay and re-admission (new admission related to the initial cause of admission) were also assessed.

Statistical analysis

Dichotomous variables were expressed as percentages. Continuous variables were presented as medians and interquartile ranges (IQR), or means and standard deviations according to distribution. Variable normality estimation was carried out using the Shapiro-Wilk test. CT-scan incidence was calculated by taking the number of patients undergoing CT-scan as the numerator, and the total of patients admitted for external cause lesions at the emergency department as the denominator. For univariate analysis purposes, comparisons were performed using the Chi-squared test for dichotomous variables, and the Mann-Whitney test for continuous variables. Statistical significance was established at $p < 0.05$. The analyses were conducted using the Stata® 14.0 statistical software (StataCorp, 2014, College Station TX, USA). The study had been approved by the ethics committee of our healthcare facility.

RESULTS

From January 2011 to December 2017, 737 patients under 18 years of age presented at our healthcare facility with external cause lesions. Of them, 174 required surgery and were included in this study (Fig. 1).

Table 1 features an overview of patient characteristics. Median age was 15 years (IQR: 12-17), with no differences between groups. 82.8% of patients were male. In both groups, penetrating trauma was more frequent than closed trauma. However, the proportion of patients with penetrating trauma in the surgery group was significantly higher than in the CT-scan group ($p = 0.001$). Violent lesions accounted for 131 of the total (76.6%), with the proportion being higher in patients directly undergoing surgery than in patients undergoing a previous CT-scan ($p = 0.003$).

No significant differences were found between groups in terms of hemodynamic instability. Regarding systolic blood pressure z-scores according to sex and age, median in the surgery group was -0.02 (IQR: -1.93 - 1.32), whereas median in the CT-scan group was 0.60 (IQR: -0.40 - 1.58), the difference being statistically significant ($p = 0.043$). However, no differences were recorded in terms of low blood pressure frequency ($p = 0.177$) or tachycardia at admission ($p = 0.134$).

In the CT-scan group, the most frequent lesions were pulmonary lesions (50%) and hollow viscus lesions (50%). 20 patients (41.7%) had solid organ lesions, and 16 patients (33.3%) were diagnosed with hemothorax.

All patients undergoing CT-scan prior to surgery were diagnosed with at least one lesion at imaging. At surgery, 3 out of 48 patients (6.3%) had no evident lesion.

No significant differences in terms of surgical findings were found between the CT-scan group and the surgery

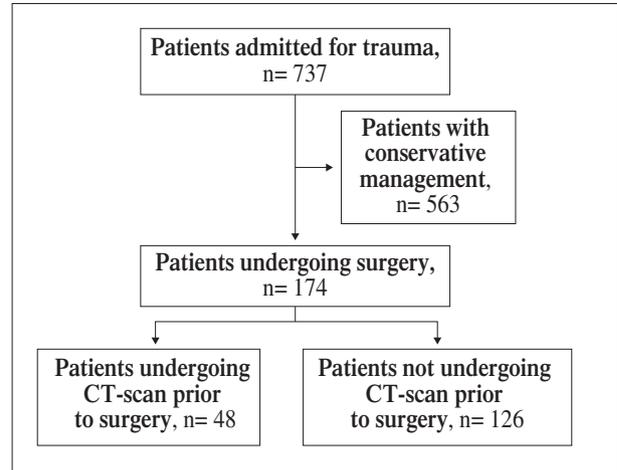


Figure 1. Patient selection diagram.

group. Regarding outcomes, no significant differences were noted in re-admissions ($p = 0.476$) and mortality ($p = 0.994$). ICU stay in the whole patient cohort was 4 days (IQR 2-7), with no differences being recorded between groups ($p = 0.466$).

DISCUSSION

Trauma is one of the main causes of pediatric mortality in Colombia. The use of CT-scan in cases of pediatric trauma is controversial. Owing to the high incidence of pediatric trauma, CT-scan has become a useful tool to accurately identify life-threatening lesions and therefore take adequate action⁽¹⁰⁾. In the REACT-2 clinical essay⁽¹⁷⁾, the number of non-therapeutic open surgeries was higher in instable patients, giving rise to surgical procedures which did not allow certain vessels to be accessed and were likely to have been scheduled using other CT-scan oriented endovascular techniques.

However, CT-scan exposes patients to a high radiation load, which may have consequences in the long term, such as neoplastic pathologies^(18,19). In a cohort of 174 pediatric patients with trauma, Holscher CM et al.⁽¹²⁾ concluded that the use of CT-scan does not impact patient management, but does increase radiation exposure. In addition, CT-scan does not represent a significant advantage as compared to other tools with lower oncogenic potential. A retrospective study by Golden et al.⁽²⁰⁾ in 1,035 patients, 139 of whom underwent thoracic CT-scan, showed that CT-scan had an impact on clinical strategy in 4 patients only. In this population, mediastinal alterations demonstrated at thoracic X-ray sufficed to implement a specific clinical strategy, with CT-scan being unnecessary in 80% of cases.

Our retrospective observational study aimed to compare clinical outcomes from patients undergoing CT-scan prior

Table 1. Clinical characteristics of patients admitted for external cause lesions

<i>Characteristics</i>	<i>Patients not undergoing CT-scan prior to surgery, n= 126</i>	<i>Patients undergoing CT-scan prior to surgery n= 48</i>	<i>p value</i>
Age in years, median (IQR)	15 (13-16)	15 (11.5-17)	0.789
Age-based classification, n (%)			
Preschoolers	2 (1.6)	0 (0)	0.636
Preescolares	6 (4.8)	4 (8.3)	
Schoolers	15 (11.9)	7 (14.6)	
Adolescents	103 (81.7)	37 (77.1)	
Sex, n (%)			
Female	17 (13.9)	13 (27.1)	0.044
Male	109 (86.5)	35 (72.9)	
Trauma mechanism, n (%)			
Closed	16 (12.7)	17 (35.4)	0.001
Penetrating	110 (87.3)	31 (64.6)	
Origin of penetrating abdomen*, n (%)			
Sharp object	37 (33.6)	8 (25.8)	0.052
Firearm	72 (65.5)	20 (64.5)	
Explosion	1 (0.9)	3 (9.7)	
Type of trauma, n (%)			
Car accident	9 (7.1)	13 (27.1)	0.003
Quarrel/Violence	102 (81)	29 (60.4)	
Fall from height	5 (4)	1 (2.1)	
Unknown	10 (7.9)	5 (10.4)	
Clinical variables			
Hemodynamic instability, n (%)	15 (11.9)	4 (8.3)	0.596
Preoperative transfusions, n (%)	56 (44.4)	24 (50)	0.511
SBP at admission [z-score], median (IQR)	-0.02 (-1.93 - 1.32)	0.60 (-0.40 - 1.58)	0.043
Number of patients with HR< 95P, n (%)	36 (28.6)	20 (41.7)	0.134
Number of patients with SBP< 95P, n (%)	35 (27.8)	7 (14.6)	0.177
Need for vasopressors, n (%)	46 (36.5)	27 (56.3)	0.059
CT-scan findings, n (%)			
Pulmonary lesion	--	24 (50)	--
Hemothorax	--	16 (33.3)	--
Thoracic vessel lesion	--	1 (2.1)	--
Solid organ lesion	--	20 (41.7)	--
Holly viscus lesion	--	24 (50)	--
Surgical findings, n (%)			
Heart lesion	13 (10.3)	1 (2.1)	0.462
Pulmonary lesion	25 (19.8)	10 (20.8)	0.853
Hemothorax	52 (41.3)	18 (37.5)	0.853
Thoracic vessel lesion	10 (7.9)	4 (8.3)	0.913
Solid organ lesion	33 (26.2)	17 (35.4)	0.229
Holly viscus lesion	51 (40.5)	13 (27.1)	0.112
ICU stay, median (IQR)	4 (2-7)	4.5 (2.5-8)	0.466
Re-admissions, n (%)	11 (8.7)	6 (12.5)	0.476
Mortality, n (%)	8 (6.3)	3 (6.3)	0.994

**Using penetrating trauma patients as the denominator.
IQR = Interquartile Range; HR = Heart Rate; SBP = Systolic Blood Pressure.*

to surgery with those from patients directly undergoing surgery. No significant differences were found in terms of death, ICU stay, or re-admissions. Consistent with other authors, our findings in the study population allow us to conclude that the use of CT-scan in the context of pediatric trauma should be prioritized and protocolized.

The use of imaging tests such as ultrasound examination and simple X-ray as an initial approach allows lesions to be detected and reliable decisions to be made, thus reducing radiation exposure⁽²¹⁾. In addition, new diagnostic options have been found. Contrast-enhanced ultrasonography using an intravenous suspension of perflutren protein-type A microspheres allows abdominal solid organ lesions to be diagnosed without the need for CT-scan and the resulting ionizing radiation⁽²²⁾.

Our results are based on a retrospective observational study, which means they have limitations and should be interpreted in the context of the study design and the set of data used. On the other hand, the number of CT-scans carried out in each patient was not featured in our healthcare facility's database, so the potential radiation loads received by each group could not be compared. However, our study, which was conducted in a middle-income country with a high rate of trauma, suggests that the use of CT-scan in pediatric patients with thoracic trauma could potentially be reduced, which means a diagnostic approach of pediatric trauma using lower radiation tools could be feasible. The rational use of CT-scan can be protocolized.

CONCLUSIONS

In pediatric trauma, the use of CT-scan as a diagnostic tool does not make any difference in terms of mortality, ICU stay, or re-admissions. CT-scan use should be protocolized, and less harmful tools such as ultrasound examination and simple X-ray should be implemented in order to avoid unnecessary exposure to higher radiation doses. Prospective studies are required to confirm this hypothesis.

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