Rev Colomb Cir. 2024;39:100-11
https://doi.org/10.30944/20117582.2481

ORIGINAL ARTICLE

Whole-body computed tomography in hemodynamically unstable patients with gunshot wounds: A paradigm shift in trauma management?

Uso de la tomografía corporal total en pacientes con heridas de arma de fuego y hemodinámicamente inestables: ¿Rompiendo paradigmas de atención inicial?

Yaset Caicedo, MD[1], Isabella Caicedo-Holguín, MD[1], Camilo Salazar, MD[1], Hernán Esteban Munévar, MD[1], Fernando Rodríguez-Holguín, MD[2], José Julián Serna, MD[2], Alexander Salcedo, MD[2], Carlos García, MD[3], Alberto F. García, MD, MSc[2,4], Carlos A. Ordoñez, MD, FACS[2,4]

1 Specialization Program in General Surgery, Universidad Icesi, Cali, Colombia.
2 Division of Trauma Surgery and Emergencies, Fundación Valle del Lili, Cali, Colombia.
3 Departament of Radiology, Fundación Valle del Lili, Cali, Colombia.
4 Service of Critical Care, Fundación Valle del Lili; Departament of Surgery, Universidad del Valle; School of Health Sciences, Universidad Icesi, Cali, Colombia.

Winner of the first place in the "José Félix Patiño Restrepo" National Surgical Research Contest, Resident Physicians category, Colombian Association of Surgery, 49th National Surgical Week Congress, November 2023.

Abstract

Introduction. This study aims to assess the impact of whole-body computed tomography (WBCT) in the evaluation of patients with penetrating gunshot wounds (GSW) who are hemodynamically unstable and treated at a trauma referral center.

Methods. An analytical, retrospective study was conducted based on a subanalysis of the Panamerican Trauma Society-FVL registry. Patients with GSW treated between 2018 and 2021 were included. Patients with severe cranioencephalic trauma, minor trauma, and those *in extremis* were excluded. Patients with and without WBCT were compared. The primary outcome was in-hospital mortality, and the secondary outcome was the frequency of major surgeries (thoracotomy, sternotomy, cervicotomy, and/or laparotomy) during initial care.

Received: 08/31/2023 - Accepted: 11/3/2023 - Published online: 12/15/2023
Corresponding author: Carlos A. Ordoñez, Carrera 98 # 18-49, División de Cirugía de Trauma y Emergencias, Fundación Valle del Lili, Cali, Colombia. Tel.: +57 300 631 9118. Email: ordonezcarlosa@gmail.com; carlos.ordonez@fvl.org.co
Cite as: Caicedo Y, Caicedo-Holguín I, Salazar C, Munévar HE, Rodríguez-Holguín F, Serna JJ, et al. Uso de la tomografía corporal total en pacientes con heridas de arma de fuego y hemodinámicamente inestables: ¿Rompiendo paradigmas de atención inicial? Rev Colomb Cir.Rev Colomb Cir. 2024;39:100-11. https://doi.org/10.30944/20117582.2481

Results. Two hundred eligible patients were included, with 115 undergoing WBCT and compared to 85 controls. In-hospital mortality in the WBCT group was 4/115 (3.5%) compared to 10/85 (12%) in the control group. Multivariate analysis showed that WBCT was not significantly associated to mortality (aOR: 0.46; 95% CI 0.10-1.94). The WBCT group had a relative reduction of 39% in the frequency of major surgeries, with an associated effect on reducing the need for surgery (aOR: 0.47; 95% CI 0.22-0.98).

Conclusions. Whole-body computed tomography was employed in the initial management of patients with penetrating firearm projectile injuries and hemodynamic instability. The use of WBCT was not associated with mortality but rather with a reduction in the frequency of major surgery.

Keywords: wounds and injuries; hemorrhagic shock; traumatic shock; computed tomography; major surgical procedures; hospital mortality.

Resumen

Introducción. El objetivo del estudio fue analizar el impacto del uso de la tomografía corporal total en la evaluación de los pacientes con trauma penetrante por proyectil de arma de fuego y hemodinámicamente inestables atendidos en un centro de referencia de trauma.

Métodos. Se realizó un estudio analítico, retrospectivo, con base en un subanálisis del registro de la Sociedad Panamericana de Trauma – Fundación Valle del Lili. Se incluyeron los pacientes con trauma penetrante por proyectil de arma de fuego atendidos entre 2018 y 2021. Se excluyeron los pacientes con trauma craneoencefálico severo, trauma leve y en condición *in extremis*.

Resultados. Doscientos pacientes cumplieron los criterios de elegibilidad, 115 fueron estudiados con tomografía corporal total y se compararon con 85 controles. La mortalidad intrahospitalaria en el grupo de tomografía fue de 4/115 (3,5 %) vs 10/85 (12 %) en el grupo control. En el análisis multivariado se identificó que la tomografía no tenía asociación significativa con la mortalidad (aOR=0,46; $IC_{95\%}$ 0,10-1,94). El grupo de tomografía tuvo una reducción relativa del 39 % en la frecuencia de cirugías mayores, con un efecto asociado en la disminución de la necesidad de cirugía (aOR=0,47; $IC_{95\%}$ 0,22-0,98).

Conclusiones. La tomografía corporal total fue empleada en el abordaje inicial de los pacientes con trauma penetrante por proyectil de arma de fuego y hemodinámicamente inestables. Su uso no se asoció con una mayor mortalidad, pero sí con una menor frecuencia de cirugías mayores.

Palabras clave: heridas y traumatismos; choque hemorrágico; choque traumático; tomografía computarizada; procedimientos quirúrgicos mayores; mortalidad hospitalaria.

Introduction

Trauma causes 9% mortality worldwide and is one of the leading causes of preventable deaths [1]; It contributes as one of the leading causes of death in people between 1 and 45 years old. Since it is frequently lethal or disabling, it has an additional social and economic impact [2].

Currently, the predominant approach to initial care is based on Advanced Trauma Life Support (ATLS) guidelines. These guidelines include prioritized physical examination, plain chest and pelvis x-rays, Focused Assessment with Sonography for Trauma (FAST), and selective and complementary computed tomography (CT) according to the region under study [3]. The decision to perform CT after conventional imaging is less clear in the ATLS guidelines and is subject to local protocols and equipment availability.

In recent times, technology has evolved making CT faster, more detailed, accessible in the acute trauma care setting, and with high precision in a wide range of injuries [4,5], which is reflected in a low rate of missed diagnoses [6,7]. Therefore, conventional radiological evaluation according to ATLS may no longer be the best option for initial diagnosis. Additionally, it is common for patients with severe injuries to require secondary CT in various parts of the body after conventional imaging.

Modern multidetector CT (MDCT) machines can image the head, cervical spine, chest, abdomen, and pelvis in a single exam, which has been called whole-body tomography. By using immediate, full-body CT scanning in trauma patients, detailed and rapid information about organ and tissue injuries is obtained, allowing an informed plan for further therapy [8].

The most relevant question remains whether full-body scanning with immediate CT will result in an improvement in clinical outcomes. Meta-analyses that include information from observational studies, with variability in their methodological designs, have reported a beneficial effect on mortality with the use of CT in patients with blunt trauma [9]. The REACT-2 clinical trial included 1403 patients randomized to be studied with or without whole body CT and showed that there was no difference in in-hospital mortality, even in subgroup analysis of patients with polytrauma and traumatic brain injury [10].

Whole body CT has been studied in the setting of blunt trauma and in hemodynamically stable patients. Extending its use in penetrating trauma and in patients with hemodynamic risk is still quite controversial. Patients with penetrating trauma, especially those injured by a firearm projectile, represent a challenge in the diagnostic evaluation since the damage vectors associated with projectiles and existing injuries could modify clinical behaviors. The use of CT goes against the standards proposed by ATLS for the approach to patients with penetrating trauma.

Additionally, there is a risk that the use of this technology in the care of hemodynamically unstable patients, who are transient responders, could have a detrimental effect, since the prolongation of care times can be associated with a greater risk of mortality. However, to date the evidence is variable regarding the use and possible benefit of whole body CT in this context [4,11,12]. The objective of this study was to analyze the impact of the use of total body CT in the evaluation of patients with penetrating trauma from a firearm projectile and hemodynamically unstable, treated at the Fundación Valle del Lili University Hospital, a reference center for trauma in the city of Cali, Colombia.

Methods

Type of study

A retrospective, analytical study was carried out, for which the registry of the Panamerican Trauma Society associated with Fundación Valle del Lili (PTS-FVL) was used as a source of information. The PTS-FVL registry was approved by the Research Ethics Committee of the Fundación Valle del Lili (Protocol 554 – November 22, 2011, renewed on December 27, 2022).

Whole-body tomography

The intervention to be evaluated was the use of whole-body tomography (WBCT), through a single-step computed tomography with helical acquisition. Images are obtained with a multi-slice IVR system (Aquilion ONE 320-slice computed tomography scanner. Toshiba Medical Systems Corp, Tochigi, Japan).

In the first phase, the simple acquisition of the skull is done. The second phase takes a scan of the neck, thorax, abdomen and pelvis (from the base of the skull to the lower edge of the pubis), with administration of contrast medium in two separate applications, as described in Table 1. After the second injection, the contrast image is acquired with a reference in the descending aorta ROI: 200 HU. Frequently, the team that is resuscitating the patient rethinks the segments to study, depending on the location of the wounds.

The contrast medium administered is a low osmolarity nonionic medium (Iopromide Ultravist R. Whippany, NJ: Bayer Health Care Pharmaceuticals), through an intravenous route with an 18 G peripheral catheter. A total of 130 ml is used.

Table 1. Single-phase whole-body computed tomography protocol.

Phase	Procedure	
Phase A	Simple acquisition phase: skull	
Phase B	Contrast administration phase: neck, thorax and abdomen Intravenous contrast: iodine, non-ionic, hypo-osmolar (370 mg/ml)	
	Step 1: First injection	Flow= 2.0 ml/s Contrast volume= 60 ml 45 second pause Total duration: 75 seconds
	Step 2: Second injection	Flow= 4 ml/s Contrast volume= 60-70 ml Wash= 40 ml of normal saline Duration: 25 seconds Total time: 100 seconds
	Step 3: Verified acquisition	In the descending aorta ROI= 200 HU, after the second injection

Source: Translated from Ordoñez C, García C, Parra MW, Angamarca E, Guzmán-Rodríguez M, Orlas CP, et al. Implementation of a new Single-Pass Whole-Body Computed Tomography Protocol: Is it safe, effective and efficient in patients with severe trauma? Colomb Med (Cali). 2020;51:e4224.

of contrast medium, with a biphasic technique. Sequential contrast boluses result in a single acquisition showing a combination of arterial and venous phase, with excellent image quality and rapid image reconstruction. The reconstruction of the cuts is carried out 1 mm every 0.8 mm. The total number of cuts depends on the size of the patient and the segments studied. Intravenous pyelogram can be added to the protocol, if necessary.

Trauma code

This WBCT protocol is integrated into an initial care protocol for trauma patients, called Trauma Code, which was implemented in the institution since 2015, with effects on reducing mortality, time to access surgery or of tomography, as has been documented in previous studies [8,11,13-15], where a median between admission to the emergency room and taking the WBCT in penetrating trauma of 31 minutes was described (interquartile range: 13-50 minutes), with no reported cases of contrast medium-induced nephropathy.

Patient selection

The study sample was selected from patients with penetrating trauma from a firearm projectile. Since it was considered that the care protocol had already been consolidated, patients treated between January 1, 2018 and December 31, 2021 were included. Patients with severe craniocerebral trauma [Abbreviated Injury Scale (AIS) of the Head > 3] were excluded, patients with mild trauma [Injury Severity Score (ISS) < 8] and patients with a systolic blood pressure that persisted below 60 mmHg after resuscitation maneuvers were initiated, since these patients were taken directly to surgery and unstable non-responding patients were considered.

Variables

This subanalysis collected sociodemographic information, mechanism of injury, and trauma severity using the AIS and ISS scores. Hemodynamically unstable patients were defined as those whose vital signs upon admission to the institution had a shock index greater than or equal to 1 [16].

Likewise, multiple trauma was defined as those patients with a trauma that involved more than two anatomical areas; major surgery to procedures involving cervicotomy, thoracotomy, sternotomy, or laparotomy; minimally invasive procedures in those patients who underwent thoracostomy, thoracoscopy or laparoscopy and who did not require major surgeries.

Information was collected on admission status, surgical procedures performed, red blood cell transfusion requirement, intensive care unit (ICU) admission, ICU stay, hospital stay, and clinical outcomes. The primary outcome was in-hospital mortality; secondary outcomes of interest were the need for major surgery and length of hospital stay.

Statistic analysis

In the information description, absolute frequency and relative frequency measures were used for categorical variables, while median and interquartile range were used for continuous variables. Regarding the comparison between continuous variables, the student t test was applied if they followed a normal distribution; otherwise, the Wilcoxon rank sum test was used. Comparison of categorical variables was performed using the chi-square test or Fisher's exact test, depending on the circumstances. Data were analyzed according to whether or not patients underwent WBCT upon admission.

A bivariate analysis was also performed to evaluate the association between the use of WBCT and mortality, and the use of WBCT and the need for major surgeries, using logistic regression models, with reporting of the effect measure with odds ratio and its 95% confidence interval. Measures of association were then calculated in models adjusted for admission status and injury severity. The performance of the model was reported according to the result of the Hosmer-Lesmeshow test and the area under the curve (AUC). In the effect measures in relation to the use or not of WBCT, the statistical power associated with the difference observed in this study was evaluated.

The calculations in this study were carried out using the R language version 4.3.0 and the STATA program (StataCorp, College Station, USA) version 15.1. P-values were calculated two-tailed and the level of significance was defined as $p<0.05$.

Results

Univariate Analysis

A total of 4380 patients with penetrating trauma were included in the study population, of which, applying the inclusion and exclusion criteria, 200 patients with hemodynamic instability on admission and who were transient responders were identified. Among the latter, 115 underwent WBCT and 85 were not evaluated with tomography (Figure 1). The overall median age was 27 years [interquartile range (IQR) 23-34] and 86% (171/200) were men.

Regarding the study groups, severe trauma (defined with an Injury Severity Score > 25) was 29% (33/115) in the WBCT group and 15% (13/85) in the control group, without being the difference statistically significant. Patients in the WBCT group had a proportion of severe chest trauma (Abbreviated Injury Scale (AIS) - Chest > 3) of 77% (88/115) while in the control group it was 44% (37/85), $p<0.001$ and multiple trauma of 48% (55/115) while in the control group it was 31% (26/85), $p=0.01$. However, in the control group (who did not undergo WBCT), the systolic pressure on admission was lower, the shock index was higher and the proportion with altered state of consciousness (assessed by the Glasgow Coma Scale) was higher. There were no differences in the frequency of initiation of blood component therapy between the two groups.

In relation to the primary outcome, in-hospital mortality in the group that underwent WBCT was 3.5% (4/115) versus 12% (10/85) in the control group. Among secondary outcomes, the proportion of major surgeries was lower in the WBCT group (30%; 35/115) compared with the control group (49%; 42/85). There were no differences in the proportion of Intensive Care Unit admissions or length of hospital stay between the two groups (Table 2).

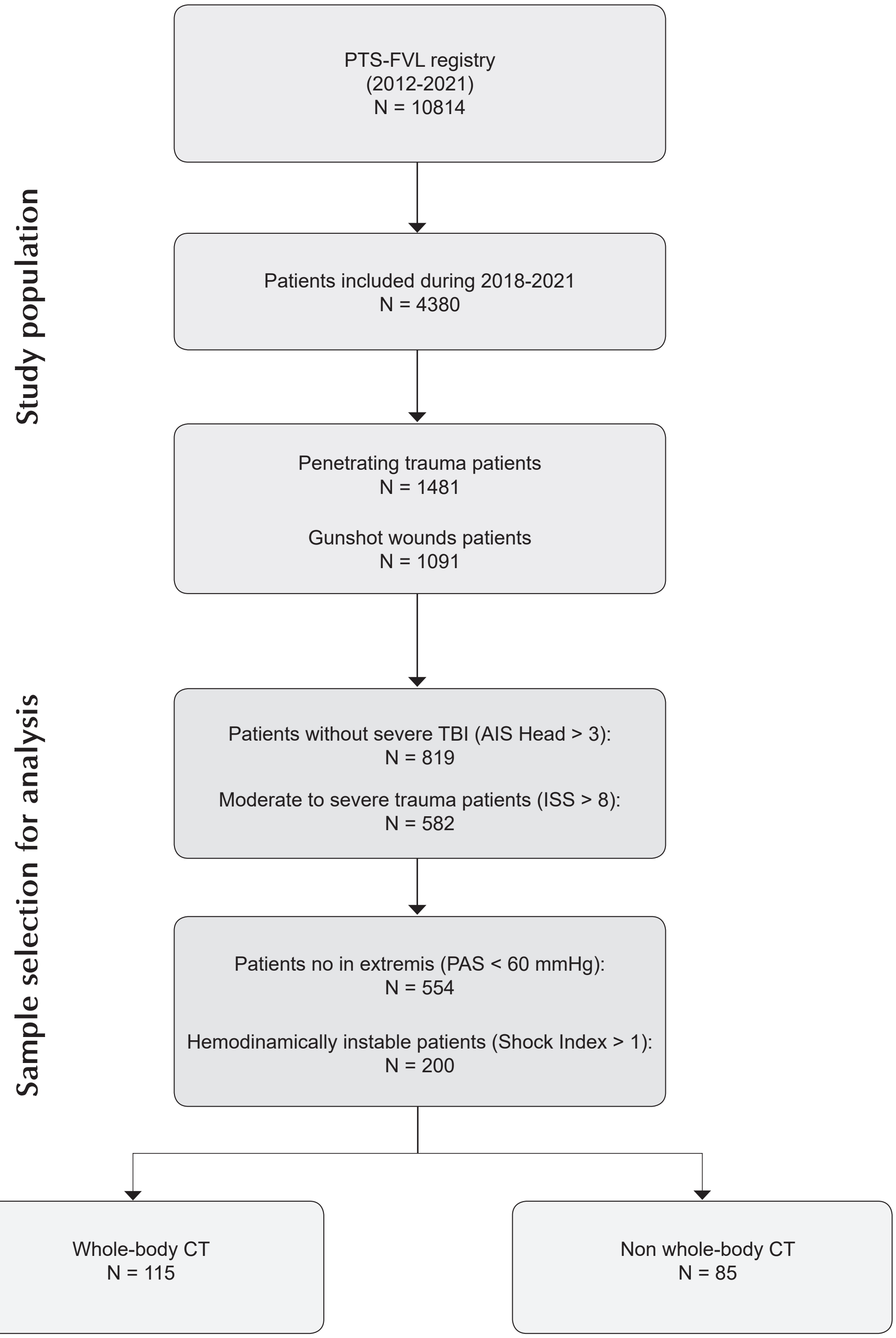

Figure 1. Patient selection flowchart included in the Study. Source: Authors' own elaboration.

Multivariate analysis

Regarding in-hospital mortality, a difference was initially detected between the groups, in favor of patients with WBCT. When evaluating the impact of the use of WBCT on mortality, corrected for variables such as age, Injury Severity Score, state of consciousness at admission and the presence of multiple trauma, it was identified that WBCT does not have an effect on the probability of in-hospital death (aOR: 0.46; 95% CI: 0.10-1.94; p=0.3) (Table 3).

Table 2. Characteristics of the patients included in the analysis according to the use or not of Whole-Body Tomography (WBCT) at admission.

	Total (n=200)	Without Whole-Body Tomography (n=85)	Whole-Body Tomography (n=115)	p-value*
Age, years, median (IQR)	27 (23-34)	27 (23-35)	27 (22-34)	0.6
Sex, n (%)				
Female	27 (14%)	12 (14%)	15 (13%)	0.8
Male	171 (86%)	72 (86%)	99 (87%)	
No data	2 (1%)	1 (0,9%)	1 (0,9%)	
Injury Severity Score (ISS), median (IQR)	18 (13-25)	17 (11-25)	18 (13-27)	0.14
ISS by category, n (%)				
Mild (ISS 9-15)	65 (33%)	31 (36%)	34 (30%)	0.084
Moderate (ISS 16-25)	89 (45%)	41 (48%)	48 (42%)	
Severe (ISS > 25)	46 (23%)	13 (15%)	33 (29%)	
AIS- Thorax > 3, n (%)	125 (63%)	37 (44%)	88 (77%)	<0.001
AIS- Abdomen > 3, n (%)	103 (52%)	50 (59%)	53 (46%)	0.075
AIS- Extremities > 3, n (%)	40 (20%)	22 (26%)	18 (16%)	0.074
Multiple trauma, n (%)	81 (41%)	26 (31%)	55 (48%)	0.014
Vital signs upon admission				
Systolic blood pressure, mmHg, median (IQR)	90 (80-100)	82 (72-97)	92 (83-103)	0.003
Heart rate, beats per minute, median (IQR)	115 (105-130)	120 (107-130)	115 (104-128)	0.2
Shock Index, median (IQR)	1.23 (1.08-1.55)	1.40 (1.09-1.69)	1.16 (1.08-1.36)	0.005
Glasgow Coma Scale (GCS), n (%)				
GCS 14-15	139 (70%)	44 (52%)	95 (83%)	<0.001
GCS 9-13	23 (12%)	16 (19%)	7 (6.1%)	
GCS < 8	38 (19%)	25 (29%)	13 (11%)	
Red blood cell transfusion requirement, n (%)	1380 (69%)	64 (75.2%)	74 (64.3%)	0.09
Surgical procedures				
Cervicotomy, n (%)	1 (0.5%)	0 (0%)	1 (0.9%)	>0.9
Toracotomy, n (%)	20 (10%)	8 (9.4%)	12 (10%)	0.8
Esternotomy, n (%)	2 (1%)	1 (1.2%)	1 (0.9%)	>0.9
Laparotomy, n (%)	64 (32%)	38 (45%)	26 (23%)	<0.001
Orthopedic reduction, n (%)	26 (13%)	10 (12%)	16 (14%)	0.7
Major surgery, n (%)	77 (39%)	42 (49%)	35 (30%)	0.006
Requirement of minimally invasive procedures, n (%)	52 (26%)	13 (15%)	39 (34%)	0.003
In-hospital mortality, n (%)	14 (7%)	10 (12%)	4 (3.5%)	0.023
Admission to Intensive Care Unit (ICU), n (%)	168 (84%)	73 (85.8%)	95 (82.6%)	0.53
Stay in ICU, days, median (IQR)	4 (1-7)	4 (2-8)	3 (1-6)	0.6
Hospital stay, days, median (IQR)	8 (5-16)	8 (4-19)	8 (5-15)	>0.9

* Wilcoxon rank sum test; Pearson's Chi-squared test; Fisher's exact test. Source: Authors' own elaboration.

When evaluating the difference in the frequency of major surgeries between the two study groups, a relative reduction of 39% was identified in favor of the group evaluated with WBCT. This phenomenon was analyzed through a multivariate analysis, where it was identified that the factor most associated with a patient undergoing major surgery was severe abdominal trauma (AIS abdomen > 3), with an adjusted OR of 3.3 (95% CI: 1.55-7.21; p=0.002). Evaluation with WBCT was associated with a reduction in the risk of major surgeries (aOR=0.47; 95% CI: 0.22-0.98; p=0.045) (Table 4).

Discussion

The use of WBCT in the evaluation of patients with penetrating gunshot trauma and hemodynamic instability was not associated with an increased risk of in-hospital mortality, but was associated with a reduction in the proportion of patients undergoing major surgery. The results of this study are pioneers in exploring the use of WBCT in this controversial scenario, which breaks management paradigms for patients with trauma.

The assessment of patients with trauma through tomography makes it possible to estimate the magnitude of traumatic injuries, and thus, make decisions regarding the therapeutic approach to follow. This therapeutic approach may include options ranging from conservative management to minimally invasive interventions, or surgeries focused on the anatomical regions affected by the trauma.

Over the past two decades, tomography has established itself as an essential component in the evaluation of trauma patients, especially in cases of blunt trauma [17]. However, the systematic use of tomography in this context is controversial due to

Table 3. Univariate and multivariate analysis on the primary outcome of in-hospital mortality.

Variable	Univariate			Multivariate		
	OR	95% CI	p-value	OR	95% CI	p-value
Age per 10 years	1.33	0.86-1.99	0.2	1.61	0.94-2.81	0.081
ISS for every 10 points	2.38	1.39-4.23	0.002	3.47	1.57-8.87	0.004
Glasgow Coma Scale > 14	0.03	0.00-0.14	<0.001	0.02	0.00-0.14	0.001
Multiple trauma	2.85	0.95-9.59	0.070	1.71	0.40-7.75	0.5
Whole-Body Tomography*	0.27	0.07-0.84	0.032	0.46	0.10-1.94	0.3

*Goodness-of-fit Test: Hosmer-Lesmeshow Test P=0.98. Area Under ROC Curve: 0.31 Pseudo-R2: 0.407. Statistical power for a difference in observed in-hospital mortality of 8.5%: 62.9%. Source: Authors' own elaboration.

Table 4. Univariate and multivariate analysis on the secondary outcome: Requirement of major Surgery.

Variable	Univariate			Multivariate		
	OR	95 % CI	p-value	OR	95% CI	p-value
AIS- Thorax > 3	0.66	0.36-1.18	0.2	0.60	0.24-1.46	0.3
AIS- Abdomen > 3	5.50	2.96-10.6	<0.001	3.30	1.55-7.21	0.002
AIS- Extremities > 3	0.13	0.04-0.34	<0.001	0.13	0.03-0.37	<0.001
Glasgow Coma Scale > 14	0.47	0.26-0.84	0.012	0.77	0.37-1.59	0.5
Shock Index	1.32	0.59-2.94	0.5	0.97	0.35-2.63	>0.9
Multiple trauma	1.60	0.90-2.86	0.11	1.44	0.64-3.26	0.4
Whole-Body Tomography*	0.47	0.26-0.83	0.010	0.47	0.22-0.98	0.045

*Goodness-of-fit Test: Hosmer-Lesmeshow Test p=0,18. Area Under ROC Curve: 0.800 Pseudo-R2: 0.198. Statistical power for a difference in observed major surgery requirement of 19%: 78.2%. Source: Authors' own elaboration.

several challenges. These challenges include the lack of consensus for the ideal timing of image acquisition, the possibility of diagnostic errors, adverse effects derived from radiation exposure, and the role of tomography for clinical decision making.

In penetrating trauma, with or without hemodynamic stability, the debate around the use of tomography intensifies even more. Delays in obtaining or appropriately interpreting images pose a significant risk of increased mortality.

Evidence of the use of WBCT in penetrating trauma is scarce. Arruza and collaborators [3] carried out a systematic review of the literature evaluating the effect of WBCT versus conventional radiological procedures in trauma patients, with high methodological rigor and quality evaluation of the studies. Fourteen publications were analyzed, of which only three studies reported patients with penetrating trauma in their inclusion criteria. This study identified that the use of WBCT did not present differences regarding the 24-hour mortality rate, incidence of multiple organ failure, the Intensive Care Unit or hospital stay. WBCT was associated with a reduction in emergency room times.

In the studies mentioned by Arruza et al., the proportion of the total population with penetrating trauma was less than 20% [18-20], given that these studies were carried out in Australia, Germany and Sweden, countries with a low incidence of penetrating trauma. Other studies carried out at the beginning of this century reported the use of different single-phase tomography protocols for the study of stable patients with penetrating trauma, for the evaluation of diagnostic capacity in the detection of abdominal visceral injuries [21-23].

WBCT in patients with penetrating trauma, especially from a firearm projectile, allows an evaluation of the degree of severity produced by the damage vector generated by the projectile and to identify the anatomical areas affected. The group of authors of this study published their first experiences in the implementation of tomography to address trauma in patients who were treated between 2012 and 2014, including 37 patients with penetrating trauma, without finding differences regarding the severity of trauma nor mortality, compared with 86 patients without tomographic study [11].

The other controversial point is whether a hemodynamically unstable patient should be transferred to CT or not. The standards of initial care of the trauma patient state that CT is considered as an adjunct in the secondary evaluation of the trauma patient. However, they often involve transferring the patient to other areas of the hospital where the equipment and personnel necessary to deal with life-threatening situations may not be available. Therefore, it is recommended that these specialized tests not be performed until the patient has been thoroughly examined and his or her hemodynamic status has stabilized. These considerations are supported by the common opinion among experienced trauma surgeons, who view performing CT in severely traumatized patients with hemodynamic instability as a potential risk for delay and complications.

In contrast, performing a CT scan in a modern trauma room offers the advantage of earlier initiation of priority-targeted treatment, which could be seen as an opportunity to improve the patient's outlook.

The long-held belief that "severely traumatized patients with hemodynamic instability should not undergo CT" has been challenged. This could be due to several factors, such as continued advances in damage control resuscitation and technological improvements in current scan machines, which offer greater resolution in less time [8,24]. Furthermore, the integration of CT into early trauma care has changed the perspective in this regard, from seeing the CT scanner as a hole of death to a circle of life.

Advances in the control of factors associated with care, regarding the integration and evolution of the organization of the trauma care team, have already been documented. The organization of an institutional response team that encompasses not only the trauma and emergency surgery group, but also a union between the emergency room, radiology area, blood bank, nursing and intensive care has had a significant impact on the improvement of care and the reduction in mortality, since its implementation in 2015 [13]. This integration has made it possible to challenge the dogma that hemodynamically unstable patients cannot be taken for tomography, since there is an entire staff that is integrated for the rapid and timely care of the trauma patient.

The present study collected information from 200 hemodynamically unstable patients, in which 57% were taken to the WBCT protocol. The use of a standardized protocol for taking images in a single shot, which allows visualization of an arterial and venous component, has contributed to timely decision-making. The group of patients taken to WBCT had no differences regarding the severity of the trauma, compared to the control group.

However, it is noteworthy that despite excluding patients in a potential *in extremis* condition (systolic blood pressure < 60 mm Hg) from being considered in the control group, this had a significant difference in physiological compromise upon admission, given by a lower systolic blood pressure, a tendency toward a higher shock rate, and greater neurological impairment. The institutional protocol leaves the decision of whether to take WBCT or not to the consideration of the team of surgeons and emergency physicians. However, when evaluating the effect of the use of WBCT on mortality, it did not represent a factor that contributed to increasing the risk of death.

On the other hand, performing a WBCT can be beneficial in making surgical decisions in the initial approach to patients with penetrating gunshot trauma, in scenarios such as multiple trauma or suspected damage vectors that compromise two anatomical areas, which become a challenge when planning surgical approaches. WBCT allows the surgeon to visualize prior to surgery, to recognize their lesion control objectives and decide on surgical management alternatives. This is how WBCT becomes the gateway for decision making, where it is no longer just the dichotomy of whether or not to perform major surgery, such as thoracotomy or laparotomy, but also to recognize alternative approaches such as minimally invasive surgery techniques. in trauma (laparoscopy or thoracoscopy), angioembolization or conservative expectant management, which have advanced in recent years [25-28].

The results of the present study showed a relative reduction of 39% in the performance of major surgeries in the group of patients evaluated with WBCT. In the multivariate analysis, which explored the impact of the severity of the injuries and the physiological compromise on the role of WBCT for performing major surgeries, a factor was observed that reduces the requirement for surgeries.

Among the limitations associated with this study, it is recognized that the source of the information comes from retrospective data, in which the assignment to the intervention being studied, regarding the use or not of WBCT, was the product of the clinical decision and not of a random assignment process. Information related to the time elapsed between the trauma and hospital care, the time spent traveling to the imaging room or performing surgery, are not included in the variables collected by the PTS-FVL registry. Likewise, detailed information on resuscitation behaviors, such as the total volume of crystalloids, volume and ratio of blood components, vasopressor support or administration of tranexamic acid is not reported in detail. These variables regarding time and initial care may be factors that impact the estimates presented.

On the other hand, it is recognized that the estimates made in the primary and secondary results did not find that the observed differences had a power greater than 80%. However, this is the first study to analyze the impact on clinical outcomes, such as mortality and associated surgical approaches, in a group of hemodynamically unstable, penetrating trauma patients. It is proposed to conduct prospective follow-up of patients who meet these criteria in the study population to evaluate the impact of this intervention.

Conclusion

Whole-body tomography can be used in the initial evaluation of patients with penetrating gunshot wounds and who are hemodynamically unstable, as it allows rapid evaluation of the severity of the trauma and making appropriate surgical decisions. The use of whole-body CT was not associated with increased mortality and was related to a reduction in the frequency of major surgeries.

Acknowledgements

The authors would like to thank the Clinical Research Center for the maintenance and support of the trauma registry of the Panamerican Trauma Society – Fundación Valle del Lili. We appreciate the work of Paola Gasca, Lina Timote, Wilson Piamba, Yensi Valencia, Mónica Criollo, Leidy Pedroza, Sandra Quenoran and Camila Galíndez.

Compliance with ethical standards

Informed consent: This study was approved by the Institutional Ethics Committee (Protocol 554-November 22, 2011, renewed on December 27, 2022). The authors declare that they followed the parameters of resolution 8430 of 1993. Since it was a retrospective review of a database, it was considered a risk-free study, so the completion of informed consent from the patients is not required.

Conflict of interest: none declared by the authors.

Use of artificial intelligence: The authors declared that they did not use artificial intelligence (AI)-assisted technologies (such as large language models, chatbots, or image creators) in the production of this work.

Funding sources: Clinical Research Center (CRC), Fundación Valle del Lili, Cali, Colombia. Protocol 554.

Author's contributions

- Conception and design of the study:: Carlos A. Ordoñez, Alberto F. García, Yaset Caicedo.
- Acquisition of data: Isabella Caicedo-Holguín, Camilo Salazar, Hernán Esteban Munévar, Alexander Salcedo, Fernando Rodríguez, José Julián Serna, Carlos García.
- Data analysis and interpretation: Carlos A. Ordoñez, Alberto F. García, Yaset Caicedo.
- Drafting the manuscript: Yaset Caicedo, Isabella Caicedo-Holguín, Camilo Salazar, Hernán Esteban Munévar.
- Critical review and approval: Carlos A. Ordoñez, Alberto F. García, Alexander Salcedo, Fernando Rodríguez, José Julián Serna, Carlos García.

References

1 GBD 2017 Disease and Injury Incidence and Prevalence Collaborators. Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990-2017: A systematic analysis for the Global Burden of Disease Study 2017. Lancet. 2018;392:1789-858. https://doi.org/10.1016/S0140-6736(18)32279-7

2 Cieza A, Causey K, Kamenov K, Hanson SW, Chatterji S, Vos T. Global estimates of the need for rehabilitation based on the Global Burden of Disease study 2019: A systematic analysis for the Global Burden of Disease Study 2019. Lancet. 2020;396:2006-17. https://doi.org/10.1016/S0140-6736(20)32340-0

3 Arruzza E, Chau M, Dizon J. Systematic review and meta-analysis of whole-body computed tomography compared to conventional radiological procedures of trauma patients. Eur J Radiol. 2020;129:109099. https://doi.org/10.1016/j.ejrad.2020.109099

4 Leidner B, Beckman MO. Standardized whole-body computed tomography as a screening tool in blunt multitrauma patients. Emerg Radiol. 2001;8:20-8. https://doi.org/10.1007/PL00011863

5 Sampson MA, Colquhoun KBM, Hennessy NLM. Computed tomography whole body imaging in multi-trauma: 7 years experience. Clin Radiol. 2006;61:365-9. https://doi.org/10.1016/j.crad.2005.12.009

6 Albrecht T, von Schlippenbach J, Stahel PF, Ertel W, Wolf KJ. [The role of whole body spiral CT in the primary work-up of polytrauma patients -comparison with conventional radiography and abdominal sonography]. Rofo. 2004;176:1142-50. https://doi.org/10.1055/s-2004-813259

7 Salim A, Sangthong B, Martin M, Brown C, Plurad D, Demetriades D. Whole body imaging in blunt multisystem trauma patients without obvious signs of injury: Results of a prospective study. Arch Surg. 2006;141:468-75. https://doi.org/10.1001/archsurg.141.5.468

8 Ordoñez C, García C, Parra MW, Angamarca E, Guzmán-Rodríguez M, Orlas CP, et al. Implementation of a new Single-Pass Whole-Body Computed Tomography Protocol: Is it safe, effective and efficient in patients with severe trauma? Colomb Med (Cali). 2020;51:e4224. https://doi.org/10.25100/cm.v51i1.4224

9 Chidambaram S, Goh EL, Khan MA. A meta-analysis of the efficacy of whole-body computed tomography imaging in the management of trauma and injury. Injury. 2017;48:1784-93. https://doi.org/10.1016/j.injury.2017.06.003

10 Sierink JC, Treskes K, Edwards MJR, Beuker BJA, den Hartog D, Hohmann J, et al. Immediate total-body CT scanning versus conventional imaging and selective CT scanning in patients with severe trauma (REACT-2): A randomised controlled trial. Lancet. 2016;388:673-83. https://doi.org/10.1016/S0140-6736(16)30932-1

11 Ordoñez CA, Herrera-Escobar JP, Parra MW, Rodriguez-Ossa PA, Mejia DA, Sanchez AI, et al. Computed tomography in hemodynamically unstable severely injured blunt and penetrating trauma patients. J Trauma Acute Care Surg. 2016;80:597-603. https://doi.org/10.1097/TA.0000000000000975

12 Treskes K, Saltzherr TP, Edwards MJR, Beuker BJA, Den Hartog D, Hohmann J, et al. Emergency bleeding control interventions after immediate total-body CT scans in trauma patients. World J Surg. 2019;43:490-6. https://doi.org/10.1007/s00268-018-4818-0

13 Carvajal S, Uribe-Buritica FL, Ángel-Isaza AM, López-Girón MC, González A, Chica J, et al. Trauma team conformation in a war-influenced middle-income country in South America: is it possible? Int J Emerg Med. 2020;13:36. https://doi.org/10.1186/s12245-020-00297-7

14 Uribe FL, Carvajal SM, Torres NF, Bustamante LA, García AF. Equipos de trauma: realidad mundial e implementación en un país en desarrollo. Descripción narrativa. Rev Colomb Cir. 2021;36:42-50. https://doi.org/10.30944/20117582.650

15 Angamarca E, Orlas CP, Herrera-Escobar JP, Rincón É, Guzmán-Rodríguez M, Meléndez JJ, et al. Uso de la tomografía corporal total en pacientes con trauma grave: ¿es efectiva y segura para definir el manejo no operatorio? Rev Colomb Cir. 2020;35:84-92. https://doi.org/10.30944/20117582.591

16 Rossaint R, Afshari A, Bouillon B, Cerny V, Cimpoesu D, Curry N, et al. The European guideline on management of major bleeding and coagulopathy following trauma: sixth edition. Critical Care. 2023;27:80. https://doi.org/10.1186/s13054-023-04327-7

17 Furlow B. Whole-body computed tomography trauma imaging. Radiol Technol. 2017;89:159CT-180CT.

18 Gordic S, Alkadhi H, Hodel S, Simmen HP, Brueesch M, Frauenfelder T, et al. Whole-body CT-based imaging algorithm for multiple trauma patients: Radiation dose and time to diagnosis. Br J Radiol. 2015;88:20140616. https://doi.org/10.1259/bjr.20140616

19 Hsiao KH, Dinh MM, McNamara KP, Bein KJ, Roncal S, Saade C, et al. Whole-body computed tomography in the initial assessment of trauma patients: Is there optimal criteria for patient selection? Emerg Med Australas. 2013;25:182-91. https://doi.org/10.1111/1742-6723.12041

20 Wurmb TE, Quaisser C, Balling H, Kredel M, Muellenbach R, Kenn W, et al. Whole-body multislice computed tomography (MSCT) improves trauma care in patients requiring surgery after multiple trauma. Emerg Med J. 2011;28:300-4. https://doi.org/10.1136/emj.2009.082164

21 Shanmuganathan K, Mirvis SE, Chiu WC, Killeen KL, Scalea TM. Triple-contrast helical CT in penetrating torso trauma: A prospective study to determine peritoneal violation and the need for laparotomy. Am J Roentgenol. 2001;177:1247-56. https://doi.org/10.2214/ajr.177.6.1771247

22 Shanmuganathan K, Mirvis SE, Chiu WC, Killeen KL, Hogan GJF, Scalea TM. Penetrating torso trauma: triple-contrast helical CT in peritoneal violation and organ injury – A prospective study in 200 patients. Radiology. 2004;231:775-84. https://doi.org/10.1148/radiol.2313030126

23 Chiu WC, Shanmuganathan K, Mirvis SE, Scalea TM. Determining the need for laparotomy in penetrating torso trauma: A prospective study using triple-contrast enhanced abdominopelvic computed tomography. J Trauma. 2001;51:860-9. https://doi.org/10.1097/00005373-200111000-00007

24 Huber-Wagner S, Mand C, Ruchholtz S, Kühne CA, Holzapfel K, Kanz KG, et al. Effect of the localisation of the CT scanner during trauma resuscitation on survival – A retrospective, multicentre study. Injury. 2014;45 Suppl 3:S76-82. https://doi.org/10.1016/j.injury.2014.08.022

25 Ordoñez CA, Parra MW, Millán M, Caicedo Y, Guzmán-Rodríguez M, Padilla N, et al. Damage control in penetrating liver trauma: Fear of the unknown. Colomb Med (Cali). 2020;51:e4134365. https://doi.org/10.25100/cm.v51i4.4422.4365

26 Salcedo A, Ordoñez CA, Parra MW, Osorio JD, Guzmán-Rodríguez M, Pino LF, et al. Damage control for renal trauma: The more conservative the surgeon, better for the kidney. Colomb Med (Cali). 2021;52:e4094682. https://doi.org/10.25100/cm.v52i2.4682

27 Serna C, Serna JJ, Caicedo Y, Padilla N, Gallego LM, Salcedo A, et al. Damage control surgery for splenic trauma: "preserve an organ - preserve a life." Colomb Med (Cali). 2021;52:e4084794. https://doi.org/10.25100/cm.v52i2.4794

28 Zafar SN, Onwugbufor MT, Hughes K, Greene WR, Cornwell EE, Fullum TM, et al. Laparoscopic surgery for trauma: The realm of therapeutic management. Am J Surg. 2015;209:627-32. https://doi.org/10.1016/j.amjsurg.2014.12.011