

Concordance between tomographic and surgical AAST injury grades in liver, spleen, and kidney due to blunt abdominal trauma

Concordancia entre los grados de lesión AAST tomográficos y quirúrgicos en hígado, bazo y riñón por trauma cerrado de abdomen

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Abstract

Objective: To determine the concordance between tomographic and surgical AAST (American Association for the Surgery of Trauma) injury grades in liver, spleen, and kidney due to blunt abdominal trauma. **Method:** A prospective, single-center, observational, comparative, and cross-sectional study was carried out in patients over 15 years-old, with liver, spleen, and kidney injury due to blunt abdominal trauma, who underwent abdominal tomography followed by exploratory laparotomy, in whom the concordance of the tomographic and surgical AAST grades of these organs was determined, from March 2017 to December 2020, at Hospital Civil de Culiacán, Sinaloa, México. **Results:** 48 patients, with a mean age of 27.9 ± 10.9 years; 41 men (85%). Spleen injury was the most frequent with 30 patients (63%), followed by liver 20 (42%) and kidney with 15 (31%). The concordance of AAST grades injury between tomography and surgery was low and moderate with kappa values of 0.234 ($p < 0.001$), 0.419 ($p < 0.001$), and 0.415 ($p < 0.001$), for liver, spleen, and kidney injuries, respectively. **Conclusions:** Tomographic and surgical AAST injury grades in liver, spleen, and kidney due to blunt abdominal trauma have low and moderate concordance, and tomographic grades are lower than surgical grades.

Keywords: Blunt trauma abdominal. Tomography. AAST. Solid viscera injury. Concordance.

Resumen

Objetivo: Determinar la concordancia entre los grados de lesión de la escala AAST (American Association for the Surgery of Trauma) tomográficos y quirúrgicos en lesiones hepáticas, esplénicas y renales por trauma abdominal cerrado. **Método:** Estudio prospectivo, unicéntrico, observacional, comparativo y transversal, en pacientes mayores de 15 años con lesión hepática, esplénica o renal por trauma abdominal cerrado, sometidos a tomografía abdominal y posterior laparotomía exploradora, en quienes se determinó la concordancia de los grados de lesión AAST tomográficos y quirúrgicos de estos órganos, de marzo de 2017 a diciembre de 2020, en el Hospital Civil de Culiacán, Sinaloa, México. **Resultados:** Se incluyeron 48 pacientes, con una edad promedio de 27.9 ± 10.9 años; de ellos, 41 eran hombres (85%). La lesión esplénica fue la

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más frecuente, en 30 pacientes (63%), seguida de la hepática en 20 (42%) y la renal en 15 (31%). La concordancia del grado de lesión AAST entre la tomografía y la cirugía fue baja o moderada, con valores kappa de 0.234 ($p < 0.001$), 0.419 ($p < 0.001$) y 0.415 ($p < 0.001$) para las lesiones hepáticas, esplénicas y renales, respectivamente. **Conclusiones:** Los grados de lesión AAST tomográficos y quirúrgicos en el hígado, el bazo y los riñones por trauma abdominal cerrado tienen baja y moderada concordancia, y los grados tomográficos son menores que los quirúrgicos.

Palabras clave: Trauma abdominal cerrado. Tomografía. AAST. Lesión de víscera sólida. Concordancia.

Introduction

Blunt abdominal trauma represents 80% of abdominal injuries seen by the emergency department. The prevalence of intraabdominal injuries among patients that are seen in the emergency room with abdominal trauma is approximately 13%¹. The majority of cases are related to road accidents (75%), such as car accidents or pedestrians being run over².

The most frequently injured solid organ in blunt abdominal trauma varies in the literature, but all publications agree that spleen and liver injuries are at the top and, in most cases, followed by kidney injuries³⁻⁷.

In patients with blunt abdominal trauma, at the time of the physical exploration, presence of pain and abdominal sensitivity increase the probability of intraabdominal injury; however, their negative predictive value is low, and, therefore, in their absence, an injury cannot be ruled out^{1,8}. The time it takes to develop symptoms or signs with the physical exploration in intraabdominal injuries shown by computerized tomography (CT), or laparotomy in blunt abdominal trauma is approximately 8 hours and 25 minutes from the time of arrival at the hospital, and patients who require any intervention develop them within 60 minutes⁹.

Simple or multiple abdominal trauma is associated with a mortality rate of 15%. Treatment is aimed at the findings of the CT scan, which is the reason why it is considered the current reference diagnosis method^{10,11}, in addition to having high sensitivity and specificity to detect relevant intraabdominal injuries¹².

However, for the adequate management of patients with blunt abdominal trauma and CT scan showing intraabdominal injuries, including the liver, spleen, and kidneys, the organ injury scale of the American Association for the Surgery of Trauma (AAST)¹³ is used, which was originally described only for the anatomical findings of the injury during surgery, and is currently essential for decision making regarding surgical or conservative treatment for intraabdominal injuries in patients who are hemodynamically

stable or stabilized in the emergency room. However, despite the high sensitivity and specificity, the CT scan may underestimate the diagnosis of these injuries^{14,15}.

The purpose of this study is to determine the concordance between the tomographic and surgical AAST injury degrees in solid viscera (liver, spleen, and kidneys) secondary to a blunt abdominal trauma.

Method

Prospective, single-center, observational, comparative, and transversal study, which included all patients over 15 years of age, regardless of gender, consecutively, who suffered any solid viscera injury (liver, spleen, and kidneys) secondary to blunt abdominal trauma, subject to abdominopelvic CT scan and subsequent explorative laparotomy, and the concordance between the tomographic and surgical AAST injury degrees of these organs was determined, within the period of time between March 2017 and December 2020 in Hospital Civil de Culiacán, Sinaloa, Mexico. The exclusion criterion was being admitted to the operating room directly due to hemodynamic instability, and the elimination criteria were having an incomplete medical record or voluntary discharge before completing the diagnostic protocol.

A Siemens Somatom Perspective multislice tomograph with 64 detectors was used in all patients. An intravenous contrast medium (iopromide 62.30 g in 100 ml) was used in the arterial and venous phase in patients where it was available for application; the availability of the contrast medium was subject to schedule, financial, and administrative circumstances.

The categorical data was described with frequencies and percentages, and numerical data with means and standard deviation. In order to compare the concordance between the AAST injury degrees in the CT scan and the surgical degrees, Cohen's kappa and the predictive values of the CT were estimated during the transoperative period.

In order to compare the degree of injury by type of solid viscera, Friedman's test was used. Other comparisons between categorical variables were made with the χ^2 test. The data was analyzed in SPSS v22, and a value of $p < 0.05$ was considered statistically significant.

The sample size was calculated in $n = 135$, estimated with Epidat v4.2, for a kappa value of 0.5, 30% positives for CT, and 40% for surgery, with an accuracy of 0.15 and confidence interval of 95%.

Results

48 patients between the ages of 16 and 54 were included (average of 27.9 ± 10.9 years), and 41 of them (85%) were male. Alcohol consumption was found in 20 (42%) patients, and cocaine use in 3 (6%). The most frequent trauma kinematics was associated with road accidents: automobile 22 (46%) and motorcycle 21 (44%). The majority of patients, 39 (81%) received prehospital care. Third-degree hypovolaemic shock was present in 16 (33%) patients, and fourth-degree in 19 (40%) (Table 1).

In the findings of solid viscera injuries by CT 22 (46%) were found in the spleen, 9 (19%) in the liver, and 9 (19%) in the kidney. No solid viscera injuries were found in 15 (31%) patients; however, free fluid was found in 15 (31%), free air in 3 (6%), and free fluid associated with retroperitoneal hematoma in zone III with pelvic fracture in 3 (6%). The most frequently associated injury was the thorax injury, in 18 (38%) patients, followed by upper limb fractures in 11 (23%), and lower limb in 10 (21%), skull in 9 (19%), brainstem in 8 (17%), and other six areas.

The most frequent AAST injury degree by CT was the second-degree spleen injury in 9 (41%) patients, third-degree liver injury in 6 (67%), and second and fourth-degree kidney injury in 3 (33%).

In the surgical findings, spleen injuries were the most frequent, in 30 patients (63%), followed by liver injuries in 20 (42%), and kidney injuries in 15 (31%). The most frequently performed surgical procedures were splenectomies in 25 (52%) patients, followed by haemostatic procedures in 20 (42%), and packing in 9 (19%). The majority of patients, 29 (60%) did not have complications, and the most frequent were superficial surgical site infection, which occurred in 6 patients (13%), followed by pneumonia in 5 (10%). 6 patients passed away (13%) (Table 2).

Significant differences were observed in solid viscera injury by AAST surgical injury degree ($p = 0.042$).

Table 1. General characteristics

n	48
Age, years	
Range	16-54
Mean	27.9
Standard deviation	10.9
Gender	
Male	41 (85%)
Female	7 (15%)
Addictions	
Alcohol	20 (42%)
Cocaine	3 (6%)
Other	1 (2%)
Trauma kinematics	
Automobile	22 (46%)
Motorcycle	21 (44%)
Aggression by third party	3 (6%)
Fall	2 (4%)
Prehospital care received	39 (81%)
Hypovolemic shock degrees	
I	2 (4%)
II	11 (23%)
III	16 (33%)
IV	19 (40%)

The most frequent injury in the spleen was a third-degree injury in 17 patients (57%) ($p = 0.047$); in the liver, degree I and IV were the most common ($p < 0.001$); and among kidney injuries, degree II and V were the most frequent ($p = 0.047$).

The concordance between the findings of injury in the CT scan and surgical findings, without taking into account the AAST degrees, were moderate for the spleen ($\kappa = 0.510$), low for the liver ($\kappa = 0.365$), and moderate for the kidney ($\kappa = 0.565$), with a CT sensitivity compared to the surgical findings estimated in 66.7%, 40%, and 53.33%, and a positive predictive value of 90.9%, 88.9%, and 88.9% for the spleen, liver, and kidneys, respectively (Table 3).

The concordance of the AAST injury degrees between the CT and the surgical findings was between low and moderate, with kappa values of 0.234 ($p < 0.001$), 0.419 ($p < 0.001$) and 0.415 ($p < 0.001$) for liver, spleen, and kidney injuries, respectively (Table 4).

The injury degree was underestimated in the CT; in liver and spleen injuries it was underestimated 18 times (37.5%), and in kidney injuries 10 times (21%). The use of a contrast medium in the CT did not significantly improve the estimation of the injury degree: in the liver, the injury degree was underestimated in

Table 2. Tomographic and surgical findings for liver, spleen, and kidney injuries. Procedures performed and complications

Tomographic injury findings	
Solid viscera injury in CT	
Liver	9 (19%)
Spleen	22 (46%)
Kidney	9 (19%)
Surgical injury findings, procedures performed, and complications	
Solid viscera injury during surgery	
Liver	20 (42%)
Spleen	30 (63%)
Kidney	15 (31%)
Procedures performed	
Splenectomy	25 (52%)
Hemostatics	20 (42%)
Packing	9 (19%)
Hepatorrhaphy	4 (8%)
Nephrectomy	3 (6%)
Small intestine resection and anastomosis	3 (6%)
Primary vesical closure	2 (4%)
Small intestine resection and ileostomy	2 (4%)
Colon resection and colostomy	2 (4%)
Thoracotomy	1 (2%)
Primary diaphragm closure	1 (2%)
Primary small intestine closure	1 (2%)
None	1 (2%)
Complications	
None	29 (60%)
Superficial surgical site infection	6 (13%)
Pneumonia	5 (10%)
Infection of the organ space surgical site	3 (6%)
Early bowel obstruction due to adhesences	2 (4%)
Necrotizing fasciitis	1 (2%)
Post-operative ileum	1 (2%)
Open abdomen and control ventral hernia	1 (2%)
Deep surgical site infection	1 (2%)
Biliary leak	1 (2%)
Mortality	6 (13%)

CT: computerized tomography.

12 (39%) without contrast, and in 6 (35%) with contrast ($p = 1.000$), in the spleen, it was underestimated in 14 (45%) without contrast, and 4 (23.5%) with contrast (with no significant difference, $p = 0.214$), and in the kidneys, 6 (19%) without contrast and 4 (23.5%) with contrast ($p = 0.727$) were underestimated (Table 5).

In some patients, the CT was reported negative for solid viscera injuries, but with findings of intraabdominal free fluid or air, and subsequently, in the surgical findings, solid viscera injuries were reported. In 12 patients, liver injuries were reported during surgery, when the CT scan had reported free fluid in 7 (58%), and intraabdominal free air in 2 (7%). In 10 patients, spleen injuries were reported during surgery, and the

CT scan had reported free fluid in 1 (10%) and intraabdominal free air in 1 (10%). Kidney injuries were reported in 7 patients during surgery, and the CT scan had reported free fluid in 5 (71%).

Discussion

This study coincides with the epidemiological characteristics found in global literature, such as higher incidence in males, younger age, and the most common trauma kinematics being road accidents^{2,16}, with a reported mortality of 15%¹⁰ (13% in our study).

The frequency of spleen, liver, and kidney injuries reported by CT and surgical findings matched the findings reported in the studies^{3,16}; however, we only included patients who had a CT scan, followed by an exploratory laparotomy, decreasing the frequency of injuries that did not require surgical treatment.

The sensitivity and specificity of the CT are reported in 96-100%, and this test is considered method of reference in abdominal trauma^{15,17}; however, this does not match the findings of this study, as for the resulting concordance between the CT and the surgical findings in spleen, liver, and kidney a sensitivity of 66.7%, 40%, and 53.3% was obtained, as well as a specificity of 88.9%, 96.4%, and 97%, a positive predictive value of 90.9%, 88.9%, and 88.9%, a negative predictive value of 61.5%, 69.2%, and 82.1%, and a diagnostic accuracy of 75%, 72.9%, and 83.3% for the spleen, liver, and kidney, respectively.

The concordance between tomographic and surgical degrees obtained was low for the liver ($\kappa = 0.234$) and moderate for the spleen and kidney ($\kappa = 0.419$ and 0.415 , respectively).

Liver injuries were underestimated 18 times (37.5%), spleen injuries 18 times (37.5%), and kidney injuries 10 times (21%), which was statistically significant, coinciding with the study by Croce et al.¹⁴, who found that solid viscera injuries are underestimated in CT scans when comparing the findings of liver injuries of pre-operative CT scans with the anatomical findings in the exploratory laparotomy. In their study, 37 patients with liver injury secondary to abdominal blunt trauma were evaluated by abdominal CT with and without intravenous contrast, and subsequently subjected to exploratory laparotomy. They found that the increase in the degree of the liver injury scale during surgery was directly correlated to the need for transfusions and surgical management, and also, to the fact that in 31 (84%) patients, the pre-operative findings in the CT were not correlated to the surgical findings; 4 patients had

Table 3. Concordance between tomographic and surgical finding in liver, spleen, and kidney injuries

Solid viscera	-	+	Kappa (p)	Sn	S	PPV	NPV	Accu.
Liver								
-	27 (96%)	12 (60%)	0.365 (< 0.001)	40%	96.4%	88.9%	69.2%	72.9%
+	1 (4%)	8 (40%)						
Spleen								
-	16 (89%)	10 (33%)	0.510 (< 0.001)	66.7%	88.9%	90.9%	61.5%	75%
+	2 (11%)	20 (67%)						
Kidney								
-	32 (97%)	7 (47%)	0.565 (< 0.001)	53.3%	97%	88.9%	82.1%	83.3%
+	1 (3%)	8 (53%)						

S: specificity; Accu: accuracy; Sn: sensitivity; NPV: negative predictive value; PPV: positive predictive value.

-: absent injury; +: injury present.

Table 4. Concordance between the tomographic and surgical AAST injury degrees in the liver, spleen, and kidney

Solid viscera	CT	Surgical							Kappa	p
		WI	I	II	III	IV	V	VI		
Liver	WI	27 (69%)	6 (15%)	4 (10%)	0 (0%)	1 (3%)	1 (3%)	0 (0%)	0.234	< 0.001
	I	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)		
	II	1 (50%)	0 (0%)	0 (0%)	0 (0%)	1 (50%)	0 (0%)	0 (0%)		
	III	0 (0%)	0 (0%)	0 (0%)	1 (17%)	4 (67%)	1 (17%)	0 (0%)		
	IV	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (100%)	0 (0%)	0 (0%)		
	V	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)		
	VI	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	(0%)		
Spleen	WI	16 (62%)	3 (12%)	1 (4%)	3 (12%)	2 (8%)	1 (4%)		0.419	< 0.001
	I	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)			
	II	2 (22%)	0 (0%)	0 (0%)	7 (78%)	0 (0%)	0 (0%)			
	III	0 (0%)	0 (0%)	0 (0%)	7 (88%)	1 (13%)	0 (0%)			
	IV	0 (0%)	0 (0%)	0 (0%)	0 (0%)	5 (100%)	0 (0%)			
	V	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)			
	VI	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)			
Kidney	WI	32 (82%)	1 (3%)	2 (5%)	0 (0%)	1 (3%)	3 (8%)		0.415	< 0.001
	I	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)			
	II	1 (33%)	0 (0%)	1 (33%)	1 (33%)	0 (0%)	0 (0%)			
	III	0 (0%)	0 (0%)	1 (100%)	0 (0%)	0 (0%)	0 (0%)			
	IV	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (33%)	2 (67%)			
	V	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	2 (100%)			
	VI	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)			

WI: without injury; CT: computerized tomography.

intrahepatic hematomas that were not discovered during the surgical procedure. 12 injuries that were classified too high by CT and 15 too low, and out of those 15 cases, 10 stagings by CT were at least two degrees lower than the surgical findings.

In another study, Homann et al.¹⁸ reported 53 patients who suffered blunt abdominal trauma with spleen and liver injuries. 36 spleen injuries and 35 liver injuries were studied. All patients had CT scans and explorative laparotomies, defining the surgical findings as

Table 5. Frequency of patients where the AAST injury degree by computerized tomography with or without intravenous contrast is underestimated

Solid viscera	Und.	Tomography		Total 48 (100%)	p
		Without contrast 31 (100%)	With contrast 17 (100%)		
Liver	No	19 (61%)	11 (65%)	30 (62.5%)	1.000
	Yes	12 (39%)	6 (35%)	18 (37.5%)	
Spleen	No	17 (55%)	13 (76.5%)	30 (62.5%)	0.214
	Yes	14 (45%)	4 (23.5%)	18 (37.5%)	
Kidney	No	25 (81%)	13 (76.5%)	38 (79%)	0.727
	Yes	6 (19%)	4 (23.5%)	10 (21%)	

Und.: underestimated cases.

definitive, with no statistically significant results found. However, they detected a lower rate of underestimation of the injuries when the CT was performed in a systematic manner by the radiologist.

However, other studies, such as the one conducted by Ruscelli et al.¹⁹, state that, even though the AAST classification for liver and spleen trauma is used globally to designate the severity of the injury, angiography should be added in order to make treatment decisions, as they mention that, by itself, the classification was not useful to conduct their therapeutic decision protocol, which may match the underestimation found in our study.

Conclusions

The AAST tomographic and surgical injury degrees for liver, spleen, and kidney injuries secondary to blunt abdominal trauma have low to moderate concordance, and the injury degrees found in the CT are lower than the surgical degrees. However, more studies are needed, where all patients undergo a CT with intravenous contrast with later phases validated by more than one specialist in the imaging field. Furthermore, it must be noted that there could be an observation bias by the surgeon when determining the degree of the injury.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

Ethical disclosures

Protection of people and animals. The authors declare that no experiments have been made on human beings or animals for this research.

Data confidentiality. The authors declare that they have followed the protocols of their work center regarding the publication of patient data.

Right to privacy and informed consent. The authors have obtained the informed consent of the patients and/or subjects referred to in the article. This document is in the possession of the corresponding author.

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