

The cost of gunshot abdominal vascular injuries: Its impact on patient, family, and hospital

El costo de la atención de las lesiones vasculares abdominales por proyectil de arma de fuego. Su impacto en el paciente, su familia y el hospital

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Abstract

Background: Violent trauma with penetrating injuries is a relevant public health issue. Penetrating abdominal wounds cause 90-95% of vascular injuries, which not only have high associated morbidity and lethality but also involve high attention costs. Cost analysis in hospitals has become a topic of great interest, as it justifies changes in hospital organization and management. **Objective:** The objective of the study was to determine the cost of gunshot abdominal vascular injuries for the patient, his family, and the hospital. **Material and methods:** We drove an observational, descriptive, prospective, and longitudinal study of patients with of gunshot abdominal vascular injuries admitted in the Mexican Red Cross Trauma Center in the Federal District from January 1, 2018, to October 31, 2018. **Results:** A total of 8149 patients were admitted in the emergency department, 149 with a diagnosis of gunshot injury, of which 6 (0.07%) had abdominal vascular injury. The total cost of medical care these patients was on average \$174,770.79 (median \$132,999.50) per capita, amount that surpasses their annual income and implies an institutional absorption of expenditure up to 95.5%. **Conclusions:** Institutional investment on the attention of high-impact pathologies and the development of strategies that facilitate access to health services are a real and priority necessity.

Keywords: Costs. Vascular injuries. Abdominal penetrating trauma.

Resumen

Antecedentes: El trauma violento con lesiones penetrantes es un problema de salud pública relevante. Las heridas penetrantes abdominales causan el 90-95% de las lesiones vasculares, las cuales tienen elevada morbilidad asociada y letalidad, e implican elevados costos de atención. El análisis de costos en los hospitales es de gran interés, pues permite justificar cambios en la organización y la gestión hospitalaria. **Objetivo:** Determinar el costo de las lesiones vasculares abdominales por proyectil de arma de fuego para el paciente, su familia y el hospital. **Material y métodos:** Se llevó a cabo un estudio observacional, descriptivo, prospectivo y longitudinal de pacientes con lesiones vasculares abdominales por proyectil de arma de fuego que ingresaron en el Centro de Trauma de Cruz Roja Mexicana en Ciudad de México entre enero y octubre de 2018. **Resultados:** Ingresaron 8149 pacientes, 149 con diagnóstico de herida por proyectil de arma de fuego, de los cuales el 0.07% tuvieron lesión vascular abdominal. El costo total de la atención médica fue en promedio de \$174,770.79 (mediana \$132,999.50) por persona, el cual supera el ingreso anual de esos pacientes e implica una absorción institucional del gasto de hasta el

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95.5%. **Conclusiones:** *La inversión institucional en la atención de patologías con alto impacto y el desarrollo de estrategias para facilitar el acceso a servicios de salud son una necesidad prioritaria real.*

Palabras clave: *Costos. Lesiones vasculares. Trauma penetrante de abdomen.*

Introduction

Violent trauma with penetrating injuries (by firearm projectile or sharp instrument) is a relevant public health problem: it is among the leading causes of death in the world and mainly affects the economically active population. Worldwide, and in non-military hospitals, vascular lesions account for 0.65% of total annual admissions to emergency services, and in Mexico, they comprise 9% of that figure. Penetrating abdominal wounds cause 90-95% of abdominal vascular lesions (which are found in 22-25% of patients undergoing laparotomy for gunshot abdominal injuries) and are estimated to be associated with a mean of two to four additional injuries; in addition, it is common for multiple vessel involvement to be observed. In general terms, lethality of arterial injuries is 35-85% and that of venous injuries is 50-90%¹⁻⁴.

Medical research has shown that many high-income countries have significantly reduced trauma-related mortality rates by implementing systems based on improvement of the quality of organization and care planning from the pre-hospital setting, initial resuscitation in the hospital, and definitive care in the short, medium, and long term. Based on this information, evaluating patients in accordance with the ATLS® protocol and providing prompt attention and adequate surgical treatment including timely decision-making regarding carrying out damage control not only ensure greater survival but also provide better overall prognosis⁵⁻¹⁰.

Cost analysis in hospitals is a topic that has aroused great interest in recent years, as it is the only way to justify these changes in hospital organization and management from the administrative point of view (whose priority goal is the search for efficiency); in other words, studies on costs have become indispensable in the health area (as in any industry) to plan these systems and their financing. On the other hand, the epidemiological situation and the scarcity of resources in low- and middle-income countries imply evaluating different means for implementing these changes at the lowest possible cost. For these reasons, it is increasingly necessary to base decision-making on studies with a medical and economic perspective¹¹⁻¹⁸.

We consider it relevant for a study with this perspective on gunshot abdominal vascular injuries to be carried out for two reasons: (1) this type of trauma is considered of high impact because it involves high morbidity and mortality due to the state of shock and associated injuries and (2) identification and containment of health services production costs have been poorly studied in Mexico and are crucial aspects for organizing and optimizing resources to obtain good results.

Methods

An observational, descriptive, prospective, longitudinal study of patients with gunshot abdominal vascular injuries who were admitted to the Mexican Red Cross Trauma Center in Mexico City from January 1, 2018, to October 31, 2018, was carried out to determine the cost of this type of trauma for the patient, his/her family, and the hospital. We recruited all patients diagnosed with abdominal gunshot wound at admission and identified those with a postsurgical diagnosis of abdominal vascular lesions; subsequently, we created a registry based on secondary sources (physical medical record and radiological and laboratory tests electronic record), where we captured the resources that generated expenses to patients and, with the help of the hospital administrative area, determined the costs of hospital medical care. Finally, we reviewed the social work notes to know patient socioeconomic level and income, and this way we had a point of comparison to determine the economic impact of the injury on the patient and his/her family.

Results

During the study period, 8149 patients were admitted to the emergency area of the Mexican Red Cross Trauma Center in Mexico City, 149 (1.82%) with gunshot wound diagnosis at admission, out of which 21 (0.25%) had a postsurgical diagnosis of isolated visceral injury or associated with other systems and 6 (0.07%) of abdominal vascular injury. There were 94 (1.15%) deaths, 15 (0.18%) corresponding to patients with abdominal gunshot wound, and 3 (0.03%) with abdominal vascular injury. Patient transfer time ranged between 25 and

60 min (mean of 37.5) and 100% of the patients with the diagnosis of interest were admitted to the shock area.

All patients with gunshot abdominal vascular injury were males, aged 23-52 years (mean: 37.5). Regarding associated intra-abdominal injuries, 1 patient (16.6%) had injuries in two organs, 3 (50%) in four organs, 1 (16.6%) in five organs, and 1 (16.6%) in six organs (Table 1). About 83.3% of patients had injuries in a single vessel and 16.6% in two vessels; 50% had injuries in the inferior vena cava, 33.3% in the iliac artery, 16.6% in the aorta, and 16.6% in the iliac vein. Vascular injuries treatment consisted of suture (66.6%) or ligation (33.3%). Bleeding during the first surgical event was 2000-5000 mL, with an average of 4080 mL.

Initial interventions surgical time ranged from 50 to 240 min (mean: 159.8); 50% of the patients only required one surgical event and 50% had to undergo unpacking, laparoscopy, second look, or surgical cleaning: 1 (16.6%) required six surgeries; another (16.6%), three; and 1 more (16.6%), two; 50% of the patients were admitted to the intensive care unit, where they stayed for 5-14 days (average: 8.6; median: 6). Total hospital length of stay ranged from 1 to 45 days (average: 12.5; median: 9).

The disease cost analysis was carried out by quantifying expense-generating medical resources that were used and the sum of their prices (Table 2). Medical care total cost of patients with gunshot abdominal vascular injury was \$1,048,624.79 Mexican pesos (mean: \$174,770.79; median \$132,999.50) per patient (minimum: \$27,727.64; maximum: \$493,103.47) (Table 3).

Socioeconomic studies showed that 50% of the patients had a family made up of three, 33.3% of two, and 16.6% of a single member. The level of education of 66.6% of patients was complete secondary school; of 16.6%, incomplete high school; and of 16.6%, technical degree. The source of income of 83.3% of the patients came from the practice of some trade (trader, construction worker, and plumber), and that of 16.6%, from a technical profession; 66.6% of patients were classified as socioeconomic level 1 and 33.3% as socioeconomic level 0 (83.3% of patients had an income lower than 1 minimum wage and 16.6%, higher).

Discussion

Abdominal vascular trauma medical relevance

As mentioned in the introduction, vascular injuries account for 0.65% of total annual admissions to

Table 1. Abdominal organ injuries from gunshot wounds associated with vascular injuries

Injured organ	Percentage
Small intestine	83.3%
Colon	50%
Liver	33.3%
Ureter	16.6%
Bile duct	16.6%
Kidney	16.6%
Stomach	16.6%
Spleen	16.6%
Vertebral body fracture	16.6%
Sacrum fracture	16.6%

Table 2. Amount of resources used in the medical care of six patients diagnosed with gunshot abdominal vascular injury

Resource that generated costs	Minimum	Maximum	Average
Patients admitted to the shock area	6	6	6
Hospitalization days	0	45	7.8
Days of intensive care unit stay	0	14	4.3
Number of laboratory tests	5	214	73.1
Number of imaging studies	0	26	11.8
Number of surgical procedures	1	6	2.3

emergency services in the world, and in Mexico, they comprise 9%². In this study, 0.07% of emergency department admissions were due to gunshot abdominal vascular. This figure is lower than that reported by Rodríguez-López et al.,² but not all patients included in that study had exclusively abdominal lesions, which could explain the discrepancy between the figures. Heuer et al.¹⁸ reported 10,530 (1.5% of emergency department admissions) cases of abdominal trauma patients with severe vascular injuries in 218 hospitals, over a period of 16 years in Germany; in this case, the difference could be due to the number of hospitals included and the time dedicated to the study. In our country, a comparative reference of a trauma center is Mexico City's Mexican Red Cross Trauma Center itself: in a retrospective study between 2015 and 2017¹⁹, 42,909 admissions to the emergency department were reported, 1.4% with gunshot wound diagnosis, out of

Table 3. Costs of medical care in six patients diagnosed with gunshot abdominal vascular injury

Resource that generated costs	Minimum cost (\$)	Maximum cost (\$)	Average cost (\$)
Costs for days of stay in the emergency department	1,200	3,703	2,458.86
Costs for days of stay in hospitalization	15,209.18	167,428.27	49,745.44
Costs for days of stay in the intensive care unit	17,500	42,000	14,000
Costs for laboratory tests	537.93	110,700	37,303.96
Costs for imaging studies	500	5,400	2,133.33
Costs for surgical procedures	19,660	61,512.50	45,022.5
Medical care total cost	27,727.64	493,103.47	174,770.79
Cost covered by the patient	200	20,000	10,905.66

which 0.19% had abdominal injuries and 0.02% abdominal vascular injury; all these figures are lower than those found in 2018. These data seem to indicate that the incidence of this type of trauma has progressively increased over the past few years.

Asensio et al.³ estimated that abdominal vascular injuries are associated with a mean of two to four additional injuries; in our study, we observed that 100% of patients had associated abdominal injuries, with an average of 4.1; an amount similar to the upper limit reported in the referred article. Asensio et al.³ also reported that multiple vascular injury is common; however, we found that 83.3% of patients had injury to a single vessel. Evidently, the relevance of additional injuries lies not only in the overall increase in the severity index of the wound but also in the complexity and duration of the required treatment, as well as in the risk for developing complications^{6,8,20,21}.

According to Heuer et al.¹⁸ and Karaolanis et al.²⁰, more than 70% of deaths in these patients will occur within the first 24 h. In our study, 66.6% of deaths occurred within the 1st day and 33.3% after 9 days due to complications such as multiple organ failure and sepsis, similar to what was established in the referred articles. Rodríguez et al.⁴ estimated mortality of arterial lesions at 35-85% and of venous lesions at 50-90%, whereas Asensio et al.²¹ reported a lethality of 79% for isolated aortic lesions and 75% for inferior vena cava lesions; our study found a mortality of 100% for aortic lesions and 50% for inferior vena cava lesions, which are high figures that do not significantly differ from those reported in the reviewed literature. As for national comparative reference, at the Mexican Red Cross Trauma Center in Mexico City, we observed an increase in gunshot abdominal vascular

lesions mortality: from 0.01% in 2015-2017 to 0.03% in 2018.

Economic relevance of abdominal vascular trauma

Heuer et al.¹⁸ reported 74.2% of gunshot abdominal vascular lesions in males aged 41.7 ± 19.2 years; in our study, we found 100% in males aged 37.5 ± 14.3 years. According to the National Institute of Statistics and Geography (Instituto Nacional de Estadística y Geografía [INEGI]), average age in our country in 2015 was 27 years; if we consider that this figure has not considerably changed over the past 3 years, it is easy to see why it is contained in the age range of patients with gunshot abdominal vascular injury²². Regarding the level of education, the INEGI education area reported that 33.5% of the population had middle-high or higher education, 37.9% had complete secondary education, 19.5% had complete primary education, and 8.9% had incomplete primary education²²; our study found that 66.6% of patients with gunshot abdominal vascular lesions had complete secondary education, 16.6% had incomplete high-school education and 16.6% had a technical degree, which are results that also reflect the situation of the population of our country.

The 2010-2011 National Occupation and Employment Survey reported that income level in the most urbanized areas is one minimum wage (\$88.36/day) in 13.4% of the population, more than 1-2 minimum wages in 61.5% and that 8.4% do not have an income²²; our study revealed that 83.3% of patients reported an income lower than 1 minimum wage, and 16.6%, higher than 1 minimum wage, with these figures showing that

the population served by the Mexican Red Cross Trauma Center in Mexico City has an income well below the national average.

According to the Organization for Economic Co-operation and Development (OECD), by 2016, almost 60% of jobs in the country belonged to the informal sector and about 22% of young people did not have formal employment, were studying, or received some form of training, in comparison with 15% in OECD countries²³. In our study, we found that the source of income of 83.3% of the patients came from some trade (trader, construction worker, plumber, etc.) and of 16.6% from a technical profession. It is clear that the high rates of informal employment inevitably limit income and, consequently, the resources available to finance health care. On the other hand, INEGI reported that only 34.8% of the population had access to public health institutions²²; in our study, no patients had an institutional medical service, which, added to the above-presented arguments, also has an unfavorable impact on therapeutic resources availability.

In 2004, Cowey et al.²⁴ carried out a review of 187 gunshot wound patients who admitted to a teaching hospital in England over a 54-month period and found that total cost of care amounted to £272,000 (equivalent to \$6,800,000 Mexican pesos), with an average of £1428 (equivalent to \$35,700)²⁴, which is higher than the figure obtained in our study, where total cost of care was found to be \$1,048,624.79, although with an average of \$174,770.79. The discrepancy between figures could be due to the fact that our study period was 10 months, and that we only considered patients with gunshot abdominal vascular injuries; however, it is clear that the amounts exceed average annual income of the population served by the Mexican Red Cross Trauma Center in Mexico City (approximately \$32,251.40).

At our Mexican Red Cross Trauma Center, which is a private, non-profit welfare institution, no patient covers full cost of care. According to our study, the patient with the lowest contribution covered 0.5% of total cost of care, and the patient with the highest contribution covered 25%. These results demonstrate that each patient with gunshot abdominal vascular lesions, which together account for 0.07% of emergency room admissions for 10 months and, consequently, 0.002% of total institutional expenditure in the same period, implies an average institutional expenditure of \$148,555.17. If we extrapolate this information to public health institutions, which cover almost 100% of total cost of care, or to private hospitals, where the patient covers 100% of total cost of care, we can

observe the magnitude of expenditure involved in this type of wounds, without taking into consideration the variability in the retail prices of the material resources necessary for their care or in the perceptions of the personnel in charge of it.

Conclusions

Although gunshot abdominal vascular lesions are rare, they constitute a relevant public health problem for the following reasons: (1) elevated mortality; (2) high risk for developing serious complications that require large number of laboratory and imaging tests, complex and specialized treatments, and prolonged hospital stay in critical medicine areas; (3) they mainly affect economically active population; and (4) total cost of care exceeds average annual income of that population, and although it represents only a small part of total institutional expenditure, it will definitely never be comparable to the value of the life of a human being. This information not only allows the medical community to have an insight of the socioeconomic reality in which their patients live to carry out truly comprehensive evaluations about the possibilities of recovery that the environment and the family offer, and contribute to the promotion of a social, comprehensive, and more humane medicine but also constitutes an argument to demonstrate to the administrative community that investment in the care of pathologies with high impact, and the development of strategies that facilitate access to health services are a real need, with results that have consequences for the entire population.

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Conflicts of interests

The authors declare that they have no conflicts of interests relevant to the development of this study.

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments have been performed on humans or animals for this research.

Confidentiality of data. The authors declare that no patient data appear in this article.

Right to privacy and informed consent. The authors declare that no patient data appear in this article.

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