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Firearm-Related Musculoskeletal Injuries in Brazilian Children and Teenagers*

Lesões musculoesqueléticas por armas de fogo em crianças e adolescentes brasileiros

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Abstract

Objective To evaluate and describe musculoskeletal injuries by firearms in children and adolescents attended in a major trauma center.

Methods This was a retrospective study that evaluated the medical records of < 18 years old patients who were victims of injuries by firearms and who presented to the emergency department of our hospital, from January 2014 to December 2016. A total of 51 patients were excluded for not showing musculoskeletal injures or for other reasons, while 126 were included. The collected data were: gender; age; way of admission; body site hit; fractures; complications and sequelae; associated injures; hospitalization time; surgeries; deaths.

Results Out of 126 patients included, 107 were male (84.9%) and 19 were female (15.1%). The mean age was 15 years and 5 months old (range: 2y + 8 months to 17y + 11 months years old). A total of 70 patients were hospitalized (55.6%), with a mean hospital stay of 9.6 days, and 21 patients were hospitalized in the intensive care unit (ICU) for a mean of 14.7 days. A total of 37 patients needed orthopedic surgery (29.4%). There were 6 deaths (4.8%). The thigh was the most hit region, in 43 injuries (24.7%). Six patients had spinal cord sequelae, and eight patients had peripheral nerves injuries. A total of 58 patients (46%) had 71 fractures, and the femur was the most hit (15.5%). A total of 52 (41.3%) patients presented with associated injuries. In the 71 fractures, the treatment was conservative in 45 (63.4%), surgical in 23 (32.4%). Three injuries resulted in death (4.2%).

Conclusion Adolescents and males are at-risk groups for firearms injuries, and the lesions are mainly on the lower limbs. Less than half of the patients had fractures, but many had complex lesions with potential for severe sequelae.

Keywords
- firearms
- musculoskeletal system/injuries
- child
- adolescent

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Resumo

Objetivo Avaliar e descrever lesões musculoesqueléticas por armas de fogo em crianças e adolescentes atendidas em um pronto-socorro de grande porte.

Métodos Estudo retrospectivo avaliando os prontuários de pacientes, vítimas de armas de fogo e menores de 18 anos de idade que deram entrada ao pronto socorro do nosso hospital, de janeiro de 2014 a dezembro de 2016. Um total de 51 pacientes foi excluído por não apresentar lesões musculoesqueléticas ou outras razões, enquanto 126 foram incluídos. Os dados colhidos foram: sexo; idade; via de entrada; tipo de lesão; balas alojadas e removidas; local do corpo atingido; fraturas; complicações e sequelas; lesões associadas; tempo de internamento e de UTI; cirurgias; e óbitos.

Resultados Dos 177 pacientes menores de 18 anos que deram entrada no pronto socorro por ferimento por armas de fogo, 126 pacientes (71,2%) atenderam aos critérios de inclusão. Foram excluídos 51 (43 por não apresentaram lesões musculoesqueléticas). Cento e sete (84,9%) eram do sexo masculino e 19 (15,1%) do feminino. A média de idade foi 15,5 anos (limites, 2 years + 8 months 17y + 11 months). Setenta pacientes foram internados por tempo médio de 9,6 dias, e 21 pacientes foram hospitalizados na unidade de tratamento intensivo (UTI) por 14,7 dias em média. Um total de 37 pacientes (29,4%) foi submetido a cirurgias ortopédicas. Houve um total de 6 óbitos (4,8%). A coxa foi a principal região atingida, em um total de 43 vezes (24,7%). Seis pacientes tiveram lesões da medula espinhal, e oito pacientes tiveram lesões de nervos periféricos. Um total de 58 pacientes (46%) teve 71 fraturas, e o fêmur foi o principal osso fraturado (11 pacientes; 15,5%). Um total de 52 pacientes (41,3%) tiveram lesões associadas. Das 71 fraturas, o tratamento foi conservador em 45 (63,4%) e cirúrgico em 23 (32,4%). Três evoluíram para óbito (4,2%).

Conclusão Os adolescentes e o sexo masculino são grupo de risco para lesões de armas de fogo, e as lesões são principalmente em membros inferiores. Menos da metade dos pacientes apresentaram fraturas, mas muitos apresentaram lesões complexas com potencial de graves sequelas.

Palavras-chave

- armas de fogo
- sistema musculoesquelético/lesões
- crianças
- adolescente

Introduction

Urban violence is one of the main social problems today, and children and adolescents are identified as the most vulnerable age groups. Some studies show the severity of the condition: in the VIVA 2014 Survey, the percentage of children and adolescents victims of violence represented 29.5% of the cases.[1] In a study in the city of Campinas, state of São Paulo, Brazil, the main cause of traumatic death among minors was by gunshot wounds (GSWs) (47%).[2]

The National School Health Survey (PeNSE), held in 2009 by the Brazilian Institute of Geography and Statistics (IBGE, in the Portuguese acronym) had as its objective to describe the prevalence of perception of 9th grade students about safety and violence criteria. In the study, the city of Curitiba, capital of the state of Paraná, Brazil, was the second capital that had more reports of fights involving firearms by students of the 9th grade of elementary education in Brazil, with 5.9% of the reports, behind only of the city of Boa Vista, capital of the state of Roraima, Brazil, with 6.4%. The average of the 26 state capitals and of the federal district was 4%.[3] According to the Informatics Department of the Brazilian Unified Health System (DATASUS, in the Portuguese acronym), between 2014 and 2016, from 220 thousand deaths from all causes, there were over 27 thousand deaths from GSWs in Brazil in the age group of up to 19 years old. In Curitiba, in the same period and age group, there were 299 deaths (out of a total of 2,226 deaths).[4]

A greater knowledge of lesions caused by firearms seems to us to be fundamental for the elaboration of policies to fight violence and to structure adequate care for victims. In Brazil, there are some studies on GSWs (including musculoskeletal),[5–9] but without a focus on minors, although homicide numbers are rising and alarming in this age group.[10] Even in the North American literature, there are few studies, for reasons related to the American legislation.[11]

The aim of the present study is to evaluate and to describe musculoskeletal injuries of patients < 18 years old diagnosed with GSW, treated between 2014 and 2016 in a large emergency room (ER) and in a large urban center.

Materials and Methods

This is a retrospective study conducted in our hospital, which serves patients by the Brazilian Unified Health System (SUS, in the Portuguese acronym). Emergency medical records and bulletins were collected by the Hospital do Trabalhador (HT) (our hospital) statistics bank, considering patients < 18 years

old who were admitted to the ER post-GSW from January 2014 to December 2016. Physical and digitized emergency bulletins (EBs), medical records, and physical and digital radiologies were accessed. The present study was approved by the Research Ethics Committee under the number CAAE 58662816.6.0000.5225 and under the opinion number 1.800.239.

All of the medical records of patients who were diagnosed with GSW were collected. The inclusion criteria were patients with at least one musculoskeletal region affected by firearms, who sought the ER of the HT as their first search, or from other health facilities on the same day they suffered the injury, and who were discharged or died at the ER. A total of 51 patients were excluded, of which 43 had no musculoskeletal injuries; another 8 were registered as transfer of service, evasions, and injury by BB guns or rubber bullets. A total of 126 patients remained for the study.

The data obtained were recorded in Microsoft Office Excel (Microsoft Corporation, Redmond, WA, USA). The access to EBs, medical records and radiologies were made through the name of the patient or by the number of the EB or of the medical record.

The data collected were: gender; date of birth; age; entry in the ER; musculoskeletal injury (yes or no); way of entry (direct search, ambulance or air transportation); type of injury; main complaint; musculoskeletal location of the shot; bullet lodged; bullet removed; fractures; associated injuries; hospitalization (yes or no); date and time of entry and discharge of internment; ICU entry and exit date and time; orthopedic treatment; orthopedic surgery; other procedures; complications; sequelae; death (yes or no); evasion (yes or no); observations (when relevant to facilitate the study).

The lesions were classified according to the type of injury into: polytrauma (PT), fracture (F), superficial (S), transfixing (T), and soft tissue (ST). We have established some definitions of terms. Polytraumas: patients with lesions in >1 musculoskeletal body region. Fractures: only one bone segment affected (according to our division). Superficial: individual lesions without perforation. Transfixing: presented input and output without fractures. Soft tissue injuries: nontransfixing perforated injuries without fractures.

The musculoskeletal location was divided into spine; shoulder; arm; elbow; forearm; wrist and hand; basin (pelvis and sacrum); thigh; knee; leg; ankle and foot; gluteus; and armpit. To be included in the study, patients should have at least one GSW in one of these regions. Three compartments were excluded due to inaccuracy of the records.

Fractures were divided by bone segments: cervical spine; thoracic spine; lumbar spine; bones of the hand; pelvis; hip joint; radius; clavicle; femur; tibia (including tibia and fibula); shoulder blade; humerus; glenohumeral joint; ulna; bones of the foot; sacrum.

Associated injuries and other procedures were classified as abdominal (including viscera and genitourinary); thoracic (lung, heart, and ribs); vascular; encephalic, and facial.

Fracture treatments were classified as "conservative", "surgical", and "untreated due to death". The existing surgical treatments in the sample were classified as: spinal arthrodesis, decompressive laminectomy, internal fixation, external fixation, external fixations followed by internal fixation, and a concomitant treatment of external and internal fixation.

Results

Out of the 177 patients <18 years old who were admitted to the ER due to GSWs, 126 patients (71.2%) met the inclusion criteria. A total of 54 patients were treated in 2014, 31 in 2015, and 41 in 2016. As for seasonality, divided by semesters, the demand was more frequent in the 1st half of the year (January-June), with 76 cases (60.3%), and 50 (39.7%) in the 2nd semester (July-December). A total of 107 patients were males (85%), and 19 were females (15%), a ratio of 5.6:1. The age ranged from 2 years and 8 months to 17 years and 11 months, with an average of 15 years and 5 months. The division of cases by age is represented in ►**Table 1**.

A total of 106 patients were from the city of Curitiba, and 20 were from other cities in its metropolitan region. Regarding the way of entry, 86 patients (68.2%) were referred to our hospital by ambulance; 38 (30.2%) by direct search; and 2 patients (1.6%) by air transportation. The type of injury of the 126 patients was distributed as follows: 37 PTs; 35 Fs; 28 STs; 17 Ts; and 9 Ss. Of the 37 PTs, 23 involved Fs (62.1%).

A total of 122 patients had a record and identification of whether the bullet was lodged or not. Of these, 61 (50%) had at least 1 bullet lodged in musculoskeletal compartments, 7 had two lodged bullets, and 2 had 3 lodged bullets: a total of 72 projectiles were lodged. Of these, 67 had records regarding the fate of the bullets, of which 25 (37.3%) were removed, and 42 (62.7%) were not removed.

Table 1 Division of patients by age

Age (years old)	Patients	%
17	46	36.50%
16	31	24.60%
15	16	12.70%
14	14	11.10%
13	5	3.40%
12	0	0.00%
11	2	1.60%
10	3	2.30%
9	1	0.80%
8	1	0.80%
7	1	0.80%
6	2	1.60%
5	1	0.80%
4	0	0.00%
3	0	0.00%
2	2	1.60%
1	0	0.00%
0	0	0.00%

Table 2 Affected musculoskeletal compartments

Compartment	Lesions	%
Thigh	43	24.70%
Leg	22	12.60%
Arm	16	9.20%
Spine	15	8.60%
Forearm	15	8.60%
Shoulder	14	8.10%
Wrist + hand	14	8.10%
Ankle + foot	11	6.30%
Gluteus	11	6.30%
Knee	9	5.20%
Elbow	2	1.10%
Basin (pelvis + sacrum)	1	0.60%
Armpit	1	0.60%

The 174 affected musculoskeletal locations are represented in ►**Table 2**.

A total of 58 patients (46%) were diagnosed with fractures. Of these, 9 (15.5%) had > 1 fractured bone segment, 5 had 2 fractured segments, and 4 had 3. There was a total of 71 fractures diagnosed (►**Table 3**). Of these, 45 (63.4%) received conservative treatment, 23 (32.4%) received surgical treatment, and 3 (4.2%) were not treated due to death.

A total of 37 (29.4%) patients underwent orthopedic surgery: 19 (15.1%) for fracture treatment (involving 23 procedures) and 18 (14.3%) for other miscellaneous procedures (1 thigh fasciotomy and tendon transfer, and the other 17 only for projectile removal and/or debridement). One patient, in addition to treating a hand bone fracture with internal fixator, underwent tenorrhaphy and neurorrhaphy on the hand.

Table 3 Fractured bone segments

BONE SEGMENT	FRACTURES	%
Femur	11	15.5%
Tibis*	10	14.1%
Thoracic spine	8	11.2%
Lumbar spine	7	9.8%
Hand bones	6	8.4%
Radius	6	8.4%
Cervical spine	5	7.0%
Humerus	5	7.4%
Ulna	3	4.2%
Pelvis	2	2.8%
Hip joint**	2	2.8%
Scapula	2	2.8%
Clavicle	1	1.4%
Glenoumeral joint	1	1.4%
Foot bones	1	1.4%
Sacrum	1	1.4%

*Four concomitantly in the fibula.
**Both in the acetabulum.

The 23 surgical treatments for fractures were: 9 internal fixations (39.1%); 5 external fixations (21.8%); 5 external fixations followed by internal fixation (21.8%); 2 spine arthrodeses (8.7%); 1 decompressive laminectomy of L5-S1 (4.3%); 1 external hip fixation; and 1 internal femoral fixation for the treatment of a subtrochanteric fracture (4.3%).

Regarding the evolution, complications and sequelae during the 1st hospital visit: there were 7 sequelae, 1 osteonecrosis of the femur head, and 6 spinal cord injuries (3 paraplegias; 1 quadriplegia; 1 hemiplegia and paraparesis of the right lower limb; 1 loss of strength and left lower limb paraparesis by root avulsion). Other complications were: eight peripheral nerve injuries, five motor; and three motosensory; four had infections, one being acute osteomyelitis; one had compartment syndrome with femoral nerve injury. One patient returned presenting with foreign body granuloma on the right elbow and required removal of the bullet.

Associated injuries occurred in 52 patients (41.3%), out of a total of 84 associated injuries, namely: 27 abdominal (32.1%); 25 thoracic (29.8%); 13 vascular (15.5%); 12 facial (14.3%); and 7 brain (8.3%). Out of the 52 patients with associated injuries, 38 underwent procedures from other medical specialties (30.2% of 126 patients). Six patients died. In 58 cases with fractures, 31 had associated injuries (53.5%).

Out of the 126 patients, 70 (55.6%) were hospitalized, and 21 (16.7%) required hospitalization in the intensive care unit (ICU). The other 56 (44.4%) only presented to the ER and were discharged. The average hospital stay of the 70 patients who were hospitalized was of 9.6 days, ranging from 1 to 84 days. The average ICU stay of the 21 patients who required intensive care was of 14.7 days, ranging from 1 to 82 days.

A total of 120 patients survived (95.2%), and 6 (4.8%) died.

Discussion

Despite the general knowledge of the violent reality we face in our country, and that children and adolescents belong to a vulnerable group, there is little data addressing the medical implications of this situation. This is, to our knowledge, the 1st national study to assess firearm injuries specifically in children and adolescents (< 18 years old). In a study developed at the Children's Hospital of Alabama, Birmingham, AL, USA, a total of 194 cases of GSWs were recorded in children < 19 years old in a period of 11 years (April 1999 to March 2010).[12] Our study, with a survey comprising 3 years and a younger age group (< 18 years old), found 169 victims (also considering nonmusculoskeletal injuries), a result which is practically equal to that of the the American study. We point out that the two hospitals are similar in size and the fact that it is legal to carry a firearm in the state of Alabama. In another study, conducted at the Carolinas

Medical Center in Charlotte, NC, USA, lasting 8 years, more than twice the period of our study, similarly including only orthopedic patients < 18 years old, there were a total of 46 injured patients, that is, 2.75 times less than in our study.[13]

It is noteworthy that there has been an increase in this type of occurrence in Brazil, according to the 2016 Violence Map.[10] Considering the whole population, the number of firearm homicides grew 592.8% between 1980 and 2014. But in the young age group, this growth was much higher: 700%. This age group, being between 15 and 29 years old, includes teenagers, who are the object of the present study. It is precisely in adolescence that the index increases exponentially.[10] Also in the records of DATASUS, there were 299 deaths in the city of Curitiba in the period between 2014 and 2016. This high number may be due to the wider age range covered by the DATASUS (up to 19 years old) – which is precisely the peak of the occurrences, which makes it difficult to compare it with our data.[4] Our study also showed the highest percentage in this age group, although it is < 18 years old. However, the onset of the peak occurred at 14 years old, suggesting that the occurrences are already reaching earlier ages.

Foreign articles, especially those from the USA, emphasize the cause of the injuries (whether violent or unintentional). This is mainly due to the difference regarding gun laws between the states of the USA . In 2014, Safavi et al[14] published a study in which the average number of injuries in children < 18 years old living in a state with no restrictions on the carrying of firearms was 3.75 times greater than in a state with strict laws about it. In our study, we could not obtain data on reasons for injury, although it was an initial interest. In American studies, most injuries are unintentional.[13] Srinivasan et al[15] published in their study that 62% of the injuries in the USA occur unintentionally (198,969 searches for GSWs in children < 19 years old in the US from 2001 to 2010 were analyzed).

Regarding orthopedic participation, our study showed that out of every four children or adolescents complaining of GSWs in the emergency room, approximately three had musculoskeletal injuries (inclusion criteria) and required at least one first orthopedic care. This data emphasizes the need for the orthopedist to have a knowledge of the profile of the injuries, the skills required for treatment, as well as the structure and equipment to provide adequate care.

As in other studies, males were more susceptible, with a proportion of 85%. In 2014, the VIVA Inquiry reported that 72% of the victims of violence of all ages are men, and this is reproduced in children and adolescents.[1]

Regarding age, the average of the present study is 15 years and 5 months, ranging from 2 to 17 years old, while for Perkins et al[13] the extremes are also from 2 to 17 years old, but the average is 12.7 years old. In Naranje et al,[16] the average was also ~ 12 years old. Approximately 90% of the patients in our study were > 13 years old, while in Perkins et al[13] this same age group comprises 72%. This divergence is probably due to the differences in the proportions already commented between intentional and unintentional injuries between the two countries.

Half of our patients had at least one lodged bullet. The bullet removal procedure was performed in approximately one third of the patients. In the study by Mazotas et al,[17] 22% of the 107 pediatric patients had secondary complications related to the localization of the projectile, but the authors only recommend its removal when it is located in joints. According to Ootani et al,[6] in the presence of a projectile in the joint, the removal must be done, because besides acting as an intra-articular free body, it also causes electrolyte disorders. In our study, one patient returned presenting with foreign body granuloma and required removal of the bullet, which was located in a joint (elbow).

In the literature, fractures occur almost half of the times the limbs are hit.[10] In our study, the rate was 46%. Nine (15%) had multiple fractures, a rate lower than that found by Naranje et al (18.4%).[16] Our article shows that the lower limbs are the most affected (56%), which corroborates the findings of other foreign studies.[10,13,16] In the Brazilian study by Ootani et al,[6] involving bone injuries by firearms in ages ranging from 5 to 54 years old, the lower limbs were also the most affected, but their proportion was larger (~ 65%).

In addition, the thigh was the main compartment affected, and the femur and the tibia had similar incidences of injuries (15% and 14%, 11 fractures in the femur, and 10 in the tibia) and this also occurred in the studies by Perkins et al[13] and by Naranje et al.[16] In the aforementioned Brazilian study, the femur was much more affected than the tibia; this may suggest a difference in epidemiology between age groups. The hand, like in our study, was the most affected upper limb site.[6]

Another important segment assessed for its potential for severe sequelae was the spine. A total of 15 patients had 22 vertebral fractures (8 thoracic, 7 lumbar, and 5 cervical). In a 2011 study, also in the city of Curitiba, which evaluated spinal cord injuries by GSWs at all ages, the most affected level was also the thoracic level (42.6%); but the cervical level had more than twice of injuries than the lumbar (37.1% and 16.6%, respectively),[8] similarly to the study by Barros Filho et al[9] (also on spine GSWs at all ages),[9] unlike ours. On the other hand, in the foreign literature, as in Naranje et al[16], only one spine fracture occurred (which was at the C5 vertebra). Six of our patients had definitive spinal cord injuries. Carter et al[11] reported that most spinal fractures do not require surgical treatment, and that surgery is not associated with better neurological prognosis. In the Brazilian literature, Barros Filho et al[5] stated that routine surgical treatment for spinal trauma does not seem appropriate. Of our 15 patients with injuries, only 3 underwent surgery.

In our study, most patients were treated conservatively (63%), differing from Perkins et al,[13] in which just over half (52%) were surgically treated. Of the surgically treated patients, approximately half were for fracture stabilization ($n = 19$) and the remaining for debridement, projectile removal, and other procedures. Like other studies,[13,16] about two thirds of the fractures required internal fixation, and 26% required external fixation.

Other lesions with significant potential for sequelae were observed. Peripheral nerve injuries (6.3%) were less common than in the study by Perkins et al[13] (with 13%). Only one lesion in our study evolved into compartment syndrome. A point commented by other authors is that although GSW is an open fracture, osteomyelitis is not common after GSW treatment,[16] and we have observed only one case in our series. Four patients developed infection (3%), a rate lower than that of Perkins et al (13%).[13] A ballistic factor may be relevant: Naranje et al[16] found 100% infection in rifle wounds, and $< 10\%$ in pistol wounds. In addition to the spine, attention should be paid to joints, where damage can be quite variable. One of our patients affected in the thigh-femoral joint developed avascular necrosis of the epiphysis.

Treatment of a firearm victim should be multidisciplinary, involving a general surgeon, a vascular surgeon, a neurosurgeon, and an orthopedist.[7] A total of 52 patients had associated injuries (41%), a rate similar to that of Naranje et al.[16] Most injuries were abdominal and thoracic, which differs from an extensive US retrospective study of juvenile GSW, in which brain injuries were the second most frequent (less frequent only than musculoskeletal injuries).[12] One possible cause for this divergence is that the US study states that brain injuries are proportionally more frequent in children < 9 years old, and in our study only 10% of the patients were in this age group. Another fact is that the death rate of this study was 9.3%,[12] higher than ours, suggesting a different epidemiology.

Approximately 55% of our patients were hospitalized, and our average length of stay was longer than those of Perkins et al[13] and of Naranje et al.[16] (9.6 versus 6.8 versus 5.8 days). Evolution to death is uncommon, especially in the case of exclusively musculoskeletal injuries, considering that all six patients who died had associated injuries. The present study presented an incidence of $\sim 4.5\%$ of deaths, which is slightly higher than those of other studies,[15,18] but, as already mentioned, is inferior to the study by Senger et al (9.3%).[12]

Our study has limitations, such as the lack of information that could be important: general data such as motivation, ethnicity, and ballistics data; subjects that are addressed in reference articles.[10,13,16,18] Due to a significant loss to follow-up rate, we chose to focus on emergency treatment only. Further follow-up, in addition to assessing the result, may demonstrate the appearance of other potential complications. However, in the absence of other national studies, we considered it important to start a study with more basic data.

Conclusion

Orthopedic care is present in most children and adolescents who are referred to the emergency room for GSWs. Adolescents and males are the highest risk group, and injuries are mainly in the lower limbs. More than half had to be hospitalized.

Conservative treatment was possible in most fractures, and patient mortality is relatively low. Although less than half of the patients presented with fractures, many had complex lesions with the potential for severe sequelae.

Conflicts of Interests

The authors have no conflicts of interests to declare.

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