BULL HORN INJURIES. A 40-YEAR RETROSPECTIVE STUDY WITH 572 PATIENTS.

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BACKGROUND
Although bullfighting festivals were traditionally attributed to the cultural idiosyncrasies of the Ibero-American people, they also exist world-wide.

METHODS
A retrospective study was conducted, reviewing the medical records of patients treated on our service for bull horn injuries between January 1978 and December 2019.

RESULTS
There were 572 admissions due to bull horn injuries. 54 of these patients had multiple injuries. The average annual admission was 13.6 patients. The most frequent injuries were located in the lower extremities, perineum, and abdomen . Forty-seven laparotomies were performed, revealing intra-abdominal visceral impairment on 39 occasions. The most frequently injured organs were the intestine and liver. The most frequent complications were skin devitalisation, infection and post-operative eventration. The recorded mortality was 0.87%.

CONCLUSION
We wish to highlight the importance of injuries caused by bull horns worldwide. These are high-impact injuries with specific intrinsic characteristics that require regulated medical and surgical care.

KEYWORDS
Bullfighting. Bull horn injury. Wound. Trauma. Acute Trauma Care.

BACKGROUND

Bullfighting is the traditional event involving an encounter between human and bull. It originated in Spain in the 11th century and includes all events in which the bull is protagonist.

Although bullfighting festivals were traditionally attributed to the cultural idiosyncrasies of the Ibero-American people, they also exist in other parts of the world, such as in the famous American rodeos, the Indian sport *Jallikattu*, and in other festivals involving bulls in some Asian and Central European countries. We must also take into account the existence of these animals in other countries and other environments where the bull is not part of a popular event and is considered a wild animal.

Several works and studies exist with regard to the specific consequences of injuries caused by wild bulls. However, very few of these studies involve a long series of cases or describe a standardised medical and surgical action.

In addition, the inherent characteristics of these animals cause injuries with specific aspects, so it is important to know the generalities of bullfighting injuries. We need to be aware of their impact and to establish a particular initial care plan, a specific therapeutic action, and a follow-up based on the medical and surgical care of the polytraumatised patient. [1-5]

The province of Castellon (Valencian Community, Spain) is considered one of the regions with the most bull-related activities worldwide, with more than 5,000 popular events held every year (including bulls, cows, bullfighting with young bulls, bull-leaping competitions, and bull-running in the streets). Also, professional events (the traditional bullfights) are held around 15-20 times per year. For this reason, the experience accumulated over the years in the treatment of bull horn injuries is also high.[6,7]

Due to the scarce bibliography related to these types of injuries caused by bull horns we present a case review based on the patients treated at our hospital (Hospital General Universitario de Castellon, Spain), thus conducting the largest review to date, with a total of 572 patients.

The objective of this study was to present our experience in the integral care of patients injured by bull horns, describing the characteristics of this type of injury and its possible complications.

METHODS

A retrospective study was conducted, reviewing the medical records of patients treated by the General and Digestive System Surgery Service of the Hospital General Universitario de Castellon (HGUCS), diagnosed with bull horn injuries, between January 1978 and December 2019. For our study, we used the clinical data collected by our colleagues between 1978 and 2005, described in two articles of reference in the world of bullfighting surgery. [8,9] Furthermore, this study was reviewed and approved by the institutional review board of our hospital, its Acute Care and Surgery Committee and its Ethical Committee.

Trauma and injuries not caused by the bull horn itself (osteoligamentous fractures, contusions, cranioencephalic trauma, etc.) were excluded from the study. Also excluded were minor injuries that were treated by on-site medical teams and which did not require hospital admission, as well as patients who died at the site where the injuries occurred (data not included in the objective of our study nor our hospital register). If a patient presented several injuries in the same admission, or was treated during different admissions for new injuries, these were all considered separate, since they were unrelated. Data collected included: medical record number, age, sex, city, date of admission, date of discharge, location of the wounds, existence of visceral impairment, type of treatment, anaesthesia, antimicrobial therapy, use of drains, a stay in the Intensive Care Unit (ICU), hospital stay, immediate (at time of admission) or late (within 30 days of discharge) complications, re-interventions and mortality. The results obtained were compiled and processed using SPSS 3.1.1 software.

RESULTS

Between January 1978 and December 2019, a total of 572 admissions were recorded in the General and Digestive Surgery Department of the HGUCS with a diagnosis of 'bull horn injury'. Of these, 14 were admissions of the same patient on different dates for different injuries. 54 of the patients had multiple bull horn injuries (separate anatomical locations), ranging from 2 to 6. Only 28 of the patients were transferred from other hospitals, while the majority, 544 patients (approximately 95%), were admitted by our hospital's Emergency Department.

97.7% of patients were male, with only 13 women admitted for this reason. The most bull horn injuries were reported among the 16 to 30 age range, with a mean age and median age of 36, and an interval from 7 to 87 years.

Figure 1, shows the number of admissions per year, with an annual average of 13.6 admissions, a median of 12 and a mode of 10; thus highlighting that 64% of admissions (366 patients) took place during the months with the greatest number of bull-related activities (June, July, August and September), with more than half of the cases recorded in August.

The bull horn injuries were multiple and variable in location. The lower extremities were the most affected, accounting for 59% of all injuries (372); followed by the perineum and abdomen, both 11% (69), of which more than half were penetrating goring wounds. Other locations also affected, in order of frequency, were upper extremities (49), thorax (38, of which 16 were penetrating), head and neck with a total of 18 (4 penetrating), and back, with 11. (Fig 2).

Of all the injuries, blunt lesions (blows with a horn and jabs) were treated on 322 occasions, while the remaining cases, 250, were penetrating wounds. Of the latter, more than half, 167 injuries, affected the fascial plane only (superficial lesions). In 14.5% of all cases (83), the injuries were penetrating (deeply the fascial plane), with damage to the pleural cavity on 16 occasions (no pulmonary or large vessel involvement), and bone damage on 15 occasions. Visceral involvement was evident in 8.6% of all injuries, 49, with, in order of frequency, vascular injury on 10 occasions, damage to the small intestine in 9 injuries, to the liver and large intestine on 8 occasions, to the spleen on 5, and to the urinary tract on 4 occasions. These are followed, to a lesser frequency, by

stomach/duodenum on 3 occasions, and pancreas and trachea on 1 occasion (Fig. 3). Of the penetrating injuries, 4 sheathed goring wounds were observed, with 3 of these presenting associated visceral injuries.

With regard to the specific surgical treatment of these injuries, 47 laparotomies were performed, demonstrating intra-abdominal visceral involvement on 39 occasions, as described above. The surgical techniques performed included 10 intestinal sutures (3 of which required intestinal resection), 6 colostomies, 5 splenectomies and 5 bladder sutures. In 4 cases, gastroduodenal repairs were performed (3 pyloric exclusions with Billroth II type reconstruction and 1 antrectomy with Roux-Y reconstruction). In addition, 16 pleural tubes were placed, 6 major vascular repairs were performed (ligations of veins and internal iliac artery, femoral, saphenous, and peroneal arteries; and a humero-humeral bypass for brachial artery injury) and 5 anal sphincteroplasties.

In all cases, the wounds were profusely washed with abundant saline and povidone-iodine, chlorhexidine or hydrogen peroxide, with debridement of the devitalised tissue, placement of non-suction drains (in 90% of cases) if the injury required it, suture by planes and epidermal suture with silk or 2/0 or 3/0 non-absorbable monofilament, and the wounds covered with dressings (or sometimes a compression bandage).

Local anaesthesia +/- sedation was used in most patients, 71.3% (408 cases), general anaesthesia in 105 patients and spinal anaesthesia in 19. All patients completed the tetanus vaccination schedule and received broad-spectrum antimicrobial therapy. Of the 572 patients admitted, in 126 the prescribed antibiotic treatment was not reported, in 164 only one antimicrobial agent was administered (amoxicillin-clavulanate was used in more than half of the cases) and in 282 cases $\geq$ 2 antibiotics were used, with the most frequent therapy being a combination of amoxicillin-clavulanate + metronidazole, followed by amoxicillin-clavulanate + metronidazole + Gentamicin. Evidently, the empirical or prophylactic antimicrobial therapies were modified according to the antibiograms based on the results of the cultures, which were performed for only 13% of the patients, with positive results in 43 cases (7.5%), mostly of polymicrobial origin, with *Escherichia coli*, *Pseudomonas aeruginosa* and *Enterococcus faecium* being the main culprits; and negative in 31 cases.

The time course of broad-spectrum antimicrobial therapy was variable. In 164 patients only one antimicrobial agent was administered (only superficial injuries), during a median of 7 days. In 282 cases (penetrating injuries) > 2 antibiotics were used. Most of these patients were received antimicrobial therapy for 7 days (201), 44 patients for a median of 15 days, and only a 6% (37 patients) were received a broad-spectrum antimicrobial therapy during more than 21 days.

With respect to the hospital stay period, most patients were admitted for 1-7 days (388), 162 patients for 8-30 days, and only 22 patients were hospitalised for more than 30 days; thus reporting an average hospital stay of 9.1 days, with an interval of 1-120 days, a median of 6 days and a mode of 4 days (Fig. 4).

Other characteristics reported were immediate and late or long-term complications (Table 1). Among the immediate complications (presented in 9.4% of the patients), the most frequent was skin devitalisation (35% of cases), followed by abscess/collection, unnoticed bone fractures, and bleeding. Late complications were evidenced in 3.2% of

the patients, the most prevalent being post-surgery eventration in almost half of the cases, followed by nerve injury.

The mortality reported during the study was 0.87% (5 patients), 3 patients died as a result of hypovolemic shock (one in the operating room, 2 during the post-operative period in the intensive care unit) and 2 due to septic shock.

DISCUSSION

The presence of wild bulls in different countries around the world, and their behaviour in the various environments, highlights the global importance of having a knowledge about possible attacks by these animals and consequent injuries in humans. [8,10-19]

Bull horn injuries are frequent in Spain, where bullfighting is part of the national culture. Bull-related festivals are common and are attended by local enthusiasts and people of different nationalities from around the world, and thus pose a major health issue.

All bull-related trauma (high-energy trauma) is included in the category of jagged and contusion injuries that should be considered, by definition, dirty/contaminated wounds.[20] There may be several entry/exit holes and multiple trajectories with major tissue destruction, which potentially result in associated injuries, and visceral, vascular and osteoligamentous injuries are not uncommon.[21] These injuries, therefore, have their own specific characteristics that differentiate them from other types of trauma [3-5] (Fig. 5).

Therefore, this review is not only aimed at expert bullfighting surgeons, but also at all health professionals (surgeons, traumatologists, emergency doctors, general practitioners, intensivists, anaesthetists, nurses, etc.), who may be involved in the diagnostic-therapeutic process of these patients.

It is, therefore, important to obtain the essential concepts in the medical and surgical care of these patients, based on an understanding of their epidemiology, injury mechanism, physiopathology, therapeutic options and potential complications; as well as the peculiarities intrinsic to the bull and its environment (Table 2).[8,10,12-18,22-29]

The wide range of cases in our study, with 572 patients treated in the hospital setting, makes it the largest review of bull horn injuries to date, with the exception of the series based on injuries that occurred in professional bullrings.[10,30]

Taking our extensive series as a reference, we can conclude that bull horn injuries were more frequent in males aged between 16 and 30, with an average age of 36 years, similar to the results of other recent publications.[8-11,19,29]

Although the existence of more popular events each year has resulted in a higher percentage of injuries caused by bulls, this fact is not reflected in the number of hospital admissions in our study, which was 15% lower in the last 20 years compared to the first 20 years in the registry. This may be due to the presence in recent years of general surgeons where the event takes place, who attend to and treat the more minor injuries that do not require referral to a hospital; and the death on the spot of those with the most serious injuries (data not included in our review). Thus, it seems obvious to point to a greater number of injuries during the months in which the most events are held, namely

the summer. Figure 6, shows the evolution of injuries reported over the last 15 years with respect to the number of hospital admissions, penetrating injuries, need for intensive care, and deaths.

Approximately 10% of the injured patients had multiple injuries. Wounds to a depth of more than 10 cm, or with several trajectories, accounted for almost 40% of the total injuries, which reflects the importance of injury kinematics and the different movements of the bull during the 'cogida' (tossing in the air).[8,22,28,30,31-33]. As described in other series,[8,29,31-34] the most frequent injuries were to the lower extremities. More than half of the cases presented blunt lesions only (blows and jabs with the horn), while, of the penetrating wounds, 33% presented visceral injuries.

Regarding the treatment of these injuries, we conclude that once the area has been anaesthetised, the wounds and their possible routes should be explored thoroughly, with an exhaustive cleaning with physiological serum and antiseptic solution, exercising caution with the use of oxygenated substances, due to the described risk of gas embolism.[35] After debridement and removal of foreign bodies, a suture by planes and the systematic placement of non-aspiratory drains should be performed, due to the risk of infection and post-surgical hernias, which in our series were 5.2 and 1.4% respectively, constituting the most frequent complications.

In relation to the specific treatment of wounds, we recommend performing an exploratory laparotomy at the slightest suspicion of penetration into the abdominal cavity, reflecting 24% of exploratory laparotomies in our study. This percentage may decrease with the implementation of laparoscopic surgical exploration, which has demonstrated comparable results to open access in haemodynamically-stable abdominal trauma patients.[36-38] It should be noted that, as with all types of abdominal trauma, the organs most affected are the spleen, liver, and small intestine.[1-5,28,39]

As for the analgesic therapy provided, as explained in the work of Molina et al.,[40,41], in a situation of stress or haemorrhagic shock, the sympathetic-adrenergic and neuroendocrine systems are activated, which in turn activate the brain's analgesic system. Therefore, these patients often do not experience pain or excessive pain after being tossed. Nevertheless, analgesic treatment is a fundamental pillar in the perioperative period of patients, which conditions a satisfactory recovery. In our study we reported a good anaesthetic quality, with local anaesthetic used for contusions and goring injuries with a compromised fascial plane, and general anaesthetic for more severe goring injuries, with no reported cases of anaesthesia complications or chronic pain in our series.

Bull-related injuries should be considered highly contaminated/dirty, with a considerable percentage of infectious complications, 6% in our series, which can sometimes be serious and with a high morbimortality, reported as 6-25% in some series.[8,9,28-30,34,42] Therefore, a wide antibiotic coverage for any injuries with these characteristics is important for dealing with aerobic (gram-positive and gram-negative) and anaerobic germs, with associated antitetanic prophylaxis, due to the high transmission potential of *Clostridium tetani*; even with negative results in the cultures obtained.[43] Although no protocolised antibiotic therapy exists, in our series, the most used combination was amoxicillin-clavulanate and metronidazole, followed by amoxicillin-clavulanate, metronidazole and gentamicin. Following the main guidelines on antibiotics and traumatic injuries[44], we

reported a time course of broad-spectrum antimicrobial therapy variable, depending on the injured tissue and its complications.

The length of hospital stay depends on multiple factors, as presented by Monferrer et al.[9], the most important of which are the inherent characteristics of the bull (bravery, strength, type of horn and tip), of the injured person, of the wound (trajectory, visceral involvement, infection) as well as the environment factor. In our series, we observed that most admissions did not exceed 7 days, with a mean of 9.1 days and a median of 6 days, for the least severe injuries. Thus, in patients with visceral involvement, the majority stayed between 8-30 days in hospital, with an average of 18.9 days and a median of 9, in addition to a greater need for intensive care (35% of cases), which demonstrates its greater severity and comorbidity. Furthermore, all patients who had a hospital stay of >30 days were in the Intensive Care Unit.

We reported a mortality of around 1% (0.87%), especially secondary to hypovolemic shock. However, if we calculate and compare mortality based on the first and last 20 years, we find that over the last 20 years mortality from bull horn injuries doubled (0.6% vs. 1.22%, respectively), reflecting the severity of these injuries and the importance of their urgent management, despite advances in medical and surgical care.

We conclude by highlighting the importance of injuries caused by bull horns worldwide, especially in countries with the greatest number of bull-related events, since these are high-impact injuries with specific intrinsic characteristics that require regulated medical and surgical care and assistance, in multi-traumatised patients with non-negligible morbidity and mortality.

AUTHORSHIP

A.M.H., and D.M.R. participated in the study design. A.M.H., D.M.R., MV.G.M., N.A.M., E.L.L., E.A.H., R.Q.M., R.C.P., and JM.L.S. participated conceived of the study and contributed to the data analysis, article execution and review. A.M.H. participated in the writing. D.M.R., and JM.L.S participated in the critical review. A.M.H., and D.M.R. wrote the article, and all authors contributed substantially to its drafting and revision. A.M.H. takes responsibility for the article as a whole.

DISCLOSURE

The authors declare no funding or conflicts of interest.

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Figure

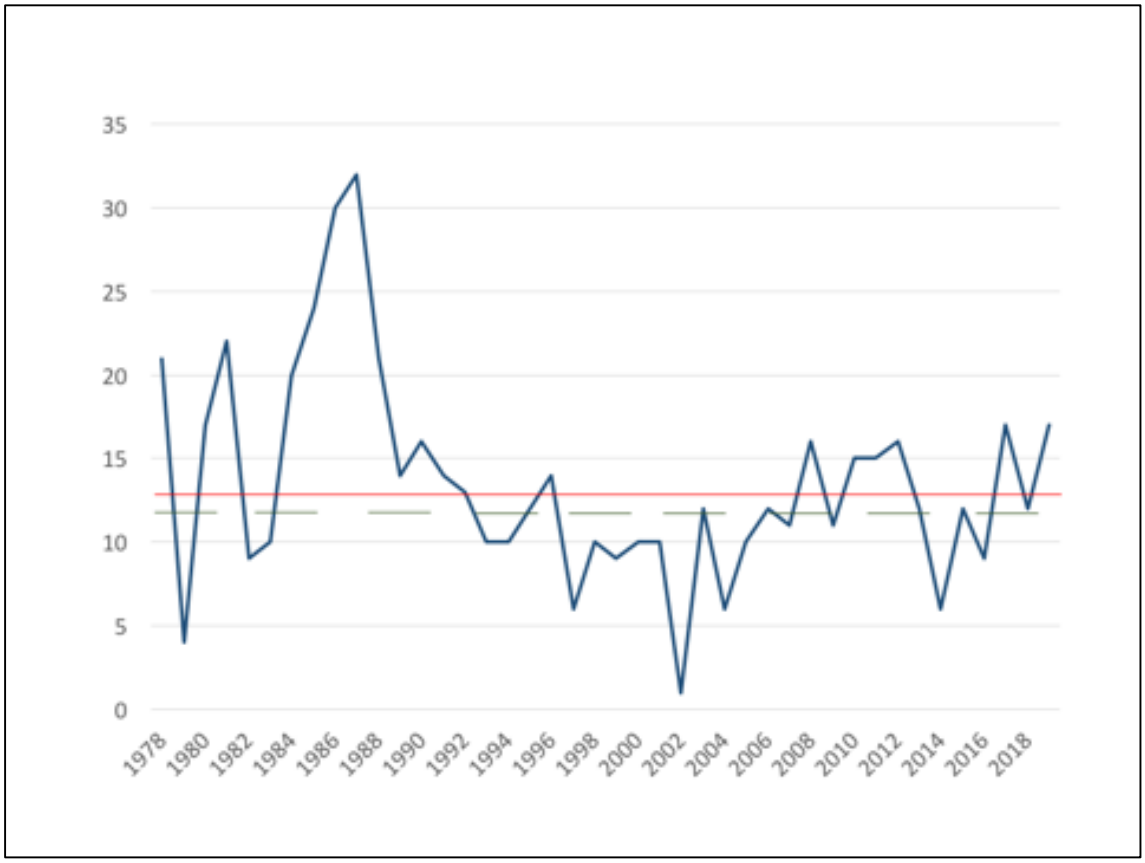

Figure 1. Number of annual hospital admissions secondary to bull horn injuries. (— Annual average, —— Annual median).

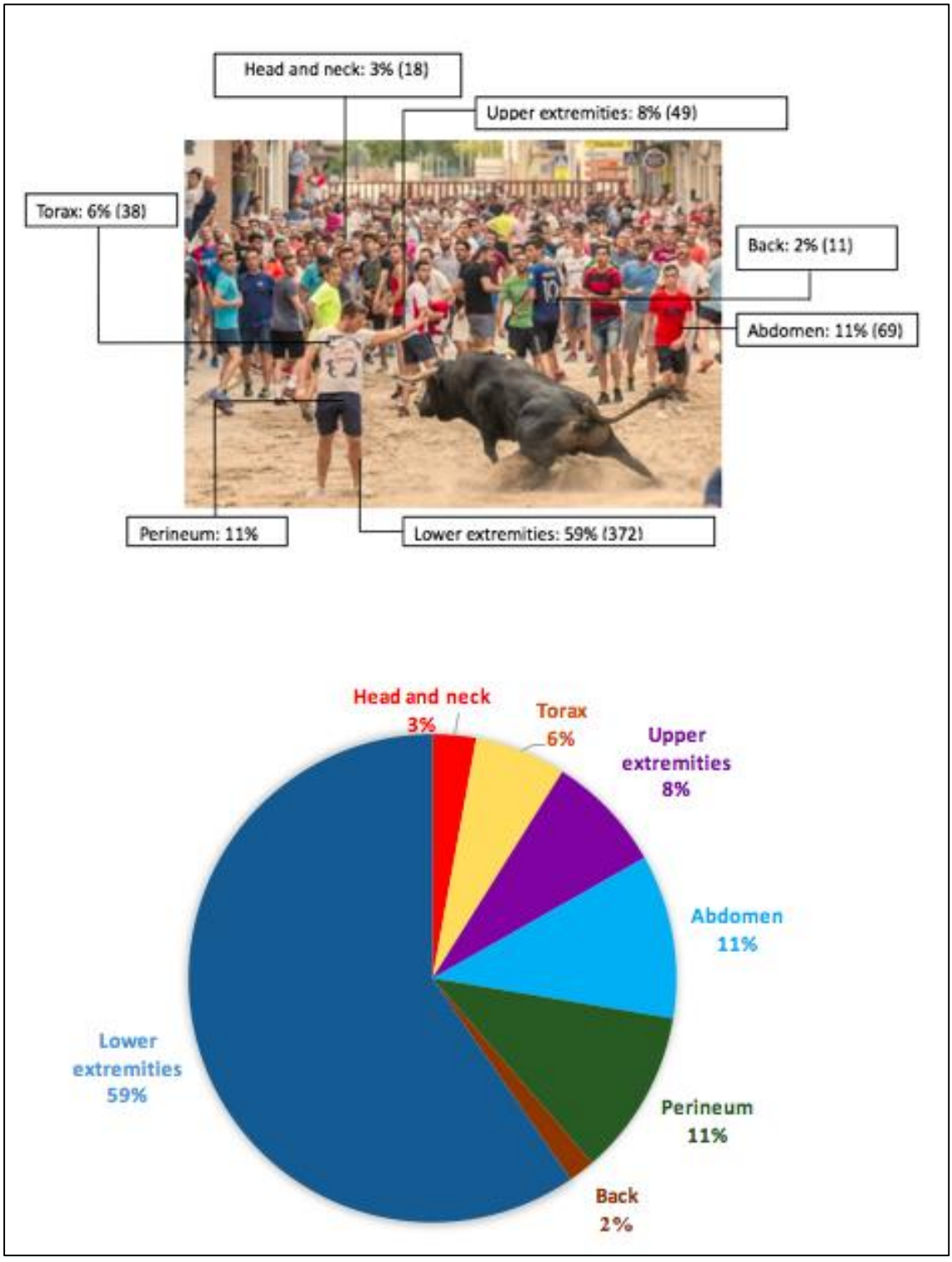

Figure 2. Picture of one of the typical bullfighting festivals in the province of Castellon, reflecting the anatomical location of the main bullfighting injuries.

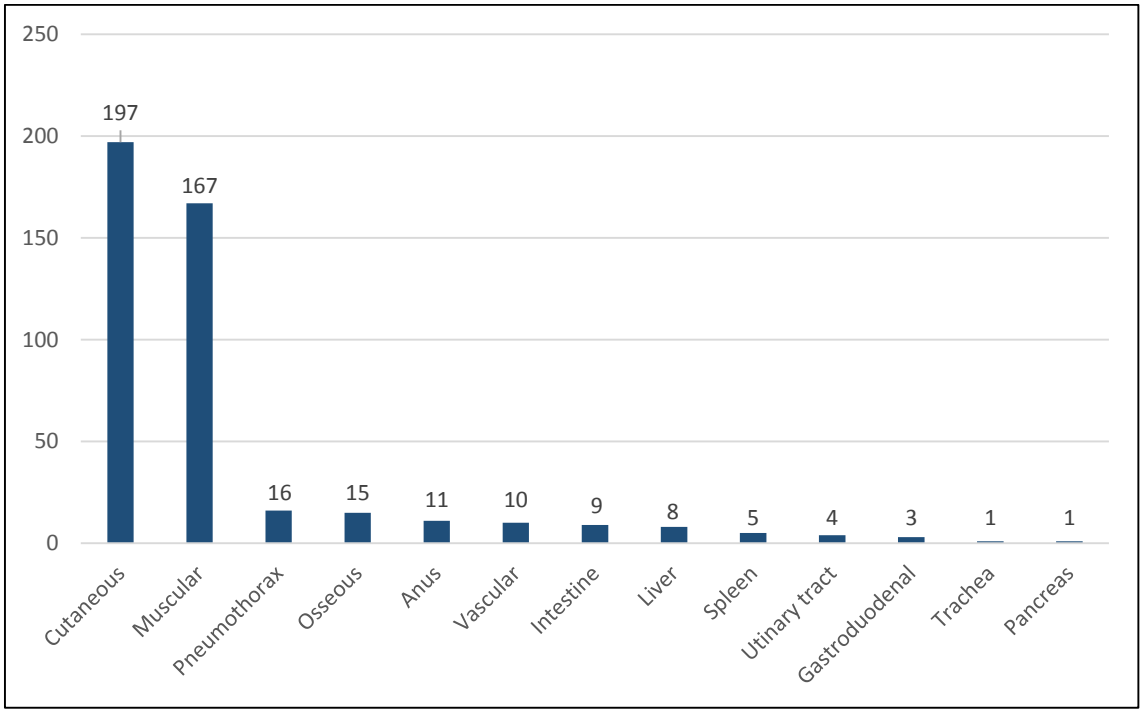

Figure 3. Different injuries produced by the bull's horn.

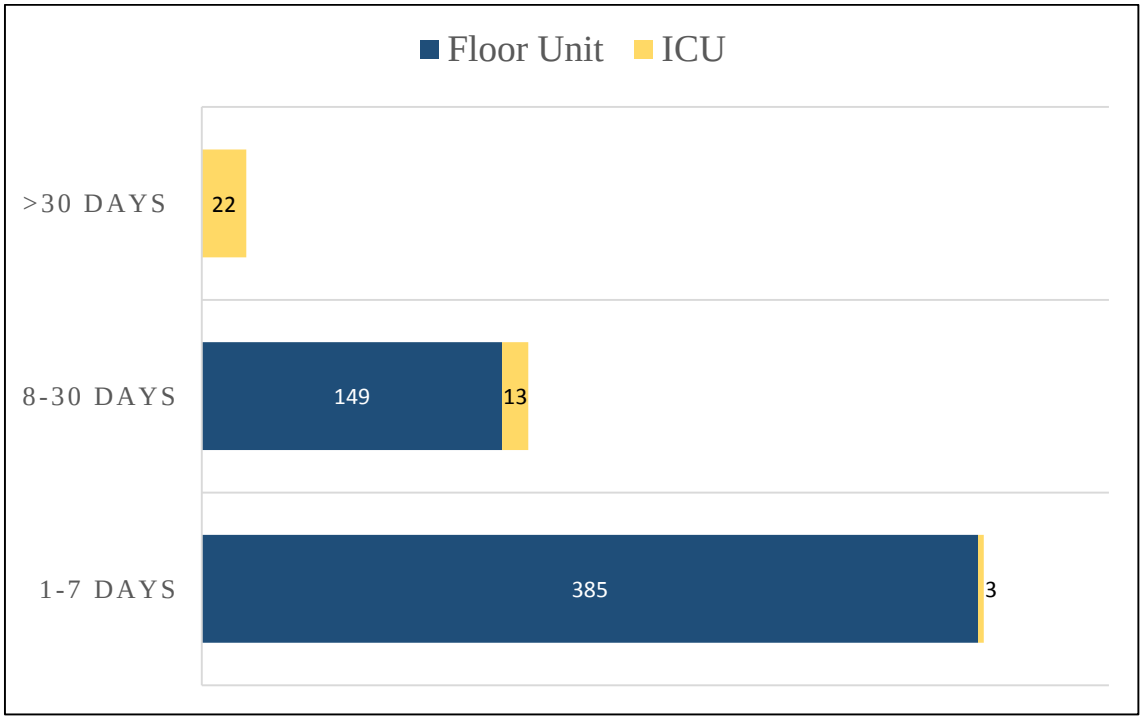

Figure 4. Hospital stay (days), highlighting the stay at Floor Unit and ICU.

Figure 5. Bullfighting injuries.

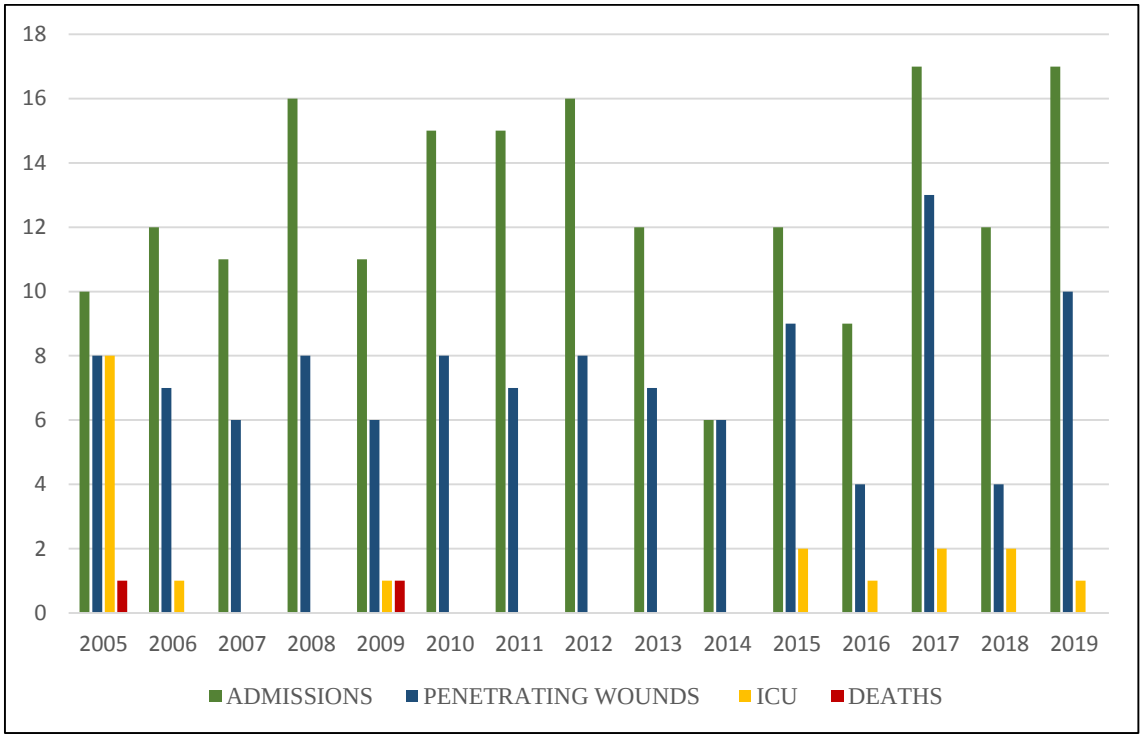

Figure 6. Evolution of the significance of injuries over the last 15 years.

Table

There are no funding or conflicts of interest and informed consent was obtained from the patient to publish these images.

BACKGROUND

Bullfighting is the traditional event involving an encounter between human and bull. It originated in Spain in the 11th century and includes all events in which the bull is protagonist.

Although bullfighting festivals were traditionally attributed to the cultural idiosyncrasies of the Ibero-American people, they also exist in other parts of the world, such as in the famous American rodeos, the Indian sport *Jallikattu*, and in other festivals involving bulls in some Asian and Central European countries. We must also take into account the existence of these animals in other countries and other environments where the bull is not part of a popular event and is considered a wild animal.

Several works and studies exist with regard to the specific consequences of injuries caused by wild bulls. However, very few of these studies involve a long series of cases or describe a standardised medical and surgical action.

In addition, the inherent characteristics of these animals cause injuries with specific aspects, so it is important to know the generalities of bullfighting injuries. We need to be aware of their impact and to establish a particular initial care plan, a specific therapeutic action, and a follow-up based on the medical and surgical care of the polytraumatised patient. [1-5]

The province of Castellon (Valencian Community, Spain) is considered one of the regions with the most bull-related activities worldwide, with more than 5,000 popular events held every year (including bulls, cows, bullfighting with young bulls, bull-leaping competitions, and bull-running in the streets). Also, professional events (the traditional bullfights) are held around 15-20 times per year. For this reason, the experience accumulated over the years in the treatment of bull horn injuries is also high.[6,7]

Due to the scarce bibliography related to these types of injuries caused by bull horns we present a case review based on the patients treated at our hospital (Hospital General Universitario de Castellon, Spain), thus conducting the largest review to date, with a total of 572 patients.

The objective of this study was to present our experience in the integral care of patients injured by bull horns, describing the characteristics of this type of injury and its possible complications.

METHODS

A retrospective study was conducted, reviewing the medical records of patients treated by the General and Digestive System Surgery Service of the Hospital General Universitario de Castellon (HGUCS), diagnosed with bull horn injuries, between January 1978 and December 2019. For our study, we used the clinical data collected by our colleagues between 1978 and 2005, described in two articles of reference in the world of bullfighting surgery. [8,9] Furthermore, this study was reviewed and approved by the institutional review board of our hospital, its Acute Care and Surgery Committee and its Ethical Committee.

Trauma and injuries not caused by the bull horn itself (osteoligamentous fractures, contusions, cranioencephalic trauma, etc.) were excluded from the study. Also excluded were minor injuries that were treated by on-site medical teams and which did not require hospital admission, as well as patients who died at the site where the injuries occurred (data not included in the objective of our study nor our hospital register). If a patient presented several injuries in the same admission, or was treated during different admissions for new injuries, these were all considered separate, since they were unrelated. Data collected included: medical record number, age, sex, city, date of admission, date of discharge, location of the wounds, existence of visceral impairment, type of treatment, anaesthesia, antimicrobial therapy, use of drains, a stay in the Intensive Care Unit (ICU), hospital stay, immediate (at time of admission) or late (within 30 days of discharge) complications, re-interventions and mortality. The results obtained were compiled and processed using SPSS 3.1.1 software.

RESULTS

Between January 1978 and December 2019, a total of 572 admissions were recorded in the General and Digestive Surgery Department of the HGUCS with a diagnosis of 'bull horn injury'. Of these, 14 were admissions of the same patient on different dates for different injuries. 54 of the patients had multiple bull horn injuries (separate anatomical locations), ranging from 2 to 6. Only 28 of the patients were transferred from other hospitals, while the majority, 544 patients (approximately 95%), were admitted by our hospital's Emergency Department.

97.7% of patients were male, with only 13 women admitted for this reason. The most bull horn injuries were reported among the 16 to 30 age range, with a mean age and median age of 36, and an interval from 7 to 87 years.

Figure 1, shows the number of admissions per year, with an annual average of 13.6 admissions, a median of 12 and a mode of 10; thus highlighting that 64% of admissions (366 patients) took place during the months with the greatest number of bull-related activities (June, July, August and September), with more than half of the cases recorded in August.

The bull horn injuries were multiple and variable in location. The lower extremities were the most affected, accounting for 59% of all injuries (372); followed by the perineum and abdomen, both 11% (69), of which more than half were penetrating goring wounds. Other locations also affected, in order of frequency, were upper extremities (49), thorax (38, of which 16 were penetrating), head and neck with a total of 18 (4 penetrating), and back, with 11. (Fig 2).

Of all the injuries, blunt lesions (blows with a horn and jabs) were treated on 322 occasions, while the remaining cases, 250, were penetrating wounds. Of the latter, more than half, 167 injuries, affected the fascial plane only (superficial lesions). In 14.5% of all cases (83), the injuries were penetrating (deeply the fascial plane), with damage to the pleural cavity on 16 occasions (no pulmonary or large vessel involvement), and bone damage on 15 occasions. Visceral involvement was evident in 8.6% of all injuries, 49, with, in order of frequency, vascular injury on 10 occasions, damage to the small intestine in 9 injuries, to the liver and large intestine on 8 occasions, to the spleen on 5, and to the urinary tract on 4 occasions. These are followed, to a lesser frequency, by

stomach/duodenum on 3 occasions, and pancreas and trachea on 1 occasion (Fig. 3). Of the penetrating injuries, 4 sheathed goring wounds were observed, with 3 of these presenting associated visceral injuries.

With regard to the specific surgical treatment of these injuries, 47 laparotomies were performed, demonstrating intra-abdominal visceral involvement on 39 occasions, as described above. The surgical techniques performed included 10 intestinal sutures (3 of which required intestinal resection), 6 colostomies, 5 splenectomies and 5 bladder sutures. In 4 cases, gastroduodenal repairs were performed (3 pyloric exclusions with Billroth II type reconstruction and 1 antrectomy with Roux-Y reconstruction). In addition, 16 pleural tubes were placed, 6 major vascular repairs were performed (ligations of veins and internal iliac artery, femoral, saphenous, and peroneal arteries; and a humero-humeral bypass for brachial artery injury) and 5 anal sphincteroplasties.

In all cases, the wounds were profusely washed with abundant saline and povidone-iodine, chlorhexidine or hydrogen peroxide, with debridement of the devitalised tissue, placement of non-suction drains (in 90% of cases) if the injury required it, suture by planes and epidermal suture with silk or 2/0 or 3/0 non-absorbable monofilament, and the wounds covered with dressings (or sometimes a compression bandage).

Local anaesthesia +/- sedation was used in most patients, 71.3% (408 cases), general anaesthesia in 105 patients and spinal anaesthesia in 19. All patients completed the tetanus vaccination schedule and received broad-spectrum antimicrobial therapy. Of the 572 patients admitted, in 126 the prescribed antibiotic treatment was not reported, in 164 only one antimicrobial agent was administered (amoxicillin-clavulanate was used in more than half of the cases) and in 282 cases $\geq$ 2 antibiotics were used, with the most frequent therapy being a combination of amoxicillin-clavulanate + metronidazole, followed by amoxicillin-clavulanate + metronidazole + Gentamicin. Evidently, the empirical or prophylactic antimicrobial therapies were modified according to the antibiograms based on the results of the cultures, which were performed for only 13% of the patients, with positive results in 43 cases (7.5%), mostly of polymicrobial origin, with *Escherichia coli*, *Pseudomonas aeruginosa* and *Enterococcus faecium* being the main culprits; and negative in 31 cases.

The time course of broad-spectrum antimicrobial therapy was variable. In 164 patients only one antimicrobial agent was administered (only superficial injuries), during a median of 7 days. In 282 cases (penetrating injuries) > 2 antibiotics were used. Most of these patients were received antimicrobial therapy for 7 days (201), 44 patients for a median of 15 days, and only a 6% (37 patients) were received a broad-spectrum antimicrobial therapy during more than 21 days.

With respect to the hospital stay period, most patients were admitted for 1-7 days (388), 162 patients for 8-30 days, and only 22 patients were hospitalised for more than 30 days; thus reporting an average hospital stay of 9.1 days, with an interval of 1-120 days, a median of 6 days and a mode of 4 days (Fig. 4).

Other characteristics reported were immediate and late or long-term complications (Table 1). Among the immediate complications (presented in 9.4% of the patients), the most frequent was skin devitalisation (35% of cases), followed by abscess/collection, unnoticed bone fractures, and bleeding. Late complications were evidenced in 3.2% of

the patients, the most prevalent being post-surgery eventration in almost half of the cases, followed by nerve injury.

The mortality reported during the study was 0.87% (5 patients), 3 patients died as a result of hypovolemic shock (one in the operating room, 2 during the post-operative period in the intensive care unit) and 2 due to septic shock.

DISCUSSION

The presence of wild bulls in different countries around the world, and their behaviour in the various environments, highlights the global importance of having a knowledge about possible attacks by these animals and consequent injuries in humans. [8,10-19]

Bull horn injuries are frequent in Spain, where bullfighting is part of the national culture. Bull-related festivals are common and are attended by local enthusiasts and people of different nationalities from around the world, and thus pose a major health issue.

All bull-related trauma (high-energy trauma) is included in the category of jagged and contusion injuries that should be considered, by definition, dirty/contaminated wounds.[20] There may be several entry/exit holes and multiple trajectories with major tissue destruction, which potentially result in associated injuries, and visceral, vascular and osteoligamentous injuries are not uncommon.[21] These injuries, therefore, have their own specific characteristics that differentiate them from other types of trauma [3-5] (Fig. 5).

Therefore, this review is not only aimed at expert bullfighting surgeons, but also at all health professionals (surgeons, traumatologists, emergency doctors, general practitioners, intensivists, anaesthetists, nurses, etc.), who may be involved in the diagnostic-therapeutic process of these patients.

It is, therefore, important to obtain the essential concepts in the medical and surgical care of these patients, based on an understanding of their epidemiology, injury mechanism, physiopathology, therapeutic options and potential complications; as well as the peculiarities intrinsic to the bull and its environment (Table 2).[8,10,12-18,22-29]

The wide range of cases in our study, with 572 patients treated in the hospital setting, makes it the largest review of bull horn injuries to date, with the exception of the series based on injuries that occurred in professional bullrings.[10,30]

Taking our extensive series as a reference, we can conclude that bull horn injuries were more frequent in males aged between 16 and 30, with an average age of 36 years, similar to the results of other recent publications.[8-11,19,29]

Although the existence of more popular events each year has resulted in a higher percentage of injuries caused by bulls, this fact is not reflected in the number of hospital admissions in our study, which was 15% lower in the last 20 years compared to the first 20 years in the registry. This may be due to the presence in recent years of general surgeons where the event takes place, who attend to and treat the more minor injuries that do not require referral to a hospital; and the death on the spot of those with the most serious injuries (data not included in our review). Thus, it seems obvious to point to a greater number of injuries during the months in which the most events are held, namely

the summer. Figure 6, shows the evolution of injuries reported over the last 15 years with respect to the number of hospital admissions, penetrating injuries, need for intensive care, and deaths.

Approximately 10% of the injured patients had multiple injuries. Wounds to a depth of more than 10 cm, or with several trajectories, accounted for almost 40% of the total injuries, which reflects the importance of injury kinematics and the different movements of the bull during the 'cogida' (tossing in the air).[8,22,28,30,31-33]. As described in other series,[8,29,31-34] the most frequent injuries were to the lower extremities. More than half of the cases presented blunt lesions only (blows and jabs with the horn), while, of the penetrating wounds, 33% presented visceral injuries.

Regarding the treatment of these injuries, we conclude that once the area has been anaesthetised, the wounds and their possible routes should be explored thoroughly, with an exhaustive cleaning with physiological serum and antiseptic solution, exercising caution with the use of oxygenated substances, due to the described risk of gas embolism.[35] After debridement and removal of foreign bodies, a suture by planes and the systematic placement of non-aspiratory drains should be performed, due to the risk of infection and post-surgical hernias, which in our series were 5.2 and 1.4% respectively, constituting the most frequent complications.

In relation to the specific treatment of wounds, we recommend performing an exploratory laparotomy at the slightest suspicion of penetration into the abdominal cavity, reflecting 24% of exploratory laparotomies in our study. This percentage may decrease with the implementation of laparoscopic surgical exploration, which has demonstrated comparable results to open access in haemodynamically-stable abdominal trauma patients.[36-38] It should be noted that, as with all types of abdominal trauma, the organs most affected are the spleen, liver, and small intestine.[1-5,28,39]

As for the analgesic therapy provided, as explained in the work of Molina et al.,[40,41], in a situation of stress or haemorrhagic shock, the sympathetic-adrenergic and neuroendocrine systems are activated, which in turn activate the brain's analgesic system. Therefore, these patients often do not experience pain or excessive pain after being tossed. Nevertheless, analgesic treatment is a fundamental pillar in the perioperative period of patients, which conditions a satisfactory recovery. In our study we reported a good anaesthetic quality, with local anaesthetic used for contusions and goring injuries with a compromised fascial plane, and general anaesthetic for more severe goring injuries, with no reported cases of anaesthesia complications or chronic pain in our series.

Bull-related injuries should be considered highly contaminated/dirty, with a considerable percentage of infectious complications, 6% in our series, which can sometimes be serious and with a high morbimortality, reported as 6-25% in some series.[8,9,28-30,34,42] Therefore, a wide antibiotic coverage for any injuries with these characteristics is important for dealing with aerobic (gram-positive and gram-negative) and anaerobic germs, with associated antitetanic prophylaxis, due to the high transmission potential of *Clostridium tetani*; even with negative results in the cultures obtained.[43] Although no protocolised antibiotic therapy exists, in our series, the most used combination was amoxicillin-clavulanate and metronidazole, followed by amoxicillin-clavulanate, metronidazole and gentamicin. Following the main guidelines on antibiotics and traumatic injuries[44], we

reported a time course of broad-spectrum antimicrobial therapy variable, depending on the injured tissue and its complications.

The length of hospital stay depends on multiple factors, as presented by Monferrer et al.[9], the most important of which are the inherent characteristics of the bull (bravery, strength, type of horn and tip), of the injured person, of the wound (trajectory, visceral involvement, infection) as well as the environment factor. In our series, we observed that most admissions did not exceed 7 days, with a mean of 9.1 days and a median of 6 days, for the least severe injuries. Thus, in patients with visceral involvement, the majority stayed between 8-30 days in hospital, with an average of 18.9 days and a median of 9, in addition to a greater need for intensive care (35% of cases), which demonstrates its greater severity and comorbidity. Furthermore, all patients who had a hospital stay of >30 days were in the Intensive Care Unit.

We reported a mortality of around 1% (0.87%), especially secondary to hypovolemic shock. However, if we calculate and compare mortality based on the first and last 20 years, we find that over the last 20 years mortality from bull horn injuries doubled (0.6% vs. 1.22%, respectively), reflecting the severity of these injuries and the importance of their urgent management, despite advances in medical and surgical care.

We conclude by highlighting the importance of injuries caused by bull horns worldwide, especially in countries with the greatest number of bull-related events, since these are high-impact injuries with specific intrinsic characteristics that require regulated medical and surgical care and assistance, in multi-traumatised patients with non-negligible morbidity and mortality.

AUTHORSHIP

A.M.H., and D.M.R. participated in the study design. A.M.H., D.M.R., MV.G.M., N.A.M., E.L.L., E.A.H., R.Q.M., R.C.P., and JM.L.S. participated conceived of the study and contributed to the data analysis, article execution and review. A.M.H. participated in the writing. D.M.R., and JM.L.S participated in the critical review. A.M.H., and D.M.R. wrote the article, and all authors contributed substantially to its drafting and revision. A.M.H. takes responsibility for the article as a whole.

DISCLOSURE

The authors declare no funding or conflicts of interest.

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