Camel-related Major Vascular Injuries: A 20-years' Experience

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Abstract

Background: Majority of animal-related injuries in United Arab Emirates are caused by camels. We aimed to study the anatomy, biomechanism and outcome of major camel-related human vascular injuries and correlate them to the camel anatomy and behavior.

Methods: We retrospectively studied all patients who were admitted to Al-Ain Hospital with camel-related major vascular injury during January 2001 to January 2020. A special protocol was designed to collect the data. An adult 7-year-old male camel skull was prepared and web-based video clips of camel bites to humans were analysed to have an in-depth understanding of the biomechanism of injury.

Results: Seven patients were studied, all were males having a median age of 26 years. Five out of six bite injuries (83%) occurred during the camel rutting season. The injuries were severe and life threatening. Four involved the carotid artery, one the femoral artery and vein, one the external iliac vein and one the aorta which was due to a fall from a camel. Although the standard of surgical care was high, the outcome was poor. Six patients were admitted to the ICU for a median of 5 days. One patient died, one was vegetative, and one had arm paralysis. The elongated jaws of the camel having its biting component at the front, and the strong masseter muscles at the back increases the strength of its bite grip. Each bite causes four small elliptical wounds of the canine teeth which resembles two stab wounds of 8 cm long, penetrating deeply and injuring major vessels. Aggressive camels bite repeatedly to kill their victims.

Conclusions: Camel-related vascular injuries have a poor clinical outcome. Although the basis of their surgical management is similar to other vascular injuries, their poor outcome is related to the aggressiveness of the attacking camel, the anatomy of its jaw, and its intention to kill. Neck wounds of camel bites can be closed primarily after debridement. Studying these unusual injuries gives an insight into the “one globe one health approach” in which humans interact with the animals and the environment around them. It is important to understand the camel behavior for injury prevention.

Introduction

Our world has a delicate balance between the environment, animals and human existence reflecting the need for the “one globe, one health approach”. This has been more evident during the current COVID-19 Pandemic [1, 2]. Humans depend on domestic animals for their daily lives. Nevertheless, they can be occasionally injured by these animals. In developed countries, around 50% of the population are injured at least once in their life by an animal bite, with an incidence of 50 to 200 per 100 000 inhabitants per year [3, 4] causing around 1% of Emergency Department visits [5].

The type of animal-related human injuries varies in different countries depending on the existing animals living close to humans, the camel is one of them. The relationship between the camel and man has developed over centuries. The camel was domesticated before 4000 years in the Arabian Peninsula. It became an integral part of daily life as a source of food, milk, leather, a method for transportation, a sport activity, and cultural heritage. There are more than 20 million camels globally, 75% in Northern and East

Africa while the rest live in the Middle Asia, and Australia [6, 7]. Camels were shifted to Australia in 1840 to be used as a transportation method when exploring vast deserts. Out of six camels bought and transported from the Canary Islands, only one survived which was called Harry. Harry killed its owner few years later [8]. Camels were released in the beginning of the 19th century when modern automobiles were developed. Currently, there are more than 1.2 million camels living freely in the deserts of central Australia [9].

Eighty percent of animal-related injuries in the United Arab Emirates (UAE) are caused by camels [10]. Our trauma group has been studying the camel-related human injuries for the last two decades [11]. These injuries are so complex and vary depending on different factors including the size and height of the patient, the anatomy, age, gender, and behavior of the camel, and the season in which the injury occurred. Death of these injuries may occur due to bleeding from major vessels, crushing asphyxia of the chest, or severe head injuries [12, 13]. We have encountered dramatic life-threatening major vascular injuries caused by camels [14-16]. Searching the literature of camel-related major vascular injuries, majority were single case reports of the carotid [17, 18], axillary [19], brachial [20], or femoral artery [21] injuries. We could find only one original article on this topic [22]. It studied 23 patients with major vascular injuries from India, 96% were in the upper limbs, all were salvaged. Another study from India reported 98 vascular injuries which were managed over one year. It had six (6.1 %) camel-related injuries but their details were not reported [23]. Our understanding of the complexity of these injuries developed over the last two decades. We thought that it is now the time to have an in-depth analysis of the biomechanism of these major injuries by correlating them to the anatomy of the camel and its behavior. Accordingly, we aimed to study the anatomy, biomechanism and outcome of major camel-related human vascular injuries and correlate them to the camel anatomy and behavior.

Patients And Methods

Ethical consideration

This study was approved by Al-Ain Hospital Human Research Ethics Committee (AAHEC-02-21-006). Patients who are admitted to Al-Ain or their caregiver sign a written form giving their permission to the hospital to use their anonymous data for research.

Patients

This is a retrospective study of all patients who were admitted to Al-Ain Hospital with camel-related major vascular injury during the period from January 2001 to January 2020.

Setting

Al-Ain Hospital is the main Trauma Centre of Al-Ain City, Abu Dhabi, which has a catchment population of around three quarter million inhabitants. It has advanced trauma care including a state of art Emergency Department, 16 slice CT scanners, 24-hour interventional radiology facility, operating theatre and a well-equipped ICU within 150 meters distance each. The hospital has a 500-bed capacity with 24 hours availability of a general surgeon, neurosurgeon, vascular surgeon, plastic surgeon, orthopedic surgeon, thoracic surgeon, pediatric surgeon, anesthetist, and intensivist. The patients are treated according to the ATLS guidelines as it is obligatory for all those involved in trauma management to be ATLS certified which should be renewed regularly.

Study protocol

A special protocol was designed to collect the studied variables of the current study. This included demography, description of the incidence of injury, mechanism of injury, wound description, major vessels injured, clinical presentation, vital signs on arrival, associated injuries, surgical management, ICU stay, length of hospital stay, complications, and patient outcome till discharge.

Analysing the biomechanism of the injury

The skull of an adult 7-year-old camel was prepared to have a three dimensional model that would help us understand the anatomy of the camel skull, the biomechanism of injury and correlate it to the pattern of injury of humans. The camel head of freshly slaughtered male Omani dromedaries was procured from Al Khazna Camel Slaughterhouse, Abu Dhabi Food Control Authority (ADFCA), Al-Ain, UAE. It was dissected to remove the soft tissues including the skin and muscles and then subjected to a slow process of chemical digestion by immersing the camel head in 20 % sodium peroxide that would digest soft tissues but not bones. During a period of two weeks, this process was repeated three times. The skull was then washed with water and immersed in 5% hydrogen peroxide for another three days. The website was searched to collect videos related to camel bites of the neck and lower limbs of humans to help us have an in depth understanding of the mechanism of injury [24, 25].

Statistics

Simple statistics was used to describe the data because of the small sample size. Continuous data were presented as median (range) and categorical data as number (%). Data were analyzed manually by ordering the ranks while percentages were calculated manually using a hand calculator (Casio Calculator SX-320P, Casio Computer Co., Ltd, Tokyo, Japan).

Results

Clinical results

There were seven patients admitted with camel-related major vascular injuries during the 20-year-period, around one patient every three years (**Table 1**). All these patients were males from the Indian subcontinent. They had a median (range) age of 26 (11-45) years. All injuries occurred in the farms. Five patients out of six having bite injuries (83%) were injured on the months of November to January, which is the rutting season of camels. We admit an average of 20 patients with camel-related injuries annually to Al-Ain Hospital [11] indicating that major vascular injuries constitute 1.75% of all camel-related injuries.

Six patients were injured by camel bites, four of them to the neck (**Figure 1**), one to the groin (**Figure 2**), and one to the abdomen (**Figure 3**). These resulted in carotid artery injuries in four patients, all on the left side, left femoral artery and vein injury in one patient, and right common iliac vein in one patient. The last patient fell while riding a camel and sustained aortic artery injury (**Figure 4**). Three patients presented with massive bleeding, shock, and coma.

Five patients had surgery, one had aortic stenting, and one with massive brain infarction had no intervention. Surgery included interposition vein grafts for two common carotid artery injuries and synthetic polytetrafluoroethylene graft (PTFE) for a common carotid artery injury. One had end to end anastomosis of the femoral artery and primary repair of the femoral vein while the last had primary repair of the right common iliac vein. Wounds were properly debrided. All wounds were primarily closed to cover the vascular repairs except the abdominal wounds (Case 7) which were left open. All patients received Anti-tetanus and anti-rabies vaccinations, and broad spectrum antibiotics for 7 days covering aerobic and anaerobic bacteria.

Table 2 shows the clinical management and its outcome. Six patients stayed in the ICU for a median (range) of 5 (1-42) days. Hospital stay had a median (range) of 22 (6-110) days. Four patients had major complications. Cerebral infarction occurred in two patients, brachial plexus paralysis in one patient, retroperitoneal necrotizing fasciitis in one patient, wound infection associated with bleeding in one patient, and abdominal incisional hernia in one patient. Four patients recovered completely, one had left brachial plexus paralysis, one was in a vegetative status, while one died.

Analysis of the biomechanism of injury

The incisors of the upper jaw of the camel are strong and tusk-like (**Fig 5**). Those of the lower jaw point upwards and horizontally in front of the upper incisors. The canine teeth of the camel are located behind the incisors. They are sharp and long reaching up to 4 cm in length. They are larger in male camels compared with female camels. The upper canine teeth point backwards while the lower points forwards which gives their bite a strong tight closure for gripping and fighting. The teeth of the camel are completely separated by a 6 cm gap into two components. The front are for biting and fighting while the back molar teeth are flat and used for grinding food. [26, 27].

The mastication muscles including the masseter, lateral and medial pterygoideus and digastricus muscles are well developed, which explains the strength of the camel bite. Furthermore, the masseter muscle is very tendinous and is situated far caudally compared to other animals. This enables the camel to open its jaws widely and to have a strong bite [27]. Analysis of the real-life web-based videos clearly indicates that the mechanism of camel bites include both penetrating and blunt trauma. The camel has a strong teeth grip and power to be able to pick an adult man up and throw him away for meters causing blunt trauma.

Discussion

Our study has shown that camel-related major vascular injuries are mainly caused by camel bites. Studying the odontology of the camel enabled us to correlate the bite wound to the number of bites. Majority of these bites occurred during the winter rutting season when aggressive male camels were in heat. Majority were in the neck causing carotid artery injuries. Although the surgical care at our hospital was timely and of high international standard, the clinical outcome was poor. This poor outcome is related to the aggressiveness of the attacking camel, the anatomy of its jaw, and its intention to kill.

Although camel bites constitute 25% of camel related injuries in our setting [11], they constituted 86% (6/7) of major vascular injuries in this study, and 1.75% of all camel-related injuries in our hospital. Within our own experience, this lies in between major blunt vascular injuries of hospitalized patients of road traffic collisions (1.3%) [28] and war-related penetrating major vascular injuries (10%) [29].

The biomechanism of camel bite injuries includes penetrating, crushing and blunt trauma [30]. The elongated jaws of the camel with its biting component at the front, and its well-developed tendinous masseter muscles further back gives the camel the ability to open the mouth widely and the strength to bite strongly. Each bite by the canine teeth will have four skin wounds. Counting the number of puncture of wounds will indicate the number of bites. Aggressive camels will bite repeatedly. Since each canine tooth is 4 cm long, the two upper and lower canine teeth will work as a knife. Each bite will resemble two stab wounds of 8 cm long. Although canine teeth had small wounds on the skin, they can penetrate deeply injuring the major superficial vessels in the neck and groin. The camel aims at biting thin areas like the leg, arms and neck [31]. Nevertheless, if the body of the victim is small (like a child), the camel can bite the head, thigh, or the abdomen. Superficial major vessels are more prone to camel bite injuries.

83% of camel bites in this study were between November and January. Camels rut in the cold winter season which is between November and March in Africa and the Middle East while it is between May and September in Australia. Sexually active male camels become very aggressive and difficult to handle and tend to bite in this season. Male camels have a long pinkish elongated structure protruding from the mouth which is covered by froth and used to show up for female camels. It is anatomically a diverticulum of the soft palate and called the "Dulla" [22, 32]. Male camels are dangerous when they are in heat or angry, they should be handled carefully, and avoided by bystanders [15, 31]. The Dulla is a warning red sign that the camel is very dangerous.

The saliva of a camel contains both aerobic and anaerobic bacteria which may spread quickly after camel bites causing necrotizing fasciitis if not debrided properly [33-35]. Camel bite wounds should be covered by broad spectrum antibiotics. We routinely give anti-rabies vaccination for camel bites [30]. Camels get rabies if bitten by desert foxes [36]. Nevertheless, there are no documented rabies cases transmitted to man from camel bites. All neck wounds in our study were primary closed without infection. The retroperitoneal necrotizing fasciitis of the abdomen occurred (case 3) despite keeping the wounds open. This was most properly related to the colonic injury. The only patient who may have benefited from keeping the wound open was probably the femoral region wound. Since it was important to cover the arterial anastomosis by tissues, this could have been done using the subcutaneous tissue without closing the skin. There is evidence supporting primary closure of bite wounds, especially in the face and neck [37] although a recent Cochrane systematic review suggested that this is not strong [38]. Sharma et al study closed all 22 camel bite upper limb vascular injury wounds without wound infection [22].

The outcome of these injuries was not favorable. One patient died, one was vegetative, and one had arm paralysis. Sharma et al [22] treated 22 camel bite vascular upper limb injuries; 13 by end to end anastomosis, and ten by reversed saphenous vein grafts with 100% limb salvage. Interestingly they had only one carotid artery injury, which was not operated on because the patient arrived three days after the injury. We assume that more severely injured patients died before arriving to their hospital representing a selection bias. This is similar to other experiences in vascular trauma from India [39, 40]. In contrast, our patients arrived to the hospital soon after their life-threatening vascular injuries.

Case 7 is the only case of camel-related aortic injury in the literature. Fall from more than 3 meters high from a camel and hitting the ground on a fixed point (the right shoulder) caused a high energy acceleration deceleration comminuted scapular fracture and traumatic aortic pseudoaneurysm. We had previously published the largest prospective study of scapular fractures in the literature which demonstrated that multiple-region scapular fractures (as in this case) had more severe chest injury than single-region scapular fractures [41].

The Haddon matrix which aims at 1) preventing the animal bite, reducing its impact, and treating it is a very useful approach for injury prevention [42]. Covering the camel mouth with a muzzle when close to bystanders can prevent its bites (**Figure 6**) [31].

Limitations

We have to acknowledge that there are certain limitations of our study. *First* the sample size is small because of the rarity of the condition. Ideally, a multicentric study would catch larger number of patients. We personally tried to collaborate with other trauma centers that treat similar cases in developing countries around us but were faced with multiple barriers like lack of trauma registries, lack of research interest, and lack of training. One solution is to build up a camel-based global registry similar to the CrocBITE which is a worldwide crocodilian attack database [43]. This is a call through the World Society of Emergency Surgery to build up such a database. Countries from India and North Africa will be

a rich source of needed information. *Second*, we studied only hospitalized patients. It is very possible that patients with major vascular injuries in the neck have died in the pre-hospital setting. *Third*, this is a retrospective study in nature. We are assured that we captured all patients with major vascular injuries treated at our hospital during the last 20 years because we were interested in this topic and prospectively documented the hospital numbers of these patients. We are confident that the reported incidence of these life-threatening injuries reflects the reality in our setting.

Conclusion

Camel-related vascular injuries have a poor clinical outcome. Although the basis of their surgical management is similar to other vascular injuries, their poor outcome is related to the aggressiveness of the attacking camel, the anatomy of its jaw, and its intention to kill. Neck wounds of camel bites can be closed primarily after debridement. Studying these unusual injuries gives an insight into the “one globe one health approach” in which humans interacts with the animals and the environment around them. It is important to understand the camel behavior for injury prevention.

Abbreviations

ADFCA: Abu Dhabi Food Control Authority

ATLS: Advanced Trauma Life Support

CT: Computer tomography

ICU: Intensive Care Unit

PTFE: Polytetrafluoroethylene

UAE: United Arab Emirates

Declarations

Authors' contributions:

Conceived the study: FAZ, S A-K, HM, AA, MSB, AJ. Designed the study: FAZ. Applied for the Ethical approval: HM, MSB, Retrieved the data: FAZ, S A-K, HM, AA. Analyzed the data: FAZ, AA. Prepared the tables: HM, Prepared the figures: FAZ, S A-K, AA, Wrote and critically edited the paper: FAZ, Critically read the paper: FAZ, S A-K, HM, AA, MSB, AJ. All authors approved the final version of the paper.

Ethics approval and consent to participate:

This study was approved by Al-Ain Hospital Human Research Ethics Committee (AAHEC-02-21-006). Patients who are admitted to Al-Ain or their caregiver sign a written form giving their permission to the hospital use their anonymous data for research.

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Data are available as tables within the manuscript

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Not applicable

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The authors declare that they have no competing interests.

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Tables

Table 1

Demography and clinical presentation of patients who had camel-related major vascular injuries treated at Al-Ain Hospital, UAE during the period of 2001-2020

Case	Age (yrs)	Sex	Mechanism of injury	Clinical presentation	Wound	Injuries
Case 1	45	M	Camel bite	Coma, difficulty in breathing, hypotension, right sided paralysis	Puncture wounds of the neck, left side	Left sided carotid artery injury and brain infarction, cervical spine fracture, left haemothorax, fractured left first and second ribs and clavicle
Case 2	23	M	Camel bite	Neck wound, Lost abduction of the left arm	Puncture wounds of the neck, left side	Left common carotid artery intimal tear, Brachial plexus injury of the left side
Case 3	26	M	Camel bite	Unconscious, shock, bleeding from the abdominal wall,	Puncture wounds of the right lower abdomen	Right common iliac vein, retroperitoneal hematoma, colonic injury, lumbar spine fracture
Case 4	11	M	Camel bite	Neck wound	Puncture wounds of the neck, left side	Left common carotid artery injury with thrombosis, mandible fracture
Case 5	37	M	Camel bite	Shock, CGS 8, bleeding from a left groin wound	Cut wound left femoral region	Femoral artery and vein injury
Case 6	22	M	Camel bite	Left side of the neck	Puncture wounds of the neck, left side	Left CCA transection and thrombosis 3 cm below the bifurcation
Case 7	31	M	Fall from camel. A height of more than 3 meters	Pain right upper extremity and shoulder	None	Aortic injury Comminuted fracture of right scapula, fractured right 2-4 ribs and left first rib, bilateral haemothorax

Table 2

Management of patients who had camel related major vascular injuries treated at Al-Ain Hospital, UAE during the period of 2001-2020

Case Number	Management	ICU stay	Complication	Hospital stay	Outcome
Case 1	Conservative	6	left brain infarction	6	Died
Case 2	Interposition venous graft	4	Neuropraxia of the left axillary, musculocutaneous and suprascapular nerves	23	Left brachial plexus paresis
Case 3	Surgical repair of the right common iliac vein	26	Necrotizing fasciitis incisional hernia	59	Recovered completely
Case 4	Interposition venous graft of left carotid artery, ORIF of the mandible	0	Nil	22	Recovered completely
Case 5	End to end anastomosis of the femoral artery Femoral vein repair	42	Wound infection, active bleeding from the anastomosis, brain infarction	110	Cerebral infarction and vegetative status
Case 6	Synthetic graft for the left CCA	2	Nil	10	Recovered completely
Case 7	Aortic Stenting	1	Nil	6	Recovered completely

Figures

Figure 1

22-year-old man with a camel bite to the left side of the neck (Case 6). Observe the oval shape small size wound **(A)** which corresponds with the canine teeth of the camel. Although the puncture wound was small, it caused transection of the left common carotid artery 3 cm below its bifurcation **(B)**.

Figure 2

37-year-old man with a camel bite to the left femoral region (Case 5) causing a lacerated wound of the left femoral region **(A)** associated with femoral artery and vein injury **(B)**.

Figure 3

26-year-old man with a camel bite to the right side of the abdomen (Case 3). Notice the canine teeth small oval cut wound in the right iliac fossa (**A**, yellow arrow). Abdominal CT scan (**B**) shows very intraperitoneal air (white arrow) and a fractured lumbar spine (yellow arrow). Laparotomy (**C**) shows the penetration through the colon (arrow heads) reaching the posteriorly located right common iliac vein.

Figure 4

A 31-year-old camel rider fell on his right shoulder while he was riding a camel. He sustained severe comminuted fracture of the scapula (A) and aortic pseudo-aneurysm (B, Arrow heads) which was successfully treated by aortic stenting (C).

Figure 5

A widely opened adult camel jaw showing the different teeth types. From front to back: yellow is incisors (I), red is canines (C), green is premolar (P), and light blue is molar (M). (Skull prepared, painted, and photographed by Dr Ahmad Al Aiyan, Department of Veterinary Medicine, College of Agriculture and Veterinary Medicine, UAE University, Al-Ain, United Arab Emirates).

Figure 6

Covering the mouth by a muzzle can prevent camel bite injuries (Photographed by Professor Fikri Abu-Zidan, Department of Surgery, CMHS, UAE University, Al-Ain, United Arab Emirates).