Surgical management of injuries sustained from grizzly bear maulings treated in Vancouver, British Columbia

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BACKGROUND: Between January 1, 1992 and May 31, 1999, four patients underwent operation at Vancouver Hospital and Health Sciences Centre for injuries sustained in grizzly bear maulings.

PURPOSE: To document and discuss surgical diagnosis and treatment of grizzly bear attack victims.

METHODS: Data were collected retrospectively from clinical charts.

RESULTS: Injuries were characterized by scalp and tissue avulsions, puncture wounds, lacerations and fractures. On average, patients underwent eight operations. The mean hospital stay was 43 days. Despite irrigation, debridement and antibiotic therapy, patients developed wound colonizations or infections with multiple Gram-positive and -negative organisms. All four patients developed post-traumatic stress disorder necessitating psychiatric counselling and pharmacological treatment.

CONCLUSIONS: Grizzly bear maulings result in multiple injuries requiring careful management and complex reconstruction. Bacterial infections and post-traumatic stress disorder were common complications in this group of patients.

Key Words: *Grizzly bear; Mauling; Post-traumatic stress disorder; Scalp avulsion*

Traitement chirurgical de blessures causées par des grizzlis et traitées à Vancouver

CONTEXTE : Entre le 1^{er} janvier 1992 et le 31 mai 1999, quatre patients ont été opérés au Vancouver Hospital and Health Sciences Centre pour des blessures causées par des grizzlis.

BUT : Documenter la démarche entreprise pour le diagnostic et le traitement chirurgical des blessures causées par des grizzlis, puis en discuter.

MÉTHODE : On a procédé à une collecte rétrospective de données à partir des dossiers médicaux.

RÉSULTATS : En général, les patients présentaient une avulsion de tissu et du cuir chevelu, des blessures par perforation, des lacérations et des fractures. Ils ont subi en général huit opérations et sont restés, en moyenne, 43 jours à l'hôpital. Malgré les irrigations, le débridement et les traitements antibiotiques, il y a eu colonisation ou infection des blessures mettant en cause de nombreux germes Gram positif et Gram négatif. Les quatre patients ont souffert du syndrome de stress post-traumatique, qui a nécessité l'intervention d'un psychiatre et un traitement médicamenteux.

CONCLUSION : Les attaques par des grizzlis causent de nombreuses blessures qui exigent un traitement judicieux et des reconstructions délicates. Parmi les complications fréquentes observées dans le groupe de patients à l'étude, notons les infections bactériennes et le syndrome de stress post-traumatique.

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The grizzly bear (*Ursus arctos horribilis*), whose habitat encompasses wilderness areas of British Columbia, may weigh between 115 and 340 kg, and reach maximum lengths of 1.5 to 2 m. Its shoulder height ranges from 0.75 to 1 m, and on its hind legs, an adult grizzly bear may stand 2.74 m tall without stretching. These bears can sprint up to 48 km/h on flat terrain. The grizzly bear is the largest and most dangerous predator in the mountains and is given a wide berth, even by black bears. Grizzly bears are omnivores with a constant drive to find and consume large masses of food. This fact, coupled with their curiosity, makes contact with humans within their territory inevitable (1,2). In British Columbia, over a seven-year study period, 26 humans were attacked by grizzly bears. Three of the attacks caused fatal injuries (3).

The two major patterns of attack by grizzly bears are the defensive attack and the predacious attack. The defensive attack occurs in response to a perceived threat to cubs, food supply, individual space or safety, and often follows an abrupt, unexpected encounter. The predacious attack occurs when the bear is aggressively seeking prey and associates humans directly as a source of food. The predacious attack results in the majority of fatal encounters (4).

Severe scalp injuries are common in survivors of grizzly bear maulings. Other wounds sustained after a serious mauling include deep skin punctures inflicted by the larger canine teeth, large lacerations and tissue avulsions. Usually the head, neck, dorsal torso, proximal extremities and hands are involved (4). Typically, these injuries require extensive reconstructive plastic surgery and lengthy hospital stays (1,5).

Salient features of four patients who underwent surgery at Vancouver Hospital and Health Sciences Centre (VHHSC) after grizzly bear maulings were reviewed.

PATIENTS AND METHODS

The clinical charts of all patients who underwent operation at VHHSC for grizzly bear maulings between January 1, 1992 and May 31, 1999 were reviewed. Patient age, extent of injuries, number and type of operations, number of blood transfusions, microorganisms cultured, length of hospital stay and complications were recorded. A fifth patient was seen at VHHSC after a grizzly bear mauling during this period. This patient was admitted for observation and was excluded from the present study because the patient did not undergo operation at VHHSC. The present study received approval and authorization from the University of British Columbia Ethics Review Committee and adhered to the established guidelines concerning released patient information.

RESULTS

Four patients with a mean age of 32 ± 9.63 years were treated at VHHSC for injuries sustained as a result of grizzly bear maulings between January 1, 1992 and May 31, 1999. All four cases were the result of a defensive grizzly bear attack.

Figure 1 Intraoperative photograph of patient 1's right gastrocnemius muscle defect after irrigation and debridement. A posterior tibial nerve deficit was present

Injuries

Patient injuries sustained from these bear attacks were severe and are summarized in Table 1. All four patients suffered scalp avulsions of 50% or more, multiple lacerations and puncture wounds to numerous locations. Patient 1 also sustained a brachial artery laceration, a gastrocnemius avulsion with posterior tibial nerve deficit (Figure 1), partial thumb amputation and an ulnar nerve injury. Patient 2 suffered a carotid artery laceration, multiple facial fractures, a facial nerve laceration, avulsion of both ears and a forearm fracture. Patient 4 experienced a scalp avulsion of approximately 66% (Figure 2), as well as an avulsed C3 spinous process, a disrupted biceps brachii tendon, a metacarpal fracture, a partial digit amputation and an ear avulsion.

Operations, transfusions and length of hospital stay

All operations performed at VHHSC are summarized in Table 1. Between three and 11 separate operations were required (an average of 7.3) per patient. As shown in Table 2, 17.8 ± 10.5 transfusions were administered per patient. The average number of days in hospital was 43 ± 11 (ranging from 31 to 55 days). Patient 1 required repair of the brachial artery, ulnar nerve and posterior tibial nerve. The patient also received a free musculocutaneous latissimus flap to repair damage to the lower extremity. Patient 2 required open reduction with internal fixation (ORIF) of the facial fractures and the ulnar fracture. A free fasciocutaneous scapular flap was used to cover the scalp defect. Patient 3 underwent a bipedicle pericranial flap to close the scalp wound. Patient 4 received ORIF of a metacarpal fracture and osteotomy for revision of the digit amputation. This patient also had a free fasciocutaneous scapular flap to close the scalp defect.

Bacteriology

Upon hospital admission, patients received various antibiotics. All four patients eventually developed multiple wound colonizations or wound infections with Gram-positive and -negative organisms that required further antibiotic therapy.

TABLE 1
Summary of injuries, operations and complications in patients mauled by a grizzly bear

Patient	Age (years)	Sex	Activity (Region)	Type of attack	Injuries	Operations*	Complications
1	32	F	Tree Planting (Prince George, British Columbia)	Defensive attack	Scalp avulsion (approximately 50%) Left lower extremity lacerations and multiple puncture wounds Right brachial artery laceration Right calf muscle avulsion Right segmental posterior tibial nerve injury Left ulnar nerve injury Right thumb partial amputation Left hamate fracture	[†] Left axillary artery repair with vein graft; [†] left upper extremity fasciotomy Left brachial artery repair (redo), I/D, STSG to scalp; left ulnar nerve repair Right lower extremity and left forearm STSG; I/D I/D for secondary infection Latissimus dorsi musculocutaneous free flap to right calf with STSG over flap; right posterior tibial nerve repair with sural nerve graft; decortication of calvarium Scalp tissue expander insertion Scalp closure with advancement flap	PTSD Left upper extremity compartment syndrome requiring fasciotomy Left ulnar nerve palsy Left median nerve palsy (motor only) Left median brachial and median antibrachial nerve palsies Alopecia
2	29	M	Hunting (Kildala Arm, British Columbia)	Defensive attack	Scalp avulsion (approximately 50%) Bilateral upper extremity and neck lacerations, and multiple puncture wounds Right external carotid laceration Bilateral compound mandibular fracture Right zygomaticotemporal fracture Bilateral ear avulsion Facial nerve injury Right ulnar compound fracture	[†] I/D I/D; right ulna ORIF; multiple facial fractures ORIF I/D; scapular fasciocutaneous free flap to skull; donor site STSG; haloback ring Left lower extremity fasciotomy I/D; left lower extremity STSG D; scalp advancement flaps; right shoulder STSG D; right shoulder STSG Right ulna removal IF; otoplasty; right ear and scalp advancement flaps Scalp and right shoulder tissue expander insertion Scalp tissue expander removal; scalp advancement flap Scalp and shoulder tissue expander removal; scalp and shoulder advancement flaps	PTSD Scapular flap donor site failure Scapular flap infection causing dehiscence Left lower extremity compartment syndrome requiring fasciotomy Facial nerve palsy Tissue expander complications Alopecia
3	45	F	Hiking (Jasper Park, Alberta)	Defensive attack	Scalp avulsion (approximately 50%) Left flank, left thoracic and back lacerations, and multiple puncture wounds	[†] I/D; bipedicle pericranial flap with STSG [†] Scalp STSG I/D; osteotomy; scalp STSG	PTSD Skin graft failure (grafted in referring hospital)
4	22	M	Surveying (Fort Saint James, British Columbia)	Defensive attack	Scalp avulsion (approximately 66%) Chest, abdomen and bilateral lower extremity lacerations and multiple puncture wounds C ₃ spinous process avulsion Left ear avulsion Left ear canal transected Right biceps brachii disruption Right fourth digit partial amputation Right second metacarpal displaced fracture	I/D; left second metacarpal K-wire insertion I/D I/D; left lower extremity STSG I/D; scapular fasciocutaneous free flap to scalp; donor site STSG I/D; left lower extremity STSG Back STSG Back STSG; scalp flap revisions Tenolysis; capsulolysis; osteotomy; left second digit IF Scalp tissue expander insertion Scalp tissue expander removal; scalp advancement flap, expander reinsertion Scalp tissue expander removal; scalp advancement flap	PTSD Scapular flap donor site infection causing two failures Pseudomonas infection Left ear decreased hearing Left second metacarpal malunion Alopecia

*Operations are listed in order of occurrence; [†]Operation performed at a hospital other than Vancouver Hospital and Health Sciences Centre. D Debridement; F Female; I/D Irrigation and debridement; IF Internal fixation; M Male; ORIF Open reduction with internal fixation; PTSD Post-traumatic stress disorder; STSG Split-thickness skin graft

Figure 2) Patient 4 **Left** posterior photograph showing scalp avulsion injury (approximately 66%) and missing pericranium. **Right** lateral aspect of scalp avulsion injury. Observe the lacerations at the base of the neck

TABLE 2

Days in hospital, time to Vancouver Hospital and Health Sciences Centre (VHHSC), number of operations and total transfusions in patients mauled by a grizzly bear

Patient	Days in hospital	Time to VHHSC	Number of operations*	Total transfusions (units [†])
1	37	24 h	7	27
2	55	13 h	11*	23
3	31	20 days [‡]	3*	3
4	51	16 h	11	18
Mean	44	N/A	8	17.8
SD	11	N/A	3.8	10.5

*Includes operations performed at other hospitals; [†]1 unit = 350 cc; [‡]From Seaton General Hospital, patient 3 was sent to the University of Alberta Hospital, Edmonton and was later transferred to VHHSC to manage her scalp avulsion injury. N/A Not applicable

Infections often displayed a high level of resistance. The common organisms were *Acinetobacter baumannii*, *Morganella morganii*, *Enterococcus* species, *Escherichia coli*, *Proteus vulgaris* and *Staphylococcus epidermis* (Table 3).

Complications

Patient 1 had ulnar, median, median brachial and median antibrachial nerve palsies, and developed a compartment syndrome in the left forearm requiring fasciotomy. Patient 2 had an infection of the scapular flap and the donor site, and developed compartment syndrome in the left upper extremity requiring fasciotomy. Patient 3 had a skin graft failure. Patient 4 had recurrent infections of the donor site, malunion of the metacarpal fracture and a partial loss of hearing. *Enterococcus* species infections showed a high level of resistance.

Post-traumatic stress disorder (PTSD) was diagnosed in all four patients. This psychological condition required counselling and pharmacological treatment with selective serotonin reuptake inhibitors (SSRIs). A complete list of complications is shown in Table 1.

DISCUSSION

The force of the grizzly bear attacks resulted in severe injuries. Scalp avulsion injuries with tissue loss were common in all four patients. This is consistent with the known pattern of grizzly bear attacks in which the head and neck regions are common targets (4-6). Lacerations to the lower extremities in

TABLE 3
Microorganisms cultured in wounds sustained by grizzly bear maulings

Microorganism	Patient				Total
	1	2	3	4	
<i>Acinetobacter baumannii</i>	x	x			2
<i>Acinetobacter anitratus</i>				x	1
<i>Chryseomonas indologenes</i>		x			1
<i>Enterococci</i> species	x		x	x	3
<i>Escherichia coli</i>	x	x			2
<i>Morganella morganii</i>	x	x			2
<i>Proteus penneri</i>		x			1
<i>Proteus vulgaris</i>		x	x		2
<i>Pseudomonas aeruginosa</i>				x	1
<i>Staphylococcus epidermis</i>		x		x	2

conjunction with hand and arm fractures were also seen in the patients studied.

Injuries resulting from grizzly bear bites are prone to infection. This finding has been reported previously in the literature (4). All patients' wounds developed infection with Gram-positive and -negative microorganisms that showed a wide resistance and only responded to a combination of debridement and antibiotic therapy directed by culture and sensitivity testing. The organisms cultured from the wounds of these patients were consistent with the organisms commonly found in the mouths of grizzly bears (7). In the study by Parry et al (7), mouth cultures from 31 Alaskan grizzly and brown bears grew Gram-positive and -negative organisms. *Staphylococcus* species and group A *Streptococcus* species were reported as the most common Gram-positive organisms, and Enterobacteriaceae, *Diphtheroids* species and *Pseudomonas* species were shown to be the most common Gram-negative organisms. One letter in the literature reported an infection with *Mycobacterium chelonae*, subspecies *abscessus*, in a patient two weeks after being scratched with a grizzly bear tooth (8). It was unclear, however, whether this contamination was from the grizzly bear or from subsequent surgical intervention.

The patients in the present study suffered multiple complications as a result of their injuries. The extent of the scalp avulsion injuries made them difficult to treat. Three of the four patients had the scalp avulsed to the bone, and only one patient had intact pericranium remaining. Two free fasciocutaneous scapular flaps, one split-thickness skin graft and one pericranial flap were used to close the wounds. In three of the four patients, tissue expanders were required to treat the alopecia that resulted from the loss of scalp. The use of tissue expanders introduced further complications as seen in patient 2, in whom the expander pocket became infected and the expanders had to be removed.

Psychological complications were also examined. These patients experienced life-threatening events, and the subse-

quent response involved intense fear. Each of the patients persistently re-experienced the events in thoughts, images and dreams. Other symptoms included persistent avoidance of stimuli associated with the trauma, numbing of responsiveness, difficulty falling asleep and irritability. As such, they met the criteria for the diagnosis of PTSD. The symptoms persisted for more than one month and, therefore, could not be attributed to acute stress disorder (9). In all four patients, the disorder presented with no delayed onset. Initial treatment was supportive. Patients were encouraged to discuss the event and were provided with coping mechanisms. In addition to psychological therapy, SSRIs were employed as a pharmacological therapy.

In the initial assessment of a patient who has been mauled by a bear, the physician must consider the severity and complexity of the injuries. When these factors are combined with the known complications, the needs of these patients may exceed the resources of small centres and require referral to a tertiary care centre with a burns and plastics unit.

Experience at our centre with the management of these complex cases has produced recommendations for surgical diagnosis and treatment, subsequent to grizzly bear maulings.

Guidelines for surgical management of grizzly bear attack victims

The patient's needs may exceed the resources of smaller centres. If this is ascertained, the patient should be promptly referred to a tertiary care centre.

Early broad-spectrum antibiotics with coverage for Gram-positive and Gram-negative organisms should be promptly instituted.

Wounds should be thoroughly irrigated in an operating theatre, even if the patient is being transferred to tertiary care.

Puncture wounds should be closed secondarily, and wounds should have frequent cultures performed to detect secondary infections.

Patients should be managed in a burns and plastics unit due to the severity and complexity of their wounds.

Upon hospital admission, the psychiatry service should be consulted for diagnosis and treatment of PTSD.

CONCLUSIONS

Grizzly bear maulings resulted in multiple injuries, characterized by scalp and tissue avulsions, puncture wounds, lacerations and fractures. Patients who received operative treatment at VHHSC required careful management and complex reconstruction. Bacterial infections and PTSD were the common complications in this group of patients.

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