

PAPER

PATHOLOGY/BIOLOGY

Danielle Bury,¹ M.B., Ch.B.; Neil Langlois,^{1,2} M.D.; and Roger W. Byard,^{1,2} M.D.

Animal-Related Fatalities—Part I: Characteristic Autopsy Findings and Variable Causes of Death Associated with Blunt and Sharp Trauma

ABSTRACT: Animals may be responsible for an array of potentially lethal injuries. Blunt force injuries characteristically involve larger animals such as cattle or horses that may kick, crush, or trample a victim causing head and facial injuries. Farm workers in particular are at high risk of lethal injuries involving the head and torso. Significant blunt trauma may be found in vehicle occupants after collisions with large animals such as camels or moose. Rarely, zookeepers may be crushed by particularly massive animals such as elephants. Sharp force injuries usually involve carnivore bites, most often from dogs with a “hole and tear” pattern of wounding. Injuries from animals such as alligators and sharks may have a significant component of crushing. Incised wounds may result in death from exsanguination and air embolism. On occasion, blunt or sharp trauma from animal activity may be confused with postmortem damage or with inflicted injury from an assault.

KEYWORDS: forensic science, animal injuries, bite, crush, dogs, bears, sharks, autopsy, blunt force

Interactions with animals of all kinds may result in human fatalities from a wide variety of causes ranging from blunt force trauma to envenomation. In the United States between 1991 and 2001, a total of 1943 people died after encounters with venomous and nonvenomous animals, representing an average of 177 deaths per year. Of these fatalities, 61% were caused by nonvenomous animals, with dog attacks resulting in 17.6% of these deaths and “other specified animals” responsible for 71.5% (1).

Occupation may have an effect on the occurrence of injury and death, with the highest rates occurring in situations of greatest exposure, such as farm workers, veterinarians, cowboys and rodeo riders, animal caretakers, and hunters. Researchers are also at increased risk from injury or infection (2). Animal-related deaths were cited as the fourth most common cause of death in those aged over 55 years in the agricultural industry in Australia from 2001 to 2004, causing 7.1% of deaths. In those aged 15 years and older, horses were the main culprit causing 3.5% of deaths, followed by cattle at 1.9% (3). Those most at risk in the United States are men over the age of 65 years (2). Unusual fatalities caused by animals include drowning after being thrown into water while horse riding or deaths following aircraft crashes after collisions with flocks of birds. Twenty-six deaths in these type of airplane crashes were reported in the United States between 1992 and 1997 (2).

Forensic pathologists may encounter deaths resulting from human interactions with animals, and clinical forensic practitioners may be called upon to assess nonlethal injuries inflicted by animals. The following review provides an analysis and classification

of the range of injuries and mechanisms of death that may be encountered in such events involving blunt and sharp trauma; consideration will also be given to autopsy protocols in the investigation of such deaths. Cases have been classified by the mechanisms of death rather than by the particular species of animal involved as there is often overlap in the types of injuries that may be inflicted by animals from quite different species.

Blunt Force Injuries

This category includes cases where injuries have been caused by impact where there is no sharp penetration of body cavities. Situations include victims who have been knocked over, or kicked or trampled by large animals, and cases where animals have fallen onto motor vehicles following collisions (4–6).

There are many reported cases of large farm animals butting or kicking individuals, resulting in death, with horses and cows being the most common offenders (5,7–9). Occupation and sex bias are demonstrated in the report of nine cattle-related deaths in which eight of the victims were men with the deaths occurring on farms (5). Predictably, kicks to the head and chest result in more immediately fatal outcomes, most likely due to the effects of direct trauma to the brain, heart, or lungs (5). Head injuries such as skull fractures and subdural hemorrhage may also be caused by falls, butting, or kicking. Head and facial injuries are most common, followed by upper body, with pelvis injuries being uncommon and spinal injuries rare (10). At autopsy, injuries inflicted from a kick should be examined for the presence of distinctive markings that may have occurred from the hoof or shoe that may permit the identification of the culprit (11).

Because of their small size and physical vulnerability, children are at high risk of being kicked by farm animals such as horses. In addition, riding accidents are not uncommon, when children either

¹Forensic Science SA, 21 Divett Place, Adelaide, SA 5000, Australia.

²Discipline of Anatomy and Pathology, The University of Adelaide, Frome Road, Adelaide, SA 5005, Australia.

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fall from or are thrown off a horse. Deaths in such cases are usually caused by severe head trauma and may be related to failure to wear protective helmets. Cervical spine trauma is relatively uncommon (with only six patients affected compared to 103 with head injuries in one report [9]).

Although deaths associated with dogs usually involve sharp force injuries, on occasion, an individual may be knocked down by dogs (7) or may sustain blunt force trauma to the neck if an excited animal quickly lifts its head. This is most likely to occur if the victim has been bending over to feed an animal. At autopsy, there will be evidence of significant bruising to the soft tissues of the anterior neck with fractures of the laryngeal cartilages. Other injuries that have been described by this mechanism include lacerations of the lips and fractures of the nose and jaw (12).

Occasionally, animals may be involved in vehicle deaths, most often when a driver swerves to avoid an animal on the road and the vehicle either rolls over or collides with another object such as a tree. Less commonly, there may be injuries to vehicle occupants if a large animal such as a camel, deer, or a moose is struck and impacts the windshield or cabin. The large size and weight of such animals, combined with the speed of collision, may result in significant injuries to the vehicle occupants. An animal such as a large kangaroo may also be entrapped in a windshield after impact and cause serious injuries to occupants by kicking in attempts to escape. The majority of these cases occur at dusk or dawn when animals are foraging and moving about more freely than in the heat of the midday sun (6,13).

Rare cases of crushing have been reported in zookeepers and animal handlers who have been moving large animals such as elephants or rhinoceros. Death may be due to traumatic disruption of internal organs or to crush asphyxia. Animals such as giraffes may also injure by kicking (2). Trampling may occur in deaths related to large animals, such as camels (14). Blunt force injuries may be sustained by those handling wild dolphins or beached whales. Crush injuries may also accompany carnivore attacks, with bears, alligators, and sharks able to produce large compressive forces with their jaws. For example, certain species of sharks may produce biting forces of up to 3300 kg/cm² (15,16). Children are also susceptible to fatal crushing injuries of the cranium in dog attacks because of their small head circumferences and less robust skull bones (17).

Penetrating Injuries

Penetrating injuries involve breaching of the skin, usually by animal teeth or claws. The most widely publicized cases of fatal penetrating trauma involve dog attacks, especially when children are involved. However, nonfatal bites are much more common, with 10,339 cases of nonfatal dog bites presenting to emergency departments in Victoria, Australia, between 1998 and 2004, compared to three fatalities over the same time. Dog bites were responsible for 79.6% of all bite injuries in this study (18).

Fatalities tend to involve children, with 70% of victims being less than 10 years of age, and with the area of attack being the head, neck, and face (19–21). While debate occurs as to which are the most dangerous types or species of dogs, pit bulls, and pit bull cross-breeds have been involved in between 42 and 45% of all dog attacks. Conversely, golden retrievers are seldom reported (19,22).

Dog injuries often follow a “hole and tear” pattern, with the “hole” relating to teeth penetration of the skin followed by gripping and the “tear” produced by characteristic head shaking (22–25). Many of the dogs in fatal attacks are owned either by the family involved or by a neighbor, and most commonly are alone, although a pack mentality in groups of dogs may make it harder

for bystanders to stop an attack (26,27). In packs, dogs will tend to immobilize their prey by biting the thighs and legs to bring the victim to the ground, although this does not appear to happen as often in smaller children. The victims are then bitten repeatedly around the head and neck area, with death commonly being due to exsanguination and/or air embolism (17,28–31). The latter should be checked for at autopsy in such cases. In this regard, measurement of air in the right atrium can be performed, but the importance of finding of frothy blood has been stressed—although putrefactive accumulation of gas must be considered (32–34). Postmortem radiology with computerized tomography scanning may be used to demonstrate air embolus (35). An odontological comparison between the bite injury and the suspect animal may be used to identify the attacker (22). This may be facilitated by the use of photography and casting.

The likelihood of an attack is also related to the sex of the animal and victim, with unneutered male dogs most likely to bite, and male victims being more likely to be bitten (20,21,24,36). The disruption to collagen fibers in the skin is similar for both dog bites and high-speed bullets, indicating the considerable force that may be exerted during a dog attack (37).

The autopsy evaluation of dog and other animal attacks also requires a careful examination and necropsy of the offending animal (17). Reference should be made to local legislation in regard to requirements for the euthanasia of an animal that has caused, or is suspected of having caused, a human fatality. Examination of the animal should be considered in all cases; it may be a requirement for this to be performed by a licensed veterinary surgeon. It may also be appropriate to seek the assistance of an odontologist for assessment of bite marks. Identifying tattoos or microchips should be searched for, in addition to description and photographic documentation of collars, scars, and previous veterinary procedures. Trace evidence, such as clothing fibers, hair, or blood, may link the dog to the victim in cases where the attack was not witnessed. The stomach may also contain tissue fragments from the victim. Defleshing of the skull and jaws of the animal will enable comparison with any bite marks on the victim. Toxicological evaluation may also identify any drugs or stimulants that may have been administered to increase the dog's aggressive behavior (17).

Other domestic animals do not tend to cause fatal injuries although ferrets may cause severe facial trauma, possibly because of their attraction to milk around infants' mouths, and cats may inflict penetrating injuries of the hands with sepsis (38,39). Domestic chickens have also been known to injure humans with severe soft tissue injuries being reported in a 90-year-old woman because of a chicken attack where the birds had caused significant injuries by pecking at skin and pulling (40).

Large cats are similar to dogs in that they also target the neck region, shaking prey into submission by damaging the cervical spine. Death may also result from exsanguination (41–44). While deaths usually involve keepers in zoos, occasional reports are seen in the media of individuals who climb into large cat enclosures and suffer fatal mauling (45). These cases most likely represent suicides or involve individuals with significant psychiatric illnesses. Attacks by lions in America are rare, with around one-fifth of attacks proving fatal (46). Around one-quarter of attacks by cougars in the United States and Canada resulted in death (47,48). Bear attacks on humans are uncommon, with only approximately 10 people injured per year in the United States with one fatality. Deaths are caused by exsanguination and/or air embolism following bites to the neck. Again there may be a significant crush component to these bites depending on the size of the attacking animal (49,50). Delayed deaths can occur from infection, including rabies (48).

Bulls and buffalos, along with other horned animals, gore their victims as may sometimes be seen with matadors in Spanish bull fighting. However, deaths caused by these animals are rare with unwitnessed buffalo deaths difficult to prove because of the supposedly docile nature of the animals (5,51). In Pamplona, Spain, there is a yearly tradition of running with the bulls with 15 people having died since 1922 (52).

Both domestic and wild pigs may fatally attack humans. Wild boars incapacitate prey by repeatedly charging with their tusks causing multiple penetrating injuries, sometimes resulting in intestinal evisceration (53). Two deaths caused by domestic pigs were reported by Langley (5) where both victims sustained significant tearing and shredding injuries of the skin because of biting, with limb amputation in one case. There were also multiple fractures and extensive crush injuries. Exsanguination can result from vascular injury inflicted by the tusk of wild boar (54).

Deaths from penetrating injuries may also occur in aquatic environments during carnivore attacks. Attacks that receive the most publicity involve sharks that are usually great whites; however, there are only approximately six fatal shark attacks a year worldwide (16,55). Injuries are usually caused by rows of sharp teeth that are moved in a saw-like motion leaving deep wounds (56). In South Australia, there have been 15 deaths attributed to sharks since 1926, with two patterns of injury being identified: those with bites to the limbs who often exsanguinate after removal from the water, and those where the body is either never found or only small fragments of tissue and organs, such as the lung, are identified (16,57). When the body is recovered, study of the bite pattern may reveal the motivation behind the attack (58); comparison of serrations of bite marks to the teeth of a shark may enable the identification of the species of the attacker (59). Those most at risk of shark attack are divers and fishermen, with between 4 and 6% of deaths in Australian fisherman being attributed to sharks between 1982 and 1984. Over the same time period, 68% of deaths were caused by drowning (60).

Seals rarely attack humans although a witnessed fatal seal attack has been reported in Antarctic waters where a leopard seal attacked a 28-year-old female diver. She was attacked close to the surface before being dragged to considerable depths where she drowned, which is a characteristic pattern of seal attacks. At autopsy, there were numerous bite marks to the head where the victim had been held during the descent (61).

Stingrays have a sharp, barbed tail, and if disturbed by a swimmer close overhead, the barb may be brought upward in a defensive movement. While injuries usually involve the lower extremities, cases of fatal cardiac perforation have been reported (62,63). While such deaths involve death from rapid exsanguination, a case of a 12-year-old boy has been reported where death occurred a number of days after the injury because of venom-induced myocardial necrosis with perforation of the right ventricle resulting in lethal cardiac tamponade (64). Catfish have sharp bony stings or spines on their dorsal and pectoral fins that are used to defend against predators. While most human encounters are nonlethal, involving lacerations and envenomation, a case has been reported of chest wall penetration with death from left ventricular puncture (65).

Alligator and crocodile attacks on humans are rare occurrences with 376 reported alligator attacks in the United States from 1948 to 2006 resulting in only 15 fatalities (15). The majority of attacks occurred in the afternoon between 1200 and 1800 h, with some victims being taken from land adjacent to water's edge. Deaths result from exsanguination and drowning, with injuries showing

considerable blunt force trauma, in addition to puncture wounds from teeth (15,66).

Postmortem Issues

Pathologists working in a medical examiner system are required to determine a manner of death in all cases. The possibilities are accident, homicide, suicide, and undetermined (67). The National Association of Medical Examiners provides guidance for the determination of manner in a range of possible circumstances of death, but does not specifically address deaths related to encounters with animals. However, as classification of homicide requires death to have occurred at the hands of another person and suicide requires a self-inflicted act intended to take life, it would be anticipated that most deaths related to encounters with animals would be judged as accidental in manner.

Trauma caused by both antemortem and postmortem animal activity may be confused with inflicted injury from an assault. For example, the injury from a stingray barb may resemble that of an incised wound from a sharp weapon and so the circumstance of death must be carefully reviewed to avoid potential confusion (68).

The extent of blunt injuries sustained in certain animal attacks may also initially lead to suspicions of homicide or of some other form of impact such as a vehicle crash. This was the case in the report by Murray and Sivaloganathan (4) where a farmer had sustained severe lethal injuries from blunt trauma that included extensive soft tissue bruising, multiple fractures, and visceral injuries. After review of the circumstances and autopsy findings, it was concluded that the injuries had been caused by one of the farmer's rams. Four other similar cases were identified by the authors occurring between 1980 and 1987.

Dog attacks may leave paired incised/puncture wounds that have been mistaken for other forms of inflicted injury, sometimes with significant consequences (69,70). However, the location and pattern of injuries, with abraded margins and adjacent scratches, should readily differentiate canine bites from an attack with paired blades such as scissors.

On occasion, it may be difficult to determine whether injuries caused by animals have occurred before death or after as part of postmortem foraging (71). Domestic cats and dogs locked in homes with their dead owners may consume part or all of the deceased, particularly the soft tissues of the face and neck (72,73). In rare cases, postmortem animal injuries may raise the possibility of an assault, with genital trauma (74) suggesting ritualistic injuries or rape. Insect and rodent bites have also been confused with child abuse (75,76). Other unusual postmortem injuries may be caused by hamsters, weasels, and birds (77-79).

Conclusion

A wide range of blunt and sharp force injuries may be inflicted on humans by animals, some of which may be lethal. The autopsy evaluation may be crucial in establishing the cause of death, excluding postmortem animal predation, and to assisting in matching patterned injuries to particular animals or species. Finally, although serious injuries and deaths do result from animal attacks, it is important to place animal-related fatalities in perspective. In a report in 1999, Floyd (49) noted that in the United States the annual number of homicides was approximately 90,000, compared to one death caused by bears. The number of deaths caused by lightning and tornadoes were 374 and 150, respectively, compared to 67 fatal dog bites.

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Additional information and reprint requests:
Prof Roger W. Byard, M.D.
Discipline of Anatomy and Pathology
Level 3 Medical School North Building
The University of Adelaide
Frome Road
Adelaide 5005
Australia
E-mail: roger.byard@sa.gov.au