Case Report

Multidisciplinary analysis of bite marks in a fatal human dog attack: A case report

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ABSTRACT

Introduction: Lethal injuries by animal attacks are a matter of concern for the forensic pathologist; the presented case illustrates a two dogs attack on a 61-year-old man. The authors have focused on a multidisciplinary approach involving forensic pathologists and veterinarians.
Materials and Methods: The victim was cycling in the countryside when he was attacked by two dogs that came out of a large house. He was found lying in the street by the homeowners who called for help. The victim was transported to the hospital where he died five days later. According to recovery data and medico-legal autopsy findings the cause of death was septic shock.
Results: Forensic pathologists and veterinarians multidisciplinary evaluation revealed lacerations, abrasions, and multiple small punctures constituting bite marks over the entire body. Six skin dowels with bite marks were taken and compared with the dental cast of the dogs.
Conclusion: A comparison of the dog dental casts and the bite marks on the victim's body allowed the identification of the animals involved in the attack.

1. Introduction

1.1. Dogs and humans

Considered "man's best friend" the common domestic dog *(Canis lupus familiaris)* belongs to the *Canidae* family [1]. Recent findings have demonstrated that dogs are the result of domestication of the Eurasian wolf *(Canis lupus lupus)* more than 100,000 years ago [2]. At present, more than 400 breeds share people's homes and serve many purposes such as: hunter, guardian, shepherd, or simply companion.

However, dog bites are still a major health problem in our modern world, as their incidence is estimated to be around 1.5% of the population [3].

J. A. Oxley & al. posit that the typical context of a dog bite is related to interacting or attempting to interact with the animal (caressing or playing); nevertheless, in almost half of the cases, the dog approached the victim. In 83% of cases, the dog was not known to have bitten someone before [4].

Of course, dogs may be responsible for deaths. Even if victims may be of any age, the most vulnerable are old people and children [5]. In fatal dog attacks, no specific bite location is noticeable [6]. For non-fatal attacks some authors have subdivided injury sites by anatomic regions: in adults involvement of the arm/hand was 45.3%, the leg/ foot 25.8%, and head/neck 22.8%; while the majority (64.9%) of injuries in children were on the head/neck [7].

In the US, pit bull-type dogs, rottweilers, and german shepherds constitute the main dog breeds implicated in these fatalities. Seventy percent of fatalities are committed by a young dog within the owner's yard or its proximity. Aggressiveness in pit bulls is thought to be a genetically engrained behavioural trait. This, coupled with the fact that these dogs are often trained for fighting or protection of their owners, makes pit bulls one of the breeds predominantly involved in attacks on humans. The male, non-neutered pit bull can be very aggressive [8].

1.2. Dog bite

A bite is defined as any break in the skin caused by an animal's teeth, regardless the purpose [3]. Measuring the force of a dog bite is complicated due to the shape of the mouth and the different chewing action of each tooth. However, many studies assert that it is between 13 and 1394 N depending on the dog breed [9].

Three different patterns of dog bite have been observed:

1. post-mortem lacerations of the victim's body;
2. non-fatal dog bite wounds;
3. severe or life-threatening dog bites that directly or indirectly (through infection and sepsis) lead to the victim's death.

A dog's mouth is not sterile. Floyd E. Dewhirst et al. confirmed that the canine oral microbiome is widely divergent from that of a human, including for example *Acinetobacteria*, *Spirochaetes*, *Clostridia* and *Bacilli* [10]. *Capnocytophaga canimorsus* is a gram-negative, constituting normal oral flora in 24% of dogs and 17% of cats. It is also considered to be an etiological factor in infections in humans (such as bacteremia, endocarditis and meningitis) and may lead to sepsis [11].

2. Materials and methods

2.1. Case history

A 61-year-old man was attacked by a couple of dogs while cycling in the countryside in southern Italy. The victim, badly injured, was found lying in the street by nearby homeowners who called for help. There were no eyewitnesses to the attack. However, people who arrived to give first aid to the victim reported seeing two pitbulls a few meters from the site of the attack. Despite the intensive care and surgical approach to the wounds, the man subsequently developed fever, severe hypotension, tachycardia, and acidosis. Blood analysis revealed leukocytosis (10,35 $\times 10^3$/uL), thrombocytopenia (15 $\times 10^3$/μL), elevated value for C-reactive protein (173 mg/l), and lactate (6,6 mmol/L). The man died five days later. The bites did not pierce any vital organs. According to clinical features, blood analyses, and autopsy findings the cause of death was septic shock.

2.2. Autopsy

The victim was 164 cm tall and weighed 75 kg. The external examination of the body revealed ubiquitous lacerations, abrasions, and multiple small puncture wounds, most of them exposing the tissues below. Many of these lesions had a purulent appearance [Fig. 1].

Before starting the dissection, six skin dowels with bite marks were withdrawn to be compared with the dental cast of the two dogs [Fig. 2]. The authors chose to collect the bite marks with shallow injuries. In order to preserve the shape of the dental arch, firstly the bite marks were measured. Afterwards, they were withdrawn within skin dowels, which dimension exceeded of some centimeters the area of the lesions guaranteeing appropriate edges of intact skin. These dowels were fixed in 10% neutral buffered formalin and stored in a cool and dry place.

At autopsy, no alterations in abdominal or thoracic organs were observed. The lacerations in the right arm and forearm showed loss of cutaneous and muscular tissue and widespread necrotic areas on the remaining muscle fibers with huge phlogistic infiltration, confirmed by histological analysis. According to medical records and medico-legal autopsy findings the cause of death was septic shock, even if no specific bacterial strain was identified.

3. Results

The authors took six skin dowels from the body and compared them with the dental casts of the animals suspected of the attack. The cooperation between forensic pathologists and veterinarians allowed the identification of the two pitbulls involved in the attack. One dog had a wider canine distance and one missing tooth, so it was possible to discern the bites of one animal from the other. Then, the three dimensional comparison confirmed the identification.

4. Discussion

4.1. Bite mark identification

Due to the lack of direct witnesses, the task of the forensic pathologists was to identify which dogs had been involved in the attack. Two dogs were seen near the victim just a few moments after the attack, but their owners dismissed any accusation. A technical evaluation, involving collaboration between forensic pathologists and veterinarians, was necessary to clarify the details of the attack. Indeed, Italian law establishes the responsibility for any dog aggression lies with its owner, whereas for strays, the responsibility falls to the local major (*ex Art. 2052 cc*).

To match bite marks with dental casts, it is useful to examine the bite marks preserving the shape of the dental arch. In our case, six skin dowels with shallow, clear and preserved bite marks were collected, guaranteeing the marks to be surrounded by several centimeters of intact skin, to compare them with the dog's dental characteristics, which are individual.

Dental casts can be taken in order to examine the dog's dentition. The process of making them is similar to the one normally employed for humans. The huge difference between human and dog casting is that the animal needs to be sedated to obtain motionlessness casts. After a pre-anesthetic examination, the dog patients received an intramuscular

Fig. 1. Victim's body.

Fig. 2. Skin dowels.

combination of butorphanol (0.2 mg/kg; Dolorex 1%, Intervet, Milan, Italy) and dexmedetomidine (5 µg/kg, Medesedan 1%, Virbac, Milan, Italy). Once an adequate level of sedation had been achieved, the dogs were approached. The casting process is designed to provide a plaster of the tooth structure. The first step is to impress both dental arches on a dental impression tray loaded with alginate, then fill the negative teeth's imprint with a plaster paste [12].

Dental impression tray, alginate, and plaster paste are purchasable by common retailers of odontologist tools [Fig. 3].

The authors relied on three steps of investigation to identify the dogs involved in the aggression:

1. CANINE DISTANCE - Dogs have their own modification of carnivore dental pattern: each jaw also has one pair of elongated canines, which interlock when the jaw is closed. By measuring the distance between the canine for each jaw, it is possible to exclude animals certainly not involved in the aggression before getting the dental casts. Normally, this operation does not require sedating the dog. In order to guarantee the operator's safety, it is sufficient to tie the muzzle, as just a few centimeters of jaw opening is enough to take the measurement [Fig. 4].
2. DENTAL FORMULA – Every dog may have peculiar dental features as missing or fractured teeth, supplementary or abnormal teeth, and so on. Once incompatible dogs have been excluded through the measurement of canine distance, the second level of screening can be obtained by observing the dental formula and comparing it with the skin dowels. For this kind of analysis, a dental cast is required.
3. WHOLE DENTAL ARCH THREE DIMENSIONAL COMPARISON – This technique consists of trying to match the whole dental cast with the bite marks on the skin dowels. As a static juxtaposition of the dental arch and skin dowels might neglect the three-dimensionality of the body, a dynamic comparison between dental cast and skin wounds is fundamental in order to consider the curves of the skin surface. This step reaches the highest level of sensibility and specificity in bite mark analysis [Fig. 5].

4.2. Issues

There are not any official guidelines for animal bite identification, and only a few examples are described in the literature. For this reason, the cooperation between forensic pathologist and veterinarians with experience in bite identification was necessary.

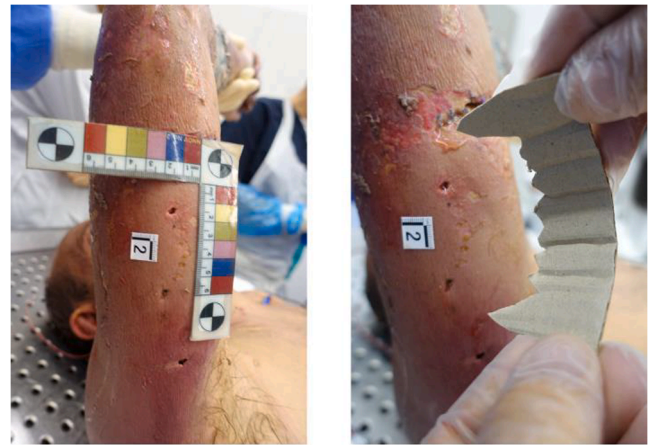

Fig. 3. Dental impression tray and alginate.

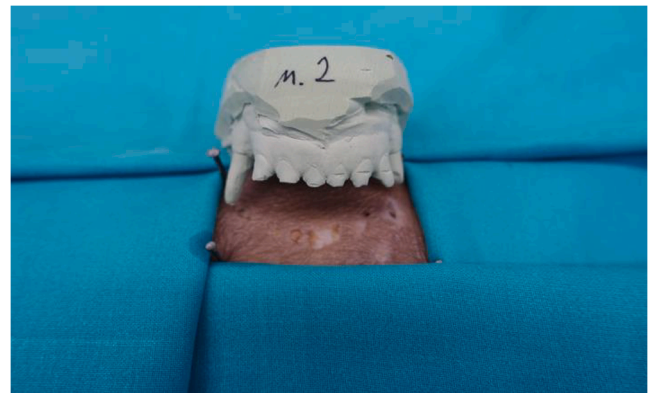**Fig. 4.** Example of canine distance measurement.

Fig. 5. Whole dental arch three dimensional comparision.

However, the bite impression may be subjected to a certain inaccuracy depending on small deformations of the impression panel. Also, the filler may be subject to modification during solidification and afterwards. Moreover, there are modifications of postmortem tissues, particularly due to dehydration, loss of muscle tone, and freezing. Furthermore, the casting process, the withdrawal of the skin dowels, and the comparison between cast and bite marks may be uncertain due to human error.

Although a higher quality of materials for the filler and impression panel may make the casts more stable, such materials are more expensive and solve neither the problem of the tissue modification nor the possibility of human error. The best way to prevent alterations of the casts is to store them far from any physical or chemical stress, such as heat, cold or humidity.

The forensic investigation aimed to identify with certainty if both dogs were involved in the attack. Although a dog's dentition is unique, the sole comparison between the bite marks and dental casts is not sufficient to identify the animal involved with certainty, therefore, this method can only produce results that have to be examined along with the circumstantial data.

4.3. Alternative methods

As suggested by A. van der Velden & al. the usual way to identify bite marks is by matching their photographs with the dental casts of the "suspect" [13].

Xerography is a significantly more accurate method. It is performed by making a life-size photocopy of the study casts, subsequently the teeth edge outlines are hand-traced onto a transparent sheet to make an

overlay and that is then compared to the bite marks. In order to overcome any subjectivity, it is possible to make a computer-assisted overlay generation by using image-processing software and thereby make a virtual comparison with a picture of the bite marks [14].

All these methods are still based on the comparison between dental casts and bite marks, so some degree of inaccuracy is unavoidable due to skin modification of the marks. For this reason, some authors suggest alternative approaches based on genetic analysis.

One of these techniques relies on profiling the dog's DNA extracted from salivary traces found in the wounds. A major issue in this case is that saliva samples needed to be taken immediately, as DNA can easily be destroyed by washing or medicating the wounds. A novel approach consists of identifying the victim's DNA from canine buccal swabs. Experimental applications of this technique have shown encouraging results [15].

5. Conclusion

Forensic odonto-stomatologic studies allow for the identification of bite marks through the individuality of human dentition. These analyses are useful in violent crimes, specifically those involving sexual abuse. Despite this, animal bites are rarely the object of bite mark analysis.

This case report discusses a multiple dog attack on a man in southern Italy. The authors focused particularly on the multidisciplinary approach between forensic pathologists and veterinarians.

The cause of death was given as septic shock and it was not possible to identify the fatal bite, because almost every wound was contaminated by the dog's oral microbioma and showed a purulent appearance.

As there is not any official protocol for dog bite analysis and identification in criminal investigation, the identification of the animals involved in the attack was carried out through the comparison between the dental casts of the "suspected" dogs and the bite marks on the victim's body.

Even though this kind of bite mark analysis may not identify with absolute certainty the dog involved in the attack, it may be considered one of the most accurate and easily applicable methods to achieve this aim.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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