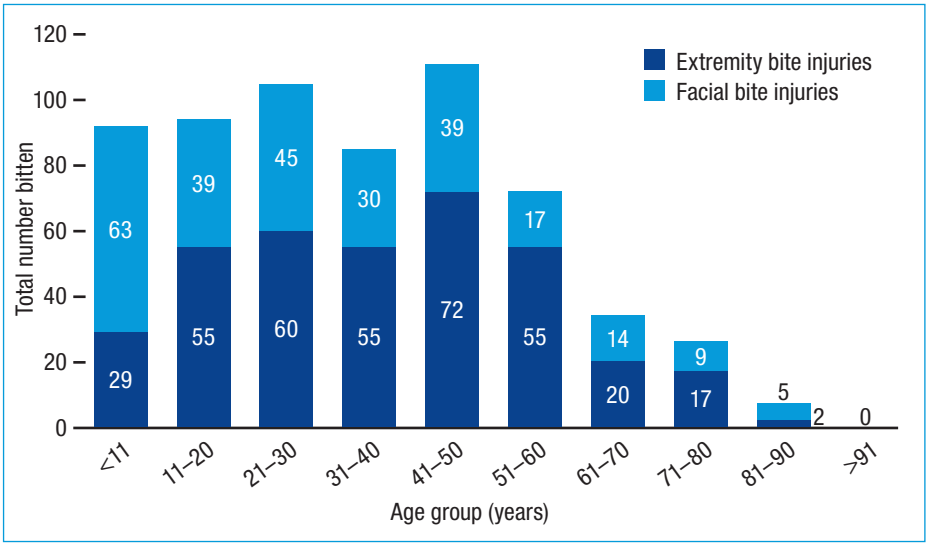
Dog bite injuries in hospital practice

Dog bite injuries are a common presentation to hospitals in the UK with patients attending through the accident and emergency department, or having initially been seen by their GP (*Figure 1*).

Most recent information indicates that there were 7227 hospital admissions from March 2014 to February 2015, an increase of 6.5% from the previous 12 months (Health and Social Care Information Centre, 2015). Over the last 10 years the number of admissions as a result of dog bite injuries has soared by a staggering 76% (Health and Social Care Information Centre, 2015). Under-reporting and poor documentation of these injuries is problematic in addressing the causes of bite injuries (Mannion et al, 2014).

Although it is difficult to fully estimate the cost to the NHS, this is suggested to be around £9 million per year (House of Commons, 2013). However, the personal, physical and psychological effects that follow a patient's experience of a dog attack are frequently forgotten among these statistics. These injuries can present a complex treatment challenge.

Figure 1. Total number of dog bite or strike injuries in a tertiary hospital in Yorkshire in a 1-year period (Mannion and Mills, 2013).



Who gets bitten?

Although anyone can be bitten by any breed of dog, there are a disproportionate number of head and facial bite wounds in young children (<10 years old). Adults more frequently sustain injuries to the limbs, most commonly the upper limb, with the wrist and hand being the most frequently bitten.

This disproportionate number of bites in young children, especially boys (Avner and Baker, 1991), more frequently and to the face, is more complex than just simple proximity to the animal's mouth. Young children often interact in a playful yet provocative manner with dogs such as petting, rough play and forceful hugging. They may be loud around the animal increasing the dog's awareness of them, but unaware of specific visual cues that can indicate the dog is becoming increasingly aroused and about to bite. Unpublished research from Racca et al (2013) showed that young children can incorrectly interpret a growling 'angry' dog as smiling. When they are attacked, children are physically less able to defend themselves.

Injuries in adults often reflect a different intent of the attacking animal, e.g. retaliation or extreme aggression, and may be inflicted when the owner tries to intervene in a dog fight. Nygaard and Dahlin (2011) found that half of all injuries to the hand were inflicted while separating two fighting dogs. Certain professions, e.g. veterinary surgeons or postal workers, are more prone to bite injuries. The use of letter pegs (devices used to deliver letters and cards through letter boxes without risking fingers) has decreased the risk of finger and hand bites while delivering the mail.

The spectrum of wounds presenting to the hospital doctor ranges from superficial punctures of the skin to serious life- and limb-threatening injuries.

Presentation and patterns of referral

Patients with dog bite injuries may present in the immediate period after the dog bite incident (frequently within 6 hours) (Foster and Hudson, 2015), or sometime after this period when the concern is with a previously untreated but now infected bite wound.

Some wounds may be simply treated and followed up by accident and emergency staff, whereas others require referral for specialist management.

In the UK referrals for complicated head, neck and facial injuries are commonly seen by maxillofacial, plastic surgery and ophthalmology specialties. Hand or limb injuries are commonly referred to plastic surgery and orthopaedic services. Vascular and paediatric surgery specialists may also be consulted with bite injury patients.

Assessment of dog bite injuries

Assessing the patient who has been bitten by a dog requires a calm and structured approach. A clear and concise history must be obtained, together with a thorough examination of the wounds.

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All major injuries resulting from dog bites should be treated in accordance with Advanced Trauma Life Support guidelines. A primary survey should start with control of the airway and the cervical spine being protected. This is especially important for young children who may have been shaken and thrown and where considerable damage to both hard and soft tissues has occurred. Identifying and dealing with life-threatening injuries can be life-saving, especially those where horrific injuries result from a severe dog bite 'mauling', or where more than one dog has been involved in the attack.

Key areas for history taking and documentation should include:

- Where, when and how did the bite occur?
- Where a child is involved, was supervision present at the time?
- Relevant medical history
- Tetanus status of the patient (rabies consideration where appropriate)
- Document the location, appearance and any damage to underlying structures
- Are there any clinical signs of infection or pus present?

Predisposing medical factors should be borne in mind regarding wound management. For example, the diabetic patient is at increased risk of wound infection. A history of alcohol dependence can affect wound healing and increases the risk of *Pasteurella* infection (Dire et al, 1994). Chronic liver or lung disease, asplenia and immunosuppressive states (patients with HIV or AIDS, or taking chemotherapy) can reduce the patient's capacity to heal optimally, and lead to an increased risk of infection especially from *Capnocytophaga*, a commensal bacteria normally found in canine saliva (Hloch et al, 2014). Consideration should also be given to current medications taken, the nutritional state and the age of the patient.

The timing of the injury to the time of presentation is also vital. Delay in presentation and treatment is a significant risk factor for a resulting wound infection (Maimaris and Quinton, 1988). A specific and detailed wound assessment should be documented, as this may be required in medicolegal cases.

More simple wounds may consist of a simple abrasion or superficial penetration of the skin layer. Puncture of the skin and exposure of subcutaneous tissues is of greater concern and usually requires more involved treatment. Damage to muscle, vessels, nerves, bone or joints must be excluded. When penetration of bony structures and crush injuries are suspected, radiological examination should be undertaken, e.g. scalp lacerations, which in a young child may penetrate the underlying bony cranium (Steen et al, 2015).

The Lackmann classification (Lackmann et al, 1992) of bite wound injury is useful for communication, audit and research (*Table 1*).

Treatment

A typical dog bite consists of a combination of puncture wounds with adjacent tearing of tissue – 'hole and tear' effect. Some degree of crush injury is also common. These puncture wounds are at a higher risk of infection, as they may harbour microorganisms deep within the wound, and the narrow entry point makes thorough cleaning difficult.

For patients with bite wounds presenting to hospital soon after injury, irrigation of the wound with saline, together with removal of any foreign bodies such as tooth fragments, should be undertaken. This is frequently irrigation with a 20 ml syringe and 19-gauge needle using 150–250 ml of saline, and debridement of any non-vital tissue as needed (Stefanopoulos and Tarantzopoulou, 2005). These measures help reduce the risk of subsequent infection (Gomes et al, 2000).

Judicious use of local anaesthetic should be administered through uninvolved adjacent skin and away from the damaged tissue, as this will allow adequate wound cleaning and debridement. The tetanus immunization status of the patient should also be addressed at this stage, together with rabies consideration where appropriate (Morgan and Palmer, 2007).

Minor bite wounds can often be managed in the accident and emergency department,

Table 1. Lackmann classification of injury

Classification	Definition
Type I	Superficial lesion without muscle involvement
Type II	Deep lesion with muscle involvement
Type III	Deep lesion with muscle involvement and tissue defect
Type IVa	Type III combined with vascular damage or nerve lesions
Type IVb	Type III combined with bone damage or organ involvement

and low risk wounds (<6 hours old with no risk factors for infection), e.g. simple lacerations and abrasions, can be managed with primary repair (Kountakis et al, 1998).

There is no statistically significant increase in the wound infection rate when low risk dog bites are closed primarily after adequate washout and debridement (Evgeniou et al, 2013). However, this is not appropriate in all cases and special care should be given to high-risk wounds:

- Wounds to the arms, hands and feet
- Delay in seeking treatment >24 hours
- Puncture wounds
- Full-thickness wounds
- Extensive crush injuries or devitalized tissue
- Associated patient factors (such as comorbidities and age).

In wounds that are clinically infected, microbiological culture and sensitivity is required to guide relevant antibiotic therapy, and will need irrigation, debridement and to be left open for 24–48 hours before a second-look procedure (Morgan and Palmer, 2007).

Facial bite injuries are a major cosmetic concern, so non-infected cases can be closed primarily, after debridement and washout. Head and neck wounds carry a relatively lower risk of infection because of the rich vascularity of the face and scalp (Skurka et al, 1986).

Treatment of dog bite wounds to the face was the subject of a prospective randomized trial by Rui-feng et al (2013) – 600 dog bite wounds were randomized into two treatment groups, immediate primary closure or left open to heal secondarily. All wounds were cleansed and debrided. There was no significant difference in infection rates or duration of infection between the two groups.

Complex wounds of the head and neck frequently require exploration under general anaesthesia to exclude damage to major structures such as the vasculature, motor nerves to the facial muscles or the airway. Extensive tissue loss can be especially challenging for the surgeon in this situation. These injuries may require multistage procedures, for example those involving significant soft tissue loss such as avulsion injuries, which should be attempted secondarily after adequate wound care.

Primary closure of dog bite injuries on the limbs and hands is seldom recommended. Dog bite injuries to the hand have a higher incidence of infection, compared to wounds in the head and neck, when closed primarily.

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An infection rate of 25% after primary suture has been shown, so is seldom recommended (Aigner et al, 1996). Thus special care should be given to these high risk wounds.

High risk wounds on the extremities should not be closed primarily, but left unsutured (with the limb raised and immobilized) with initial irrigation and debridement for 24–48 hours before a second-look procedure. Only when considered clean and free of infection should closure be arranged, if appropriate (Moore, 1997; Morgan and Palmer, 2007).

Severe bite injuries almost certainly require second-look surgery 24–48 hours after initial radical debridement, to exclude residual dead tissue or an area of infective focus (Rosen, 1985; Maimaris and Quinton, 1988). If inadequately debrided and cleaned, infection could lead to loss of function.

Complex limb and hand injuries frequently involve fractures, tendon and nerve injuries. Multiple wound washes and debridement are required in cases where infection is evident before complex structures are repaired. Possible complications from injuries to the limbs are neurovascular damage, fractures of the bones, infection of hard and soft tissues leading to tenosynovitis, septic arthritis and osteomyelitis.

Repair of these injuries should be managed as any open or contaminated injury. With bony injuries and fractures, permanent fixation should be carried out at a secondary stage after the initial wound washout and after further inspections. A similar approach is taken for the repair of tendon and nerves injuries. When there is evidence of joint involvement or clinical evidence of septic arthritis, arthrotomy and copious joint washout is required (Benson et al, 2006).

Postoperative immobilization of the hand in a plaster splint for up to 72 hours is recommended followed by aggressive physiotherapy when appropriate (Mitnovetski and Kimble, 2004).

Delayed presentation

Time from injury to presentation should be considered. Some advocate managing a wound several hours old differently to one presenting immediately following injury, as an older wound would have had time to become colonized with pathogenic bacteria and would be at greater risk of subsequent infection. There is no unifying evidence to support any particular time period. However, Brakenbury and Muwanga (1989) found benefit in the use of prophylactic co-amoxiclav for simple wounds treated between 9 and 24 hours after injury, but no significant benefit from using antibiotics on wounds treated within 9 hours of injury.

Complications

Following initial treatment, the most common complication of a dog bite injury is infection (*Table 2*). A wound inflicted by the teeth of an animal is more likely to become infected than a simple soft tissue injury caused by other means (Callaham, 1978).

Reported infection rates for dog bite wounds are between 1% and 30% (Callaham, 1978; Brakenbury and Muwanga, 1989; Capellan and Hollander, 2003). However, most studies suggest that the true infection rate lies at the lower end of that scale, in the region of 2% (Quinn et al, 2010). The lowest risk of wound infection is found in facial injury in children (Boenning et al, 1983).

Wounds that present early already with clinical signs of infection are likely to be caused by *Pasteurella* spp. A short latency period from the time of the bite to clinical signs of infection has been seen in cases where *Pasteurella* was isolated (Talan et al, 1999; Morgan and Palmer, 2007), which is characterized by an early onset of local intense cellulitis, purulent discharge and lymphangitis, usually in the first 12–24 hours after the injury (Morgan and Palmer, 2007).

Traditionally deep, piercing or puncture wounds are thought more likely to develop infection. Wounds that by their size and shape make thorough debridement difficult might be expected to become infected more readily.

A prospective survey of 769 dog bite wounds found wound depth, patient gender, and wound debridement were the clinical variables that best predicted the likelihood of developing infection (Dire et al, 1994). However, a retrospective cohort study of 431 adult patients with dog bite injuries found no correlation between depth of injury and presentation secondarily with infectious complications (Pfortmueller et al, 2013).

Table 2. Factors to consider when assessing infection risk

Patient factors
Immunocompromised patients
Pregnancy
Diabetes
Extremes of age

Antimicrobials in dog bite injury

The use of antibiotics in dog bite injury can be considered in two parts. A clinically infected wound naturally requires local treatment to the site of injury and appropriate systemic antibiotics.

Clinically, infection can be assumed when purulence, cellulitis or abscess formation are seen. Antibiotic therapy in clinically infected dog bite wounds should be selected to cover the most likely causative organisms until specific microbiology culture and sensitivity are available.

Co-amoxiclav should be the antibiotic of choice for the empirical management of infected animal bites (Skurka et al, 1986; Dire et al, 1994).

Infection in dog bite wounds tends to result from polymicrobial contamination. Talan et al (1999) found up to 16 different bacterial isolates in purulent wounds resulting from dog bites. The most commonly identified bacteria were *Pasteurella*, streptococci, staphylococci and anaerobes. Similar numbers of wounds grew mixed (aerobic and anaerobic bacteria) isolates or aerobic isolates alone (48% and 42% respectively). Antibiotic treatment of clinically infected wounds should cover both aerobic and anaerobic pathogens until specific microbiology results prove otherwise.

Talan et al (1999) recommend empirical treatment involving a number of combinations. Amoxicillin with clavulanic acid (co-amoxiclav) is recommended for prophylaxis and empirical treatment (Skurka et al, 1986; Talan et al, 1999). Ceftriaxone, a cephalosporin, has been suggested as an alternative in penicillin-allergic patients as it has some anaerobic activity, in combination with metronidazole to broaden anaerobic coverage (Mitnovetski and Kimble, 2004).

Doxycycline (or oxytetracycline) combined with metronidazole is recommended in penicillin-allergic patients (National Institute for Health and Care Excellence, 2015) as:

- Doxycycline and oxytetracycline have good activity against *Pasteurella* spp. (the most common pathogen), staphylococci and streptococci (Talan et al, 1999; Smith et al, 2003)
- Metronidazole is active against beta-lactamase-producing anaerobes.

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KEY POINTS

- Dog bites are an increasing problem, often presenting to hospital for further management.
- A thorough history and clinical examination is critical.
- Certain dog bite wounds can be considered high risk for infection.
- Wounds that present early with clinical signs of infection are likely to be caused by *Pasteurella* spp.

Ciprofloxacin and clindamycin in combination have been suggested should there be concern over the use of cephalosporins in the penicillin-allergic patient (Morgan and Palmer, 2007).

Erythromycin or flucloxacillin should never be used alone to treat bite wounds – more than 80% of *P. multocida* are resistant, and serious clinical failures including meningitis have been documented following erythromycin treatment (Morgan and Palmer, 2007).

Expert microbiological advice should be considered in the young (<12 years), and in cases of severe and established infections.

Prophylaxis

Antibiotic prophylaxis in dog bite wounds has been the subject of a number of analyses and reviews (Brakenbury and Muwanga, 1989; Cummings, 1994; Medeiros and Saconato, 2001). There is no consensus on the routine use of prophylactic antibiotics in low risk wounds, and Dire et al (1992) showed no statistically significant difference in the incidence of infection with the use of prophylactic antibiotics in low risk dog bite injuries.

Individuals are deemed high risk as a result of a combination of both patient and wound factors. Systemic antibiotics are recommended for a dog bite wound that is not obviously infected but deemed as high risk. However, routine antibiotic prophylaxis in dog bite injury remains controversial.

Duration of prophylactic antimicrobial treatment should be tailored to the individual case. Most published papers recommend a short course of 7 days for clinically uninfected uncomplicated wounds (Morgan and Palmer, 2007; Evgeniou et al, 2013; National Institute for Health and Care Excellence, 2015).

Prophylactic antibiotics are not an alternative to thorough cleansing and debridement. Co-amoxiclav covers the penicillin-resistant *S. aureus* and anaerobes and *P. multocida* (Holm and Tarnvik, 2000).

In patients allergic to penicillin, those combinations previously discussed should be considered (National Institute for Health and Care Excellence, 2015).

Follow up

Dog bite injuries treated in hospital require follow up, the timing of which depends on the size, site and infection risk of the wound. Wounds left open to heal by secondary intent will require earlier review. Where secondary reconstruction for cosmesis is anticipated, review several months later may be required. **BJHM**

Conflict of interest: none.

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