







Age group analysis of patients with dog bite injuries who visited a single regional emergency medical center and factors affecting wound infections

Dong Ho Kang, MD¹ , Jea Yeon Choi, MD¹ , Woo Sung Choi, MD, PhD¹ , Jae Ho Jang, MD¹ , Jin-Seong Cho, MD, PhD¹ ,
Sung Youl Hyun, MD, PhD² 

¹Department of Emergency Medicine, Gachon University Gil Medical Center, Gachon University College of Medicine, Incheon, Korea

²Department of Traumatology, Gachon University Gil Medical Center, Gachon University College of Medicine, Incheon, Korea

Purpose: The aim of this study was to analyze by age group the characteristics of patients with dog bite injuries, as well as determine which factors were associated with wound infections in those patients.

Methods: We reviewed patients with dog bite injuries who presented to Gachon University Gil Medical Center in Incheon, Korea from January 1, 2014 to December 31, 2018. They were classified by age group: children (0–18 years), adults (19–59 years), or elderly (≥60 years). Event profiles, wound characteristics, and infections were compared across these age groups. Multivariable logistic regression was used to identify factors associated with wound infections.

Results: Of the total 972 dog bite injuries, 272 (28.0%) were in children, 606 (62.3%) were in adults, and 94 (9.7%) were in the elderly. The median age was 30 years (interquartile range, 16–48 years) and the majority of patients (60.5%) were female. The most common place of injury was at home (73.8%) and indoors (77.0%). In children, the head and neck were the most frequent sites of injury (43%), while the most frequent site in adults and the elderly (50.8% and 59.6%, respectively) was the upper extremity. The odds ratio (OR) for wound infection was 3.997 (95% confidence interval [CI], 1.279–12.491; $P=0.017$) for head and neck injuries and 3.881 (95% CI, 1.488–10.122; $P=0.006$) for lower extremity injuries. The OR for wound infection was 4.769 (95% CI, 2.167–10.494; $P<0.001$) for significant injuries. Elderly patients had a higher risk for wound infection than other age groups (OR, 2.586; 95% CI, 1.221–5.475; $P=0.013$).

Conclusions: When analyzing patients with dog bite injuries, differences across age groups were found, with the elderly at the highest risk for significant injury and wound infection. It is recommended that age-specific approaches and strategies be used to prevent dog bite wound infections.

Keywords: Wounds and injuries; Infections; Age groups; Bites and stings; Dogs

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Correspondence to

Jea Yeon Choi, MD
Department of Emergency Medicine,
Gachon University Gil Medical Center,
Gachon University College of Medicine,
21 Namdong-daero 774beon-gil,
Namdong-gu, Incheon 21565, Korea
Tel: +82-32-460-3901
E-mail: chjy14664@gilhospital.com

INTRODUCTION

The number of households with pets has been increasing yearly, with an estimated 63 million dogs raised as pets in the United States [1] and approximately 5 million dogs and 2 million cats raised as pets in Korea [2]. With increased animal contact, the incidence of animal bite injuries and resulting medical expenditures are on the rise, becoming an important public health issue [3,4]. Animal bite injuries account for 1% of patients treated in the emergency department (ED) in the United States; in Korea, approximately 1 million cases of animal bite injuries occur annually [3].

Many types of injuries can result from dog bites, including lacerations and fractures, and dog bites there require varied types of treatment, from simple wound dressings to suturing and/or surgery. Moreover, a dog's oral secretions contain many types of bacteria [5], contributing to a high risk for bite wound infection. To prevent infections, appropriate post-bite wound care is important, and studies of the injury mechanism, wound features, treatment, and preventive measures are crucial. Several studies of animal bites, including dog bites, have been conducted [6–9]. However, in Korea most studies had a small sample size and studies of treatment or prognosis were lacking [10–12]. Therefore, this study compared by age group the characteristics and treatments for dog bite injuries among patients who presented to a single regional emergency medical center, and analyzed the risk factors for wound infection.

METHODS

Ethical statements

This study was approved by the Institutional Review Board of Gachon University Gil Medical Center (No. GCIRB2021-098). Informed consent was waived due to the retrospective nature of the study.

Study design and population

This retrospective study analyzed patients who presented with a dog bite to Gachon University Gil Medical Center, a single regional emergency medical center in Incheon, Korea, from January 1, 2014 to December 31, 2018. The participants were patients whose injury mechanism was a dog bite. Data were obtained from the hospital's ED-based Injury In-depth Surveillance (EDIIS) registry. The injury narratives recorded in the EDIIS were checked to exclude patients who were bitten by different animals or persons, as well as patients who had injuries

from a dog other than a bite.

Data collection and variables

The study data was collected from the EDIIS registry and patients' medical records. The EDIIS was established by the Korea Disease Control and Prevention Agency (KDCA) in 2006. The number of participating hospitals in this surveillance has increased from five to 23 hospitals nationwide. A trained coordinator at each hospital registers the data for 246 variables in the KDCA online system, including patient demographics, injury-related profiles, prehospital records, diagnosis, disposition, and outcomes. The KDCA manages the quality of the input data through periodic error analyses.

From the EDIIS registry, information was collected about the patients, including age, sex, mode of transportation to the ED, time and place of injury, dog owner, site of injury, surgery, and ED disposition. In addition, information about wound characteristics, treatments, and infections was collected from the medical records.

Patients were divided into three groups for analysis: children (0–18 years), adults (19–59 years), and the elderly (≥ 60 years). The season of injury was divided into four categories: spring (March–May), summer (June–August), fall (September–November), and winter (December–February). The time of injury was classified as day (08:00–16:00), evening (16:00–24:00), or night (00:00–08:00). The place of injury (place 1) was classified as home, road, commercial facility, public cultural facility, or other; and additionally into indoors or outdoors (place 2). Dog owner categories were divided by relationship into household/relative, neighbor/friend, stranger, or unknown. The anatomical sites of injury were divided into head and neck, torso, upper extremity, or lower extremity. Injuries at two or more sites were considered multiple sites.

Wound characteristics were categorized as superficial, open, muscle or tendon injuries, fracture, or amputation. Methods of wound treatment were divided into primary suturing, delayed suturing, local wound care, and unknown. A significant injury was defined as a dog bite injury that led to death, hospitalization, or surgery or caused a muscle/tendon injury, fracture, or amputation [11]. Wound infection was defined as the presence of systemic fever, local abscess, or lymphangitis. Further evidence of wound infection included erythema, swelling, increased temperature/tenderness, or drainage from the wound [13].

Statistical analysis

Statistical analysis was conducted using IBM SPSS ver. 23.0 (IBM

Corp., Armonk, NY, USA). To compare the characteristics among age groups, categorical data were analyzed using the chi-square test or the Fisher exact test, and continuous variables were analyzed using the ANOVA or Kruskal-Wallis H test, depending on the normality of the data. The predictors of significant injury and wound infection were identified using multivariate logistic regression at $P < 0.01$, by including clinically significant factors in the analysis. To identify the factors associated with significant injury, multivariate logistic regression was performed with the inclusion of age group, sex, mode of transportation to the ED, time of injury, dog owner familiarity, place 2, and bite site as variables. The factors associated with wound infection were analyzed with the inclusion of age group, sex, mode of transportation to the ED, time of injury, dog owner familiarity, place 2, bite site, primary suture, and significance of the injury as variables. Statistical significance was set at $P < 0.05$.

RESULTS

General characteristics

During the study period, 975 patients presented to the ED with a dog bite injury. After excluding two patients with a human bite and one patient with a cat bite, a total of 972 patients were analyzed. By age group, there were 272 children (28.0%), 606 adults (62.3%), and 94 elderly (9.7%). The median age was 30 years (interquartile range, 16–48 years), with most patients aged 20 to 29 years (Fig. 1). Overall, there were more female patients (60.5%), and the category of children had the lowest percentage of male

patients (48.2%) (Table 1).

The elderly most frequently arrived at the ED via a public ambulance (17.0%). The most common place of injury in all age groups was at home, followed by roads, with 77% of the injuries occurring indoors. The incidence of outdoor injuries increased with age and was significantly higher among the elderly than among other age groups (36.4%; $P = 0.003$). In terms of ownership, 620 patients (63.8%) were bitten by a dog they owned themselves or that their family owned. There were no significant differences in the season of injury among the age groups ($P = 0.062$). The injuries most commonly occurred in the evening in all age groups (58.2%), followed by day and night, respectively. The most common anatomical site of injury in children was the head and neck region, while the upper extremity was most common among the elderly. These differences were statistically significant ($P < 0.001$ and $P < 0.001$, respectively). Twenty-five patients had multiple injuries, most of whom were adults ($n = 14$, 2.3%).

Wound characteristics and treatments

Superficial injuries were most common in children, while open wounds were most common in the elderly; however, there were no statistically significant differences. The incidence of muscle or tendon injuries (10.6%, $P = 0.004$) and fractures (4.2%, $P = 0.001$) was highest in the elderly (Table 2). After ED treatment, 938 patients (96.5%) were discharged and 23 (2.4%) were admitted to the general ward. One patient was admitted to the intensive care unit due to loss of consciousness related to drinking. There were no deaths.

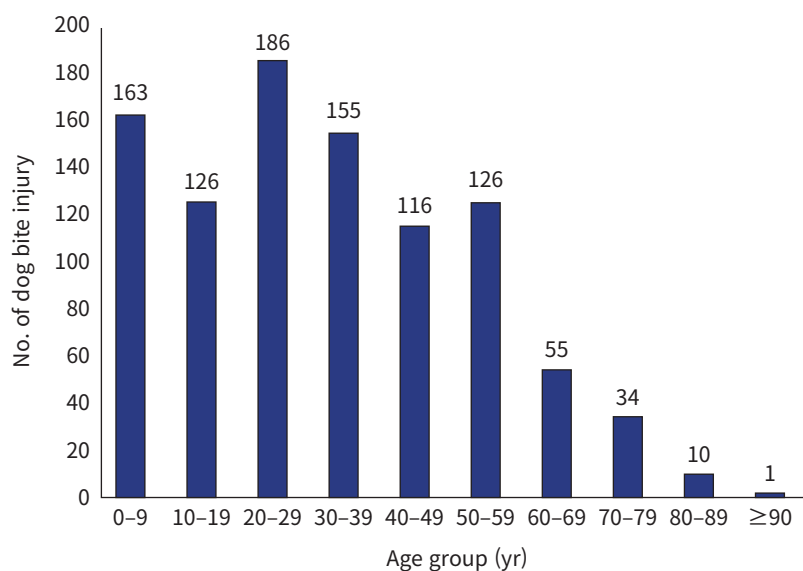


Fig. 1. Distribution of patients with dog bite injuries by age group.

Table 1. Age group characteristics and dog bite event profiles

Characteristic	Total (n=972)	Age group			P-value
		Children (n=272)	Adults (n=606)	Elderly (n=94)	
Age (yr)	30 (16–48)	7 (2–12)	35 (26–48)	68 (63–76)	
Male sex	384 (39.5)	131 (48.2)	220 (36.3)	33 (35.1)	0.003
Public ambulance	71 (7.3)	16 (5.9)	39 (6.4)	16 (17.0)	0.010
Place 1					0.002
Home	717 (73.8)	211 (77.6)	435 (71.8)	71 (75.5)	
Road	115 (11.8)	28 (10.3)	70 (11.6)	17 (18.1)	
Commercial facilities	77 (7.9)	13 (4.8)	62 (10.2)	2 (2.1)	
Public facilities	39 (4.0)	17 (6.3)	21 (3.5)	1 (1.1)	
Others	24 (2.5)	3 (1.1)	18 (3.0)	3 (3.2)	
Place 2					0.003
Indoor	748 (77.0)	220 (81.9)	468 (77.2)	60 (63.8)	
Outdoor	224 (23.0)	52 (19.1)	138 (22.8)	34 (36.2)	
Familiarity					0.480
Family/relatives	620 (63.8)	183 (67.3)	379 (62.5)	58 (61.7)	
Neighbor/friend	131 (13.5)	36 (13.2)	78 (12.9)	17 (18.1)	
Stranger	164 (16.9)	37 (13.6)	113 (18.6)	14 (14.9)	
Unknown	57 (5.9)	16 (5.9)	36 (5.9)	5 (5.3)	
Season					0.062
Spring	248 (25.5)	65 (23.9)	162 (26.7)	21 (22.6)	
Summer	265 (27.3)	71 (26.1)	162 (26.7)	32 (34.0)	
Fall	223 (22.9)	57 (21.0)	138 (22.8)	28 (29.8)	
Winter	236 (24.3)	79 (29.0)	144 (23.8)	13 (13.8)	
Time					<0.001
Day (08:00–16:00)	283 (29.1)	80 (29.4)	166 (27.4)	37 (39.4)	
Evening (16:00–00:00)	566 (58.2)	180 (66.2)	335 (55.3)	51 (54.3)	
Night (00:00–08:00)	123 (12.7)	12 (4.4)	105 (17.3)	6 (6.4)	
Bite site ^{a)}					
Head and neck	310 (31.9)	117 (43.0)	178 (29.4)	15 (16.0)	<0.001
Torso	24 (2.5)	9 (3.3)	12 (2.0)	3 (3.2)	0.449
Upper extremity	464 (47.7)	100 (36.8)	308 (50.8)	56 (59.6)	<0.001
Lower extremity	208 (21.4)	52 (19.1)	128 (21.1)	28 (29.8)	0.091
Multiple	25 (2.6)	5 (1.8)	14 (2.3)	6 (6.4)	0.045

Values are presented as median (interquartile range) or number (%).

^{a)}Sums of the proportions exceed 100% because of the presence of multiple injury.

Localized wound care, without more invasive interventions such as suturing and/or surgery, was performed in 63.0% of the patients. The percentage of patients who underwent primary and delayed suturing was highest in children (23%) and the elderly (17%), with a significant difference among the age groups ($P < 0.001$). A total of 932 patients were prescribed antibiotics in the ED and the most prescribed antibiotic was amoxicillin/clavulanate (83.4%). Surgery was performed in 16 patients (1.6%), including seven who were elderly.

Of the 55 patients who sustained a significant injury, 4.4% were children, 4.8% adults, and 14.9% elderly ($P < 0.001$). Seven-

ty-five patients were lost to follow-up and excluded from the study. Of the remaining 892 patients, 10.7% developed wound infections; the highest rate was found in the elderly (22.0%) and the lowest rate in children (7.7%; $P = 0.009$).

Factors associated with significant injury and wound infection

The factors associated with significant injury, analyzed by multivariate logistic regression, are shown in Table 3. The odds ratio (OR) for significant injury was 3.566 (95% confidence interval [CI], 1.720–7.395; $P = 0.001$) when the patient was transported to

Table 2. Characteristics and management of dog bite wounds

Variable	Total (n=972)	Age group			P-value
		Children (n=272)	Adults (n=606)	Elderly (n=94)	
Wound characteristic^{a)}					
Superficial	530 (54.5)	161 (59.2)	325 (53.6)	44 (46.8)	0.089
Open	455 (46.8)	114 (41.9)	290 (47.9)	51 (54.3)	0.236
Muscle/tendon	36 (3.7)	6 (2.2)	20 (3.3)	10 (10.6)	0.001
Fracture	10 (1.0)	1 (0.4)	5 (0.8)	4 (4.3)	0.004
Amputation	3 (0.3)	0	2 (0.3)	1 (1.1)	0.273
ED disposition					
Discharge	938 (96.5)	262 (96.3)	591 (97.5)	85 (90.4)	0.002
Admission (ward)	23 (2.4)	8 (2.9)	7 (1.2)	8 (8.5)	
Admission (ICU)	1 (0.1)	0	1 (0.2)	0	
Transfer	5 (0.5)	0	5 (0.8)	0	
DAMA	5 (0.5)	2 (0.7)	2 (0.3)	1 (1.1)	
Suture					
Primary	201 (20.7)	63 (23.2)	127 (21.0)	11 (11.7)	<0.001
Delayed	84 (8.6)	19 (7.0)	49 (8.1)	16 (17.0)	
Local wound care	612 (63.0)	180 (66.2)	378 (62.4)	54 (57.4)	
Unknown	75 (7.7)	10 (3.7)	52 (8.6)	13 (13.8)	
Antibiotics					
Amoxicillin/clavulanate	811 (83.4)	221 (81.3)	514 (84.8)	76 (80.9)	0.752
Cephalosporin	117 (12.0)	36 (13.2)	67 (11.1)	14 (14.9)	
Others	4 (0.4)	2 (0.7)	2 (0.3)	0	
None	40 (4.1)	13 (4.8)	23 (3.8)	4 (4.3)	
Surgery					
Surgery	16 (1.6)	6 (2.2)	3 (0.5)	7 (7.4)	<0.001
Significant injury					
Significant injury	55 (5.7)	12 (4.4)	29 (4.8)	14 (14.9)	<0.001
Wound infection^{b)}					
Wound infection ^{b)}	97 (10.9)	20 (7.7)	59 (10.7)	16 (22.0)	0.009

Values are presented as number (%).

ED, emergency department; ICU, intensive care unit; DAMA, discharge against medical advice.

^{a)}Sums of the proportions exceed 100% because of the presence of multiple injury. ^{b)}Excluding 75 patients with follow-up loss, 892 patients were included.

Table 3. Risk factors associated with significant injuries from dog bites

Variable	Adjusted OR	95% CI	P-value
Age group			
Children	Reference	-	0.031
Adults	1.185	0.557–2.523	0.659
Elderly	2.880	1.176–7.054	0.021
Public ambulance	3.566	1.720–7.395	0.001
Time (night)	0.621	0.345–1.118	0.112
Familiarity	0.551	0.248–1.224	0.143
Place (outdoor)	2.498	1.290–4.838	0.070
Upper extremities	2.135	1.151–3.959	0.016

OR, odds ratio; CI, confidence interval.

Table 4. Risk factors associated with infection of dog bite wounds

Variable	Adjusted OR	95% CI	P-value
Age group			
Children	Reference	-	0.045
Adults	1.413	0.815–2.450	0.218
Elderly	2.586	1.221–5.475	0.013
Public ambulance	1.955	0.962–3.973	0.064
Head and neck	3.997	1.279–12.491	0.017
Upper extremities	6.337	2.399–16.744	<0.001
Lower extremities	3.881	1.488–10.122	0.006
Primary suture	2.166	0.976–4.808	0.058
Significant injury	4.769	2.167–10.494	<0.001

OR, odds ratio; CI, confidence interval.

the ED by ambulance, 2.880 (95% CI, 1.176–7.054; $P=0.021$) in the elderly, and 2.135 (95% CI, 1.151–3.959; $P=0.016$) for upper extremity injuries.

The factors associated with wound infections are shown in [Table 4](#). The highest OR for wound infection, 6.337 (95% CI, 2.399–16.744; $P<0.001$) occurred in upper-extremity injuries, followed by injuries to the head and neck (OR, 3.997; 95% CI, 1.279–12.491; $P=0.017$) and lower extremities (OR, 3.881; 95% CI, 1.488–10.122; $P=0.006$). The OR for significant injury was 4.769 (95% CI, 2.167–10.494; $P<0.001$). By age group, the elderly had a higher risk for wound infection than children, with an OR of 2.586 (95% CI, 1.221–5.475; $P=0.013$).

DISCUSSION

This study examined the characteristics of patients with dog bite injuries and identified the factors associated with wound infection according to patient age groups. In particular, the elderly (age ≥ 60 years) had more outdoor injuries, upper and lower extremity injuries, and a higher risk of significant injury and/or wound infection. In order to prevent wound infection, healthcare providers must be careful during wound management (e.g., irrigation and debridement) and patients need to be actively educated about wound infection prevention.

In 2005, Kim et al. [11] reported a higher incidence of dog bite injuries in male patients, whereas this study found a higher percentage in female patients (60.5%). Our study results were similar to the results of another recent Korean study [10,12] as well as studies published in other countries [14]. This difference may be attributable to changes in pet culture since the study by Kim et al. [11] in 2005. The incidence of injury was high among people in their 20s and 30s and children under the age of 10, which is similar to previous reports [10–12]. Home was the most common place of injury among children compared to other age groups, which is also consistent with previous reports [10,11]. However, in this study, the rate of outdoor injuries increased with age, with 36.4% of injuries sustained outdoors among the elderly. The reason for this seems to be that children, unlike adults, spend more time at home. However, a lack of studies that specifically analyzed the older adult population makes it difficult to compare our findings to other reports. It has been reported that the incidence of dog bite injury increases during longer daylight seasons when temperatures are favorable for outdoor activities [8,10,15]. In this study, the difference between seasons was not statistically significant. Injuries were most commonly sustained in the evening, which is consistent

with a previous study that reported that injuries frequently occur during the more active times of day.

When looking at the site of dog bite injury, head and neck injuries were the most common in children, whereas upper extremity injuries became more frequent with increasing age [11,15]. Our results are in line with previous findings, showing significant differences in the site of injury across age groups. Upper extremity injuries were most common in the elderly and the rate of lower extremity injuries was also high in this age group (29.8%) when compared to the overall study population (21.4%). The reason for the high rate of head and neck bites in children may be explained by patient height [11]. That is, because children are relatively short, they sustained facial injuries more frequently than taller adults who experienced more upper extremity injuries. Adults are also more likely than children to use their arms and legs in self-defense during an attack. Head and neck injuries were the second-most common injury in adults, probably because facial contact with a dog is a common expression of intimacy. Lower extremity injuries were the second-most common injury in the elderly.

In this study, superficial injuries were common among children and adults, while open wounds were most common among the elderly. While Park et al. [10] reported that 79.2% of dog bite injuries were open wounds, Kim et al. [11] reported that puncture injuries were the most common. The difference can probably be attributed to variations in the classification of wound types. Localized wound care was the most common treatment in all age groups. The rate of primary suturing was 23.2% in children and the rate of delayed suturing was 17.0% in the elderly, similar to the results of a previous study [11]. The vascular system of the head and neck area is more developed, contributing to a lower risk of infection after suturing. Primary suturing is reported to lead to relatively good outcomes. However, healing by secondary intention (secondary wound closure) is generally recommended for other sites [16,17]. Children in this study most commonly had head and neck injuries, with a high rate of primary suturing. Amoxicillin/clavulanate was the primary prophylactic antibiotic administered for dog bite wounds [16], and in this study it was prescribed for 83.4% of the patients. Overall, 2.4% of the total patients were hospitalized, as compared to varying hospitalization rates in previous studies (1.8%–11.1%) [8,10,12,15,18]. The rate of significant injury (5.7%) was associated with old age, transport by ambulance, and upper extremity injury. Park et al. [10] reported that in addition to old age, multiple site injuries and head and neck injuries were also associated with significant injury. Another study reported that upper extremity or

multiple site injuries were also associated with hospitalization [19].

The overall incidence of dog bite wound infection is 5% to 10%, though the incidence increases to 12% to 30% for some sites of injury [6,20,21]. In this study, 10.9% of the patients developed a wound infection, with a rate of 7.7% among children and 22.0% among elderly patients. Primarily, old age, head and neck injuries, upper extremity and/or lower extremity injuries, and significant injuries were identified as factors associated with wound infection. A previous study reported the incidence of infection to be 1.9% before age 50 years and 11.8% after age 50 years. Other factors associated with infection were full thickness wounds, debridement, and female sex [6]. The high rate of infection in the elderly seems to be influenced by the high rate of upper and lower extremity injuries and significant injuries in this age group. Second, the mechanism of the bite also has an impact on infections. For example, the upper extremities, especially the fingers, are often bare and completely exposed to the dog's oral secretions during a bite, leaving them more susceptible to infection than a covered part of the body. Third, various underlying diseases, including diabetes, may increase the risk of infection. In this study, head and neck injuries were found to be associated with infection. In general, the head and neck area feature a well-developed vascular network compared to other areas, and thus, the benefits of primary suturing help offset the risk of infection. A study comparing facial injuries that were immediately closed with sutures to injuries that were treated without suturing reported that immediate closure did not increase the risk of infection [9]. However, dogs' oral secretions contain numerous microorganisms, which can cause infection [16,20,22,23], so precautions should be taken against infection for all dog bite wounds.

This study had several limitations. First, this was a single-center study; thus, the generalizability of the findings is limited, and the results may need to be validated in a larger study. Second, because this was a retrospective study, it was not possible to control for possible errors in classification caused by incomplete or inaccurate data entered into the medical records. Third, 7.7% (n = 75) of the participants were lost to follow-up; therefore, their data on wound suture type and infection were not available, which may have affected the study results. Prospective studies are needed to better analyze factors related to dog bite injuries and wound infection. Information such as dog species and size, patient height, and wound size could be meaningful.

In conclusion, dog bite injuries have differing characteristics across age groups. Indoor injuries and head and neck injuries

were common among children, while upper extremity injuries were common in adults and the elderly. The rate of outdoor injuries increased with age. Additional precautions are necessary when assessing and treating dog bite wounds in elderly patients who are at high risk of significant injury and infection. Because dog bites in all anatomical areas are associated with infection, after appropriate initial care patients should be encouraged to attend outpatient follow-up visits for an adequate period and should be hospitalized if necessary.

NOTES

Ethical statements

This study was approved by the Institutional Review Board of Gachon University Gil Medical Center (No. GCIRB2021-098). Informed consent was waived due to the retrospective nature of the study.

Conflicts of interest

The authors have no conflicts of interest to declare.

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Author contributions

Conceptualization: all authors; Data curation: DHK, JYC, JHJ, JSC, SYH; Formal analysis: all authors; Methodology: all authors; Project administration: JYC; Visualization: DHK, JYC, JHJ; Writing—original draft: DHK, JYC, WSC; Writing—review & editing: DHK, JYC, JSC, SYH.

All authors read and approved the final manuscript.

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