

Emergency department presentations with mammalian bite injuries: risk factors for admission and surgery

Animal bites, particularly by mammals, are common in Australia,^{1,2} and their treatment is a substantial public health burden.³ Clinical assessment and the subsequent decision to transfer patients to surgical centres may be challenging, especially for primary health care providers, paramedics and rural emergency departments. There have been few investigations into predictors of hospital admission and surgery for bite injury patients.^{2,4} We retrospectively analysed the characteristics of all mammalian bite injuries with which patients presented to seven major hospital emergency departments in Victoria during a 2-year period.

Methods

Study design

A retrospective review of all patients presenting with mammalian bite injuries to seven Victorian emergency departments (at the Alfred Hospital, Austin Hospital, Royal Melbourne Hospital, Frankston Hospital, Monash Medical Centre, St Vincent's Hospital and Western Hospital) during the 2-year period 1 January 2012 – 31 December 2013 was undertaken. Patients were identified using International Statistical Classification of Diseases and Related Health Problems, tenth revision, Australian modification (ICD-10-AM) codes for animal-related injury, and by searching patient record systems for the terms “bite” and “animal-related injuries”. Injuries not involving mammalian bites were excluded.

Descriptive and univariate analysis

All statistical analysis was performed with SPSS Statistics 22 (IBM). Graphs were created in Excel 2013 (Microsoft) and Prism 5 (GraphPad).

Abstract

Objectives: The incidence of animal bite injuries in Australia is high. There is currently no established method for reliably predicting whether a patient with a bite injury will require admission to hospital or surgery.

Design: A retrospective audit of mammalian bite injuries at seven major hospitals in Melbourne, Victoria, over a 2-year period. The associations between each predictor and outcome of interest were analysed with univariate and multiple regression analyses.

Setting: Seven major hospitals in Melbourne, Victoria: the Alfred Hospital, Austin Hospital, Frankston Hospital, Monash Medical Centre, Royal Melbourne Hospital, St Vincent's Hospital and Western Hospital.

Participants: Patients presenting to emergency departments with mammalian bite injuries.

Main outcome measures: Hospital admission, intravenous antibiotic therapy, surgery, reoperation, readmission.

Results: We identified 717 mammalian bite injuries. The mean age of the patients was 36.5 years (median, 34 years; range, 0–88 years), with an equal number of males and females. The overall rate of hospital admission was 50.8%, and the mean length of stay was 2.7 days. Intravenous antibiotics were administered in 46% of cases; surgery was undertaken in 43.1% of cases. The re-operation rate was 4.5%, the re-admission rate was 3%.

Conclusions: Our study provides a detailed epidemiological analysis of animal bite injuries at seven major hospitals in Victoria. Risk factors for hospitalisation and surgery may assist in identifying patients who require admission and surgical intervention.

$P < 0.05$ (two-tailed) was defined as statistically significant.

The associations between each predictor and outcome of interest were analysed with univariate methods, χ^2 tests, analyses of variance (ANOVAs) and Kruskal–Wallis tests as appropriate. Post hoc Bonferroni corrections were performed when appropriate. The choice of potential predictors was based on reports in the literature; age, sex, smoking status, diabetes mellitus, immunosuppression, time to presentation, type of animal and site of injury were assessed. The measured outcomes were hospital admission, surgery, readmission, reoperation, and positive microbiological culture.

Multiple regression analysis

We conducted multiple logistic regression analyses, with stepwise

backward elimination by likelihood ratio tests, to further clarify the associations between predictors and outcomes. The probability for stepwise elimination was set at 0.10. This method allowed us to examine the effects of multiple predictors on an outcome. For each predictor, the category with the lowest rate of the outcome of interest was designated as the baseline or reference category. Each regression model was assessed with the Hosmer–Lemeshow test, the Nagelkerke R^2 , percentage of correct predictions, and area under the receiving operating characteristic curve.

Ethics approval

The investigation was approved by all hospitals involved in this research (Alfred Health Human Research Ethics Committee, reference QA535/13; St Vincent's Hospital Human

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Results

Epidemiology of mammalian bites

We identified a total of 717 patients who presented with mammalian bite injuries to the seven Melbourne emergency departments during the study period. Their mean age was 36.5 years, with an equal number of

males and females (sex unspecified in one case). Almost all cases (96.1%) involved bites to only one anatomical region; 60.9% involved the upper limbs, 18.7% the head and neck, 14.5% the lower limbs, and 2.0% another part of the body (trunk, back or perineum). Most patients had presented to an emergency department (84.5%) within 24 hours of the injury. The overall rate of hospital admission was 50.8%, and the mean length of stay was 2.7 days. Intravenous antibiotics were administered in 46% of cases; surgery was undertaken in 43.1% of cases. The reoperation rate was 4.5%, the readmission rate was 3%.

A comparison of the demographic and other data for patients presenting with bites by different mammals is shown in **Box 1**. Almost all bites sustained by patients aged under 15 years were dog bites (92%). Further,

63.1% of patients aged 0–15 years with dog bites were bitten on the head and neck (compared with 13.3% of older patients with dog bites). Dog and human bites were significantly more likely to be seen in male than in female patients (54% and 75%, respectively were sustained by males; $P < 0.05$); the reverse was true for cat bites (72% were sustained by females).

Patients presenting with cat bites were on average older (mean age, 46.8 ± 19.3 years) than those presenting with bites by other mammals (mean age, 35.7 ± 20.5 years; $P < 0.0001$). Cat bites comprised 24.0% of all bites in patients aged 60 years or over, compared with 15.9% in other age groups. Cat bites were seen significantly more frequently in female than in male patients (72.1% v 27.9%; $P < 0.05$). There was no seasonal trend in

1 Demographic data for patients presenting with bites from different mammals

Variable	Source of bite				P
	Dog	Cat	Human	Other*	
Number of patients	509	122	36	50	
Mean age (SD), years	34.8 (21.0)	43.9 (19.3)	37.4 (16.5)	34.9 (17.1)	0.0002
Age group					< 0.0001
< 15 years	103 (20.2%)	4 (3.3%)	1 (3%)	4 (8%)	
15–29 years	127 (25.0%)	27 (22.1%)	12 (33%)	19 (38%)	
30–44 years	114 (22.4%)	38 (31.1%)	12 (33%)	12 (24%)	
45–59 years	97 (19.1%)	29 (23.8%)	8 (22%)	10 (20%)	
≥ 60 years	68 (13.4%)	24 (19.7%)	3 (8%)	5 (10%)	
Sex					< 0.0001
Female	232 (45.6%)	88 (72.1%)	9 (25%)	29 (58%)	
Male	276 (54.2%)	34 (27.9%)	27 (75%)	21 (42%)	
Unknown	1 (0.2%)	0 (0%)	0 (0%)	0 (0%)	
Site of bite				49	< 0.0001
Head and neck	119 (23.4%)	4 (3.3%)	10 (28%)	1 (2%)	
Upper limb	272 (53.4%)	105 (86.1%)	20 (56%)	39 (80%)	
Lower limb	84 (16.5%)	12 (9.8%)	1 (3%)	7 (14%)	
Trunk, back, perineum	11 (2.2%)	0 (0%)	2 (6%)	1 (2%)	
Multiple sites	23 (4.5%)	1 (0.8%)	3 (8%)	1 (2%)	
Diabetes mellitus	14 (3.5%)	9 (8.7%)	1 (3.8%)	1 (2%)	0.12
Current smoker	71 (18.0%)	19 (18.6%)	10 (38.5%)	14 (35%)	0.007
Immunosuppression	12 (3.0%)	3 (2.9%)	2 (7.4%)	1 (2%)	0.62

All percentages are column percentages. *Monkey, rat, possum and bat bites. †Data on diabetes, smoking and immunosuppression status were not recorded for all patients. ♦

2 Outcomes for patients presenting with mammalian bites

Clinical outcome	Source of bite				P
	Dog	Cat	Human	Other*	
Number of patients	509	122	36	50	
Median time to presentation (IQR), days	0 (0–0)	0.5 (0–1.75)	0 (0–1)	0 (0–4)	< 0.0001
Time to presentation of 2 days or more	54 (11.4%)	29 (24.2%)	5 (14.7%)	17 (34.0%)	< 0.0001
Admission	262 (51.5%)	78 (63.9%)	12 (33.3%)	12 (24.0%)	< 0.0001
Surgery	246 (48.3%)	41 (33.6%)	11 (30.6%)	11 (22.0%)	< 0.0001
Median length of stay (IQR), days	1 (0–2)	2 (1–3.75)	2 (0–3)	2 (1–2.75)	< 0.0001
Positive wound or blood culture	32 (6.3%)	28 (23.0%)	4 (11.1%)	3 (6.0%)	< 0.0001
Administration of intravenous antibiotics	227 (44.6%)	79 (64.8%)	13 (36.1%)	11 (22.0%)	< 0.0001
Re-admissions (percentage of prior admissions)	7 (2.7%)	1 (1.3%)	1 (8.3%)	2 (16.7%)	0.021
Re-operation (percentage of prior operations)	8 (3.3%)	3 (7.3%)	1 (9.1%)	2 (18.2%)	0.074

IQR = interquartile range. All percentages are column percentages. *Monkey, rat, possum and bat bites. ♦

the frequency of presentation of mammalian bites according to type of bites (data not shown).

Box 2 summarises the rates of hospital admission and the management outcomes for patients presenting with the different bite types. Patients with dog bites usually presented to a hospital on the day of the injury, while presentation with bites by cats and other mammals was often delayed for up to 2 days. Hospital admission rates were significantly higher for cat bites (64% v 48% for all other bites; $P < 0.05$), and surgery rates were significantly higher for patients with dog bites (48% v 30% for all other bites; $P < 0.05$). Patients with cat and dog bites were more likely to receive intravenous antibiotics than were those with bites from other mammals ($P < 0.05$).

Predictive factors for admission to hospital

Patient age, type of animal, the site of injury, and time to presentation of 2 days or more were all significantly associated with admission to hospital ($P < 0.01$ for all tests). Children under 15 years of age and adults over 60 years of age were more likely to be admitted; the probability also increased with age from the age of 30 years. Admission was more frequent for patients with cat and dog bites than for bites by other mammals. Patients with isolated bites to the head and neck or an upper limb were more likely to be admitted than those

with bites to the trunk, back or perineum. However, bites to multiple sites were associated with the greatest risk for admission (**Box 3**). Finally, smoking was identified by multiple regression analysis as a significant risk factor for admission (adjusted odds ratio [aOR], 1.99 v non-smokers; 95% CI, 1.21–3.28). Sex, immunosuppression and diabetes were not significant risk factors for admission.

Predictive factors for surgery, re-admission and re-operation

Surgery was significantly more frequent for patients with bites by dogs ($P < 0.05$) and bites to the head and neck, upper limb or multiple sites, and was more frequent in patients who smoked. Patients aged 15–29 years were more likely to undergo surgery as a result of their bite, but this difference was not statistically significant ($P < 0.10$). Sex, diabetes and immunosuppression were not statistically significantly associated with surgery (**Box 4**).

After pooling data for all mammalian bites, time to presentation of greater than 2 days was associated with an increased risk of re-operation (OR, 4.41; 95% CI, 1.39–13.95; $P = 0.019$).

Discussion

Our findings show that presentations by patients to emergency departments with animal bites are

frequent, and that a substantial proportion of these patients are hospitalised or undergo surgery. Our data identified certain trends that are consistent with other findings in the literature. Males were more likely to sustain bite injuries, especially by dogs,^{5–9} and cat bites were more common in females, as in previous reports.¹ In children under 15 years of age, dog bites were more common than other bites (92% of all mammalian bites in this age group were dog bites); further, 20.2% of all dog bites were presented by children under 15 years of age, similar to other reported findings.^{1,5–7,10}

We also confirmed that the average age of patients presenting with cat bites was higher than for patients presenting with other animal bites.¹⁰ The most common site of injury for animal bites of any type was an upper limb, consistent with previous studies,¹ although some authors found that the lower limbs were the predominant site of injury for dog bites.^{8,9} In our study, dog bites more frequently caused head and neck injuries in younger patients than in adults. It has been proposed that children are at particular risk because of their shorter stature, lower capacity for self-defence, and poorer risk awareness with regard to potentially provocative behaviour.^{7,9}

Patients with dog bite injuries usually presented to hospital on the day of the injury, while presentations with bites by cats and other

3 Univariate and multivariable predictors and prediction score for hospital admission following a mammalian bite injury

Risk factors for admission	Admission rate	Multiple logistic regression model (n = 545)		
		Univariate tests (n = 717) Unadjusted OR (95% CI)	Adjusted OR (95% CI) P	
Animal type				
Other	24%	1		< 0.0001
Human	33%	1.58 (0.61–4.09)	1.42 (0.44–4.60)	0.555
Dog	52%	3.36 (1.72–6.58)	3.54 (1.60–7.85)	0.002
Cat	64%	5.61 (2.66–11.85)	5.55 (2.32–13.25)	< 0.0001
Age group				
15–29 years	37%	1		0.001
< 15 years	55%	2.13 (1.32–3.44)	2.16 (1.17–4.01)	0.014
30–44 years	48%	1.61 (1.06–2.45)	1.84 (1.09–3.12)	0.023
45–59 years	56%	2.21 (1.42–3.45)	2.01 (1.17–3.45)	0.011
≥ 60 years	68%	1.85 (1.28–2.69)	3.84 (2.04–7.21)	< 0.0001
Sex				
Female	49%	1		
Male	52%	1.12 (0.83–1.50)	NA	NA
Site of bite				
Trunk, back or perineum	7%	1		0.003
Lower limb	37%	7.48 (0.94–59.48)	5.52 (0.61–50.0)	0.129
Upper limb	53%	14.51 (1.88–112)	10.94 (1.26–95.3)	0.03
Head and neck	59%	18.67 (2.37–147)	14.72 (1.63–133)	0.017
Multiple sites	57%	17.33 (1.98–151)	22.02 (2.12–229)	0.01
Diabetes mellitus				
No	53%	1		
Yes	72%	2.26 (0.93–5.49)	NA	NA
Current smoker				
No	53%	1		
Yes	61%	1.35 (0.89–2.05)	1.99 (1.21–3.28)	0.007
Immunosuppression				
No	54%	1		
Yes	61%	1.36 (0.52–3.55)	NA	NA
Time to presentation				
< 2 days	49%	1		
≥ 2 days	65%	1.90 (1.23–2.93)	2.39 (1.30–4.36)	0.005

NA = not applicable (not included in multivariate model because not significant in univariate model); OR = odds ratio. ♦

mammals were often delayed. This could be explained by the smaller wound sizes of cat bites, so that patients do not seek medical attention until after infections have developed.^{11,12} That patients with dog bites had the highest rate of surgery is reasonable, given the depth and complexity of dog bite wounds.^{5,13} Higher hospital admissions of patients with cat bites may be

related to the need for prophylactic intravenous antibiotics, as is currently recommended.^{2,14}

Our study found a relatively high admission rate of 50.8% for mammalian bites. This is at the high end of a broad range of admission rates reported in the literature (4.7–51%).^{6-9,15} The variability of these estimates may be explained by

differences in the sources of the collected data; some studies analysed surveillance data based on presentations to general practice clinics,^{1,15} while the emergency department presentations in our study may include a larger proportion of more serious injuries. We also found that delayed presentation for treatment increased the risk of hospitalisation, surgery and reoperation.

4 Univariate and multivariable predictors and prediction score for surgery following a mammalian bite injury

Risk factors for surgery	Surgery rate	Multiple logistic regression model (<i>n</i> = 545)		
		Univariate tests (<i>n</i> = 717)		<i>P</i>
		Unadjusted OR (95% CI)	Adjusted OR (95% CI)	
Animal type				< 0.0001
Other	22%	1		
Human	31%	1.56 (0.59–4.14)	1.39 (0.44–4.44)	0.576
Dog	34%	1.79 (0.83–3.87)	1.92 (0.82–4.42)	0.135
Cat	48%	3.32 (1.66–6.62)	4.47 (2.03–9.81)	< 0.0001
Age group				0.074
15–29 years	35%	1		
< 15 years	55%	2.29 (1.42–3.70)	1.77 (0.95–3.32)	0.074
30–44 years	38%	1.11 (0.72–1.70)	1.63 (0.97–2.77)	0.067
45–59 years	50%	1.85 (1.18–2.88)	2.13 (1.24–3.66)	0.006
≥ 60 years	44%	1.45 (0.88–2.38)	1.61 (0.89–2.89)	0.113
Sex				
Female	41%	1		
Male	45%	1.15 (0.85–1.54)	NA	NA
Site of bite				0.002
Trunk, back or perineum	7%	1		
Lower limb	33%	9.14 (1.19–70.50)	7.886 (0.90–69.0)	0.062
Upper limb	41%	6.31 (0.79–50.28)	12.80 (1.52–108)	0.019
Head and neck	50%	13 (1.49–113)	21.13 (2.08–214)	0.01
Multiple sites	60%	19.26 (2.45–152)	23.89 (2.71–211)	0.004
Diabetes mellitus				
No	53%	1		
Yes	52%	0.96 (0.43–2.15)	NA	NA
Current smoker				
No	52%	1		
Yes	58%	1.29 (0.85–1.95)	1.96 (1.20–3.18)	0.007
Immunosuppression				
No	53%	1		
Yes	56%	1.13 (0.44–2.90)	NA	NA
Time to presentation				
< 2 days	47%	1		
≥ 2 days	36%	0.63 (0.41–0.97)	NA	NA

NA = not applicable (not included in multivariate model because not significant in univariate model); OR = odds ratio. ♦

This is consistent with most studies,⁴ with the exception of one which found that smoking, an immunocompromised state, and location of the bite over a joint or tendon sheath were associated with hospitalisation.¹⁴ Our study confirmed the previously reported association between higher age and the risk of hospitalisation for bite injuries.⁴ Some traditional risk factors, such as diabetes and immunosuppression,

were not significantly associated with hospitalisation, surgery or complications in our study, perhaps because only 3% of our sample were affected by these factors.

A limitation of this study was the retrospective nature of the data collection. Further, the outcomes we analysed were limited to reported hospitalisation and surgery; there was no long term patient follow-up,

so that there were no recorded data about any subsequent disabilities.

Our study identified risk factors associated with hospitalisation and surgery. Further analysis of surgical findings in patients who have sustained bite injuries is needed, as this could allow the derivation of risk-stratifying scoring systems from regression models that predict whether a patient will require

hospitalisation or surgery. A scoring system could prove beneficial for guiding primary health care providers and emergency physicians in identifying low-risk and high-risk patients who can be managed

conservatively or in the outpatient setting, as well as who require timely interhospital transfer or assessment by a surgical unit.

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