Association between patient-related factors and risk of calcium oxalate and magnesium ammonium phosphate urolithiasis in cats

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Objective—To determine whether breed, age, sex, or reproductive status (ie, neutered versus sexually intact) was associated with the apparent increase in prevalence of calcium oxalate (CaOx) uroliths and the decrease in prevalence of magnesium ammonium phosphate (MAP) uroliths in cats over time.

Design—Case-control study.

Animals—Case cats consisted of cats with CaOx (n = 7,895) or MAP (7,334) uroliths evaluated at the Minnesota Urolith Center between 1981 and 1997. Control cats consisted of cats without urinary tract disease admitted to veterinary teaching hospitals in the United States and Canada during the same period (150,482).

Procedure—Univariate and multivariate logistic regression were performed.

Results—British Shorthair, Exotic Shorthair, Foreign Shorthair, Havana Brown, Himalayan, Persian, Ragdoll, and Scottish Fold cats had an increased risk of developing CaOx uroliths, as did male cats and neutered cats. Chartreux, domestic shorthair, Foreign Shorthair, Himalayan, Oriental Shorthair, and Ragdoll cats had an increased risk of developing MAP uroliths, as did female cats and neutered cats. Cats with CaOx uroliths were significantly older than cats with MAP uroliths.

Conclusions and Clinical Relevance—Results suggest that changes in breed, age, sex, or reproductive status did not contribute to the apparent reciprocal relationship between prevalences of CaOx and MAP uroliths in cats during a 17-year period. However, cats of particular breeds, ages, sex, and reproductive status had an increased risk of developing CaOx and MAP uroliths. (*J Am Vet Med Assoc* 2000;217:520–525)

The Minnesota Urolith Center has analyzed uroliths from cats for almost 2 decades. During this period, we have observed substantial changes in mineral composition. In 1981, for instance, uroliths from 69 cats were analyzed. Fifty-four (78%) cats had uroliths composed of **magnesium ammonium phosphate (MAP)**, and only 1 cat had uroliths composed of **calcium oxalate (CaOx)**.[1] In 1994, on the other hand, uroliths from 2,164 cats were analyzed. Seven hundred thirty-four (34%) had MAP uroliths, and 1,181 (54%) had CaOx uroliths.[1] This observation prompted us to question whether differences in interrelated risk factors were responsible, at least in part, for changes in prevalence of CaOx and MAP uroliths in cats.

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A prevailing opinion has been that treatment designed to minimize recurrence of MAP uroliths has resulted in an increase in the occurrence of CaOx uroliths. The primary basis for this opinion is that diet-induced urine acidification is an effective method of dissolving and preventing formation of sterile MAP uroliths in cats, but diet-induced urine acidification promotes hypercalciuria and, thus, is a risk factor for formation of CaOx uroliths. Similarly, a reduction in the dietary magnesium content to minimize formation of sterile MAP uroliths in cats has been suggested to increase the risk of CaOx urolith formation, because urinary magnesium inhibits formation of CaOx crystals in human and rats.[2] However, these opinions have not been substantiated in cats with naturally occurring urolithiasis, and although feeding diets designed to minimize formation of sterile MAP uroliths may contribute to the increased prevalence of CaOx uroliths and decreased prevalence of MAP uroliths, a cause-and-effect relationship has not yet been documented.

Epidemiologic studies of CaOx urolithiasis in other species prompt us to hypothesize that nondietary factors may be involved in the apparent reciprocal relationship between prevalence of CaOx uroliths and prevalence of MAP uroliths in cats. For example, older dogs and cats have a higher risk of naturally occurring CaOx urolithiasis, whereas younger animals have a higher risk of MAP urolithiasis. Mean age of dogs with CaOx uroliths (mean ± SD, 8.5 ± 2.9 years)[3] was greater than mean age of dogs with MAP uroliths (6.0 ± 2.9 years).[4] Similarly, in 1 study,[1] mean age of cats with CaOx uroliths (7.3 years) was greater than mean age of cats with MAP uroliths (5.6 years). The proportion of household cats in North America > 6 years old increased from 24 to 47% between 1983 and 1996.[5] It is possible, therefore, that the increase in prevalence of CaOx uroliths between 1983 and 1996 is attributable, at least in part, to an increase in age of the cat population. Changes in the proportion of male and female cats may also have influenced the prevalence of MAP and CaOx uroliths, in as much as results of 2 epidemiologic studies[6,7] suggest that neutered males had a higher risk of developing CaOx uroliths, whereas neutered females had a higher risk of developing MAP uroliths. Breed-related differences may also be important. Results of 1 study[7] suggest that Burmese, Himalayan, and Persian breeds had a higher risk of developing CaOx uroliths and lower risk of developing MAP uroliths.

Another factor that could have contributed to the apparent reciprocal relationship between prevalences of CaOx and MAP uroliths is inbreeding of purebred cats that have a higher risk of developing 1 type of urolith and a lower risk of developing the other. For example, inbreeding cats has been linked to primary hyperoxaluria.[8]

Because of the uncertainty as to which factors contribute to this apparent reciprocal relationship, the purpose of the study reported here was to determine whether breed, age, sex, or reproductive status (ie, neutered vs sexually intact) was associated with the increased prevalence of CaOx uroliths and the decreased prevalence of MAP uroliths in cats.

Materials and Methods

Case selection—Case cats consisted of cats with CaOx or MAP uroliths submitted to the Minnesota Urolith Center for quantitative analysis between Jan 1, 1981 and Dec 31, 1997. Uroliths were analyzed by means of optical crystallography, infrared spectroscopy, or x-ray diffraction. Only cats with uroliths composed of at least 70% CaOx or at least 70% MAP were included in the study. Because CaOx and MAP uroliths were rarely detected in cats < 1 year old, cats < 1 year old were also excluded from the study.

Control selection—Control cats consisted of cats admitted to veterinary teaching hospitals in the United States and Canada between Jan 1, 1981 and Dec 31, 1997 and were identified by searching the records of the Veterinary Medical DataBase. Cats < 1 year old and cats with urinary tract diseases were excluded.

Statistical analyses—Frequencies of breed, age, sex, reproductive status, and location of urolith were calculated for case cats, using standard statistical software.[9,a,b] Crude **odds ratios (OR)** and 95% **confidence intervals (CI)** were calculated by Woolf's method to assess whether breed, age group (1 to < 2 years old, 2 to < 4 years old, 4 to < 7 years old, 7 to < 10 years old, 10 to < 15 years old, ≥ 15 years old), sex (male vs female), and reproductive status (neutered vs sexually intact) were risk factors for CaOx and MAP urolithiasis. If any expected cell frequency in a contingency table was < 5, the Fisher exact test was performed.[10]

The 17-year study period was arbitrarily grouped into 3 intervals (1981 through 1986, 1987 through 1992, and 1993 through 1997) to determine whether risk factors changed over time. Odds ratios for breed, age group, sex, and reproductive status were calculated for each time interval. The **Breslow-Day (B-D)** statistic was then calculated to determine whether OR were homogenous over these 3 time intervals.[11] The **Mantel-Haenszel summary of OR (OR_{MH})** was calculated when the Breslow-Day test was not significant. Values of $P < 0.05$ were considered significant.

Multivariate logistic regression analyses were performed, using the hierarchically well-formulated modeling method,[12] to find the best risk model for breed, age group, sex, and reproductive status. After adjustments for confounding factors and interactions were made, risk factors for developing uroliths were determined from the best model.

Table 1—Crude and adjusted odds ratios (OR) for development of calcium oxalate (CaOx) and magnesium ammonium phosphate (MAP) uroliths among cats of various breeds

		Cats with CaOx uroliths				Cats with MAP uroliths			
Breed	No. of control cats	No. affected	Crude OR	Adjusted OR	95% CI	No. affected	Crude OR	Adjusted OR	95% CI
Abyssinian	718	14	0.39*	0.36	0.20–10.63	6	0.19*	0.17	0.07–10.40
Angora	138	3	0.44	0.34	0.11–1.09	5	0.82	0.70	0.29–1.72
Balinese	160	5	0.63	0.50	0.18–1.36	2	0.28	0.29	0.07–1.16
Bengal	1	1	20.03	151.28	7.49–999	1	22.53	45.10	2.53–802.79
Birman	228	3	0.26*	0.40	0.13–1.27	2	0.20*	0.26	0.06–1.03
Bombay	32	1	0.63	0.58	0.08–4.33	1	0.70	0.72	0.10–5.32
British Blue	49	2	0.82	0.68	0.16–2.83	2	0.92	0.41	0.06–2.98
British Shorthair	18	7	7.80*	13.03	4.87–34.82	3	3.76	2.92	0.66–13.03
Burmese	732	57	1.56*	1.26	0.95–1.68	5	0.15*	0.14	0.06–0.35
Chartreux	15	1	1.34	2.29	0.28–18.80	3	4.51*	5.97	1.66–21.51
Domestic shorthair	74,557	4,393	1.43*	1.31	1.25–1.38	4,509	2.12*	1.70	1.62–1.79
Exotic Shorthair	76	11	2.90*	3.38	1.68–6.81	2	0.59	0.68	0.17–2.79
Foreign Shorthair	59	21	7.15*	6.64	3.75–11.77	48	18.46*	16.92	11.12–25.74
Havana Brown	22	6	5.47*	6.77	2.49–18.38	0	NA	NA	NA
Himalayan	2,514	751	6.54*	7.86	7.15–8.65	221	2.01*	2.15	1.85–2.49
Japanese Bobtail	52	1	0.39	0.68	0.09–5.05	1	0.43	0.60	0.08–4.40
Korat	23	1	0.87	1.02	0.13–7.92	0	NA	NA	NA
Maine Coon	617	27	0.88	0.66	0.44–1.00	39	1.43*	1.31	0.93–1.84
Manx	830	36	0.87	0.90	0.64–1.27	47	1.28	1.14	0.83–1.57
Mixed	53,726	1,160	0.33*	0.31	0.29–0.33	1,344	0.45*	0.41	0.39–0.44
Ocicat	33	3	1.82	2.42	0.70–8.38	4	2.73	3.53	1.22–10.23
Oriental Shorthair	28	4	2.86	3.24	1.07–9.79	4	3.22*	3.51	1.21–10.18
Persian	4,698	722	3.30*	3.53	3.22–3.86	303	1.47*	1.44	1.27–1.63
Ragdoll	23	9	7.85*	11.22	4.74–26.56	5	4.90*	5.33	1.98–14.35
Rex	207	10	0.97	1.14	0.59–2.18	1	0.11*	0.12	0.02–0.86
Russian Blue	346	10	0.58	0.55	0.29–1.03	3	0.19*	0.19	0.06–0.59
Scottish Fold	81	21	5.21*	6.10	3.53–10.52	2	0.56	0.67	0.16–2.76
Siamese	10,206	212	0.40*	0.31	0.27–0.35	108	0.23*	0.18	0.15–0.22
Snowshoe	2	1	10.02	6.91	0.53–90.51	0	NA	NA	NA
Somali	25	1	0.80	0.90	0.12–6.95	0	NA	NA	NA
Tonkinese	107	10	1.87	1.81	0.93–3.54	1	0.21	0.20	0.03–1.46
Total	**150,323**	**7,504**	**NA**	**NA**	**NA**	**6,672**	**NA**	**NA**	**NA**

*Significantly ($P < 0.05$) different from 1.
Adjusted OR were adjusted for age group, sex, and reproductive status.
CI = Confidence interval. NA = Not applicable.

Table 2—Odds ratios for development of CaOx and MAP uroliths among cats of various ages

Age group	No. of control cats	Cats with CaOx uroliths No. affected	OR	95% CI	Cats with MAP uroliths No. affected	OR	95% CI
1 to < 2 years	45,268	77	Ref	NA	367	Ref	NA
2 to < 4 years	34,520	961	16.37	12.97–20.65	1,661	5.94	5.30–6.65
4 to < 7 years	25,181	2,505	58.48	46.59–73.41	2,407	11.79	10.55–13.17
7 to < 10 years	16,544	1,898	67.45	53.67–84.76	1,478	11.02	9.82–12.37
10 to < 15 years	22,162	1,787	47.40	37.71–59.58	785	4.37	3.86–4.95
≥ 15 years	6,807	172	14.86	11.34–19.46	55	1.00	0.75–1.32
Total	**150,482**	**7,400**	**NA**	**NA**	**6,753**	**NA**	**NA**

Ref = Reference category. *See* Table 1 for remainder of key.

Table 3—Odds ratios over time for development of CaOx and MAP uroliths among cats ≥ 4 years old (compared with cats < 4 years old)

Period	Control cats No. ≥ 4 years old	No. < 4 years old	Cats with CaOx uroliths No. ≥ 4 years old	No. < 4 years old	OR	95% CI	Cats with MAP uroliths No. ≥ 4 years old	No. < 4 years old	OR	95% CI
1981–1986	25,556	34,270	21	9	3.13	1.43–6.83	307	209	1.97	1.65–2.35
1987–1992	28,995	32,609	795	162	5.52	4.66–6.54	1,214	537	2.54	2.29–2.82
1993–1997	16,143	12,909	5,546	867	5.12	4.75–5.52	3,204	1,282	2.00	1.87–2.14
Total	**70,694**	**79,788**	**6,362**	**1,038**	**6.92**	**6.47–7.39**	**4,725**	**2,028**	**2.63**	**2.49–2.77**

Results

Uroliths from 17,218 cats were submitted to the Minnesota Urolith Center for analysis during the study period. Of these, 7,934 (46%) had CaOx uroliths, and 7,456 (43%) had MAP uroliths. The remaining had uroliths composed of calcium phosphate (n = 118), purines (953), cystine (33), xanthine (28), mixed minerals (208), or compound minerals (385) or had other types of uroliths (103). Thirty-nine cats with CaOx uroliths and 122 cats with MAP uroliths were < 1 year old and were, therefore, excluded from the study. Thus, 7,895 case cats had CaOx uroliths and 7,334 case cats had MAP uroliths. A total of 150,482 control cats were identified.

Crude Odds Ratios

Breed—Case cats with CaOx uroliths included 37 breeds of cats (**Table 1**). Ragdoll, British Shorthair, Foreign Shorthair, Himalayan, Havana Brown, Scottish Fold, Persian, and Exotic Shorthair cats had significantly higher risks of developing CaOx uroliths than did cats of other breeds (OR > 2), and Birman, mixed breed, Abyssinian, and Siamese cats had significantly lower risks of developing CaOx uroliths (OR < 0.5).

Case cats with MAP uroliths included 31 breeds of cats. Foreign Shorthair, Ragdoll, Chartreux, Oriental Shorthair, **domestic shorthair (DSH)**, and Himalayan cats had significantly higher risks of developing MAP uroliths (OR > 2), and Rex, Burmese, Abyssinian, Russian Blue, Birman, Siamese, and mixed breed cats had significantly lower risks of developing MAP uroliths (OR < 0.5).

Age—Calcium oxalate and MAP uroliths were found in cats of all age groups. Mean ± SD age of cats with CaOx uroliths was 90 ± 41 months. Cats with MAP uroliths were significantly younger (69 ± 38 months) than cats with CaOx uroliths.

Cats in 4 age groups had a significantly increased risk of developing CaOx or MAP uroliths (**Table 2**). Cats ≥ 15 years old had an increased risk of developing CaOx uroliths, but were not at risk of developing MAP uroliths. Cats ≥ 7 but < 10 years old had the highest risk of developing CaOx uroliths; they were 67 times as likely to develop CaOx uroliths as were cats ≥ 1 but < 2 years old. In contrast, cats ≥ 4 but < 7 years old had the highest risk of developing MAP uroliths; they were 10 times as likely to develop MAP uroliths as were cats ≥ 1 but < 2 years old.

For the Breslow-Day test, it was necessary to divide cats into 2 age groups, those < 4 years old and those ≥ 4 years old. Cats ≥ 4 years old were 7 times as likely to develop CaOx uroliths and 2.5 times as likely to develop MAP uroliths as were cats < 4 years old (**Table 3**).

Sex—Of 7,685 cats with CaOx uroliths for which sex was reported, 59% were male and 41% were female. Male cats were 1.5 times as likely to develop CaOx uroliths as were females (**Table 4**). In contrast, of 7,077 cats with MAP uroliths for which sex was reported, 58% were female and 42% were male. Male cats were 0.7 times as likely to develop MAP uroliths as were females.

Reproductive status—Of 7,685 cats with CaOx uroliths for which reproductive status was reported, 95% were neutered and 5% were sexually intact. Neutered cats were 7 times as likely to develop CaOx uroliths as were sexually intact cats (**Table 5**). Similarly, of 7,077 cats with MAP uroliths for which reproductive status was reported, 91% were neutered and 9% were sexually intact. Neutered cats were 3.5 times as likely to develop MAP uroliths as were sexually intact cats.

Urolith location—Ninety-two percent of CaOx uroliths were retrieved from the bladder or urethra or were voided, and 5% of CaOx uroliths were retrieved

Table 4—Odds ratios over time for development of CaOx and MAP uroliths among male cats (compared with female cats)

	Control cats		Cats with CaOx uroliths				Cats with MAP uroliths			
Period	Males	Females	Males	Females	OR	95% CI	Males	Females	OR	95% CI
1981–1986	28,672	30,889	17	14	1.31	0.65–2.65	261	270	1.04	0.88–1.24
1987–1992	30,516	30,563	563	441	1.28	1.13–1.45	813	1,046	0.78	0.71–0.85
1993–1997	15,023	13,758	3,983	2,667	1.37	1.30–1.44	1,913	2,774	0.63	0.59–0.67
Total	**74,211**	**75,210**	**4,563**	**3,122**	**1.48**	**1.41–1.55**	**2,987**	**4,090**	**0.74**	**0.71–0.78**

Table 5—Odds ratios over time for development of CaOx and MAP uroliths among neutered cats (compared with sexually intact cats)

	Control cats		Cats with CaOx uroliths				Cats with MAP uroliths			
Period	Neutered	Sexually intact	Neutered	Sexually intact	OR	95% CI	Neutered	Sexually intact	OR	95% CI
1981–1986	39,862	19,689	22	9	1.21	0.56–2.62	335	196	0.84	0.71–1.01
1987–1992	44,989	16,081	918	86	3.82	3.06–4.76	1,680	179	3.36	2.87–3.92
1993–1997	24,148	4,602	6,377	273	4.45	3.93–5.05	4,397	290	2.89	2.56–3.27
Total	**108,999**	**40,372**	**7,317**	**368**	**7.36**	**6.63–8.81**	**6,412**	**665**	**3.57**	**3.30–3.87**

from the kidney or ureter; 24% of cats with CaOx uroliths in the kidney or ureter also had uroliths in the urinary bladder. In 3% of cats, location of the uroliths was not specified.

Ninety-six percent of MAP uroliths were retrieved from the bladder or urethra or were voided, and 0.6% were retrieved from the kidney or ureter; 31% of cats with MAP uroliths in the kidney or ureter also had uroliths in the urinary bladder. In 3% of cats, location of the uroliths was not specified.

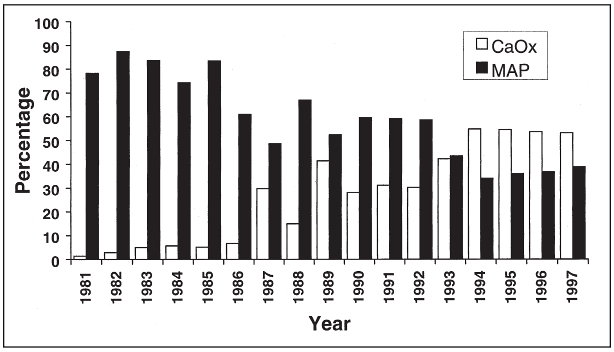

Figure 1—Percentages of uroliths evaluated at the Minnesota Urolith Center between 1981 and 1997 that were calcium oxalate (CaOx) or magnesium ammonium phosphate (MAP).

Changes Over Time

Between 1981 and 1997, the percentage of uroliths submitted to the Minnesota Urolith Center for analysis that were CaOx increased from 1 to 53% and the percentage that were MAP decreased from 78 to 39% (**Fig 1**).

Breed—There were insufficient numbers of cats during the 3 time intervals to calculate OR for all breeds. Therefore, OR were determined only for Himalayan, Persian, Siamese, DSH, and mixed breed cats. Domestic shorthair cats were combined with mixed breed cats, because these 2 terms appeared to be used interchangeably by owners. Evaluation of the Breslow-Day statistic for Himalayan (1.20 [$P = 0.565$] for cats with CaOx uroliths; 0.54 [$P = 0.787$] for cats with MAP uroliths), Persian (0.10 [$P > 0.9$] for cats with CaOx uroliths; 0.12 [$P > 0.9$] for cats with MAP uroliths), Siamese (3.51 [$P = 0.236$] for cats with CaOx uroliths; 6.22 [$P = 0.047$] for cats with MAP uroliths), and mixed breed (7.79 [$P = 0.028$] for cats with CaOx uroliths; 0.62 [$P = 0.762$] for cats with MAP uroliths) cats indicated that risks for cats of these 4 breeds was the same during the 3 time periods studied. Himalayan and Persian cats were 5.8 (OR_{MH}; 95% CI, 5.2 to 6.4) and 3.2 (95% CI, 2.9 to 3.5) times, respectively, as likely to develop CaOx uroliths as were cats of other breeds. Siamese and mixed breed cats were 0.56 (95% CI, 0.49 to 0.65) and 0.46 (95% CI, 0.43 to 0.49) times, respectively, as likely to develop CaOx uroliths as were cats of other breeds. Himalayan, Persian, and mixed breed cats were 1.8 (95% CI, 1.6 to 2.1), 1.4 (95% CI, 1.3 to 1.6), and 1.2 (95% CI, 1.1 to 1.3) times, respectively, as likely to develop MAP uroliths as were cats of other breeds. Siamese cats were 0.30 (95% CI, 0.24 to 0.36) times as likely to develop MAP uroliths as were cats of other breeds.

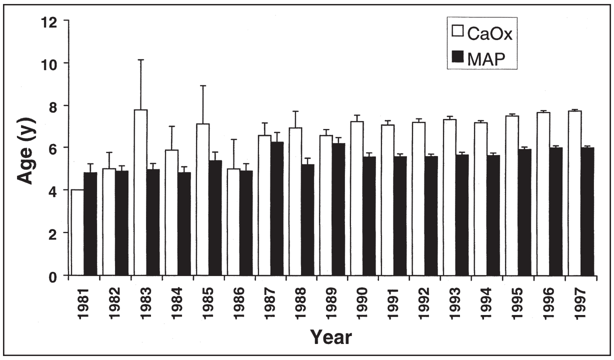

Figure 2—Mean ages of cats with CaOx or MAP uroliths evaluated at the Minnesota Urolith Center between 1981 and 1997; error bars represent SEM.

Age—When comparing mean ages of cats with

CaOx or MAP uroliths by year, statistically significant, but not biologically significant, differences were observed for cats with MAP uroliths (**Fig 2**). Cats with CaOx uroliths were significantly older than cats with MAP uroliths from 1990 through 1997.

For cats ≥ 4 years old, the OR for development of CaOx uroliths were the same (B-D test, 2.27; P = 0.391) over the 3 time periods studied. Compared with cats < 4 years old, cats ≥ 4 years old were 5.2 (OR_{MH}; 95% CI, 4.8 to 5.5) times as like to develop CaOx uroliths. In contrast, OR for development of MAP uroliths among cats ≥ 4 years old were significantly different (B-D test, 15.46; P < 0.001) among the 3 time periods. From 1981 through 1986, the OR was 2.0; from 1987 through 1992, the OR was 2.5; and from 1993 through 1997, the OR was 2.0.

Sex—For cats with CaOx uroliths, the OR for males, compared with females, were the same (B-D test, 0.94; P = 0.653) over the 3 time periods studied (Table 4). Males were 1.35 (OR_{MH}; 95% CI, 1.29 to 1.42) times as likely to develop CaOx uroliths as were females. In contrast, for cats with MAP uroliths, the OR for males, compared with females, were different (B-D test, 36.41; P < 0.001) among the 3 time periods. From 1981 through 1986, the OR was 1.0; from 1987 through 1992, the OR was 0.8; and from 1993 through 1997, the OR was 0.6.

Reproductive status—For cats with CaOx uroliths and for cats with MAP uroliths, the OR for neutered cats, compared with sexually intact cats, were different (B-D test for CaOx, 12.86; P = 0.006; B-D test for MAP, 175.20; P < 0.001) among the 3 time periods studied. For cats with CaOx uroliths, from 1981 through 1986, the OR was 1.2; from 1987 through 1992, the OR was 3.8; and from 1993 through 1997, the OR was 4.5. For cats with MAP uroliths, from 1981 through 1986, the OR was 0.8; from 1987 through 1992, the OR was 3.4; and from 1993 through 1997, the OR was 2.9 (Table 5).

Multivariate Logistic Regression

The OR for breeds were not confounded by age (≥ 4 years old vs < 4 years old), sex (male vs female), or reproductive status (neutered vs sexually intact) among cats with CaOx or MAP. When OR were adjusted for age group, sex, and reproductive status, Bengal, British Shorthair, Ragdoll, Himalayan, Havana Brown, Foreign Shorthair, Scottish Fold, Persian, Exotic Shorthair, and Oriental Shorthair cats had a significantly greater risk of developing CaOx uroliths than did cats of other breeds (OR > 2). Siamese, mixed breed, and Abyssinian cats had a significantly lower risk of developing CaOx uroliths than did cats of other breeds (OR < 0.5). Bengal, Foreign Shorthair, Chartreux, Ragdoll, Ocicat, Oriental Shorthair, and Himalayan cats had a significantly greater risk of developing MAP uroliths than did cats of other breeds (OR > 2). Rex, Burmese, Abyssinian, Siamese, Russian Blue, and mixed breed cats had a significantly lower risk of developing MAP uroliths than did cats of other breeds (OR < 0.5).

Only data for selected breeds (Siamese, Himalayan, Persian, DSH, and mixed breed cats) were used to develop a model that would best predict risk of urolith formation. Himalayan and Persian cats were considered to be at high risk, and Siamese cats were considered to be at low risk; DSH and mixed breed cats were grouped and used as the reference category. Cats ≥ 4 years old were considered to be at high risk, and cats < 4 years old were used as the reference category. Male cats were considered to be at high risk, and female cats were used as the reference category. Neutered cats were considered to be at high risk, and sexually intact cats were used as the reference category.

Multivariate logistic regression revealed that Himalayan and Persian cats were 5.5 times (95% CI, 3.9 to 7.7) as likely to develop CaOx uroliths as were mixed breed cats. The risk that Siamese cats would develop CaOx uroliths (OR, 0.9; 95% CI, 0.4 to 1.7) was not significantly different from that for mixed breed cats. Cats ≥ 4 years old were 14.6 times (95% CI, 10.7 to 19.8) as likely to develop CaOx uroliths as were cats < 4 years old. Male cats were 1.32 times (95% CI, 1.25 to 1.40) as likely to form CaOx uroliths as were female cats. Neutered cats were 9.5 times (95% CI, 7.1 to 12.8) as likely to develop CaOx uroliths as were sexually intact cats.

Multivariate logistic regression also revealed that Himalayan and Persian cats were 2.6 times (95% CI, 1.8 to 3.6) as likely to develop MAP uroliths as were mixed breed cats, and that the risk that Siamese cats would develop MAP uroliths (OR, 0.8; 95% CI, 0.4 to 1.5) was not significantly different from that for mixed breed cats. Cats ≥ 4 years old were 6.8 times (95% CI, 5.2 to 8.8) as likely to develop MAP uroliths as were cats < 4 years old. Male and female cats had similar risk (OR, 1.3; 95% CI, 0.9 to 1.7) for developing MAP uroliths. Neutered cats were 6.7 times (95% CI, 5.3 to 8.4) as likely to develop MAP uroliths as were sexually intact cats.

Discussion

Factors examined in the present study could be considered to have contributed to the reciprocal relationship between prevalences of CaOx and MAP uroliths in cats only if those factors increased the risk that CaOx uroliths would develop and concomitantly decreased the risk that MAP uroliths would. With the exception of Burmese cats, therefore, results of the present study did not support the hypothesis that breed contributed to the increase in prevalence of CaOx uroliths and the decrease in prevalence of MAP uroliths from 1981 through 1997. Although Burmese cats had a significantly increased risk of developing CaOx uroliths and significantly decreased risk of developing MAP uroliths, they represented only 0.4% of cats with uroliths. Furthermore, the popularity of Burmese cats appears to have decreased during the study period. The number of Burmese cats registered with the Cat Fanciers' Association decreased from 1,323 cats (3% of 46,029 registered cats) in 1982 to 970 cats (1% of 73,879 registered cats) in 1992.[13]

A reciprocal relationship between prevalences of CaOx and MAP uroliths was not detected for DSH, European Shorthair, Himalayan, Persian, and Ragdoll (n = 10,982) cats, inasmuch as cats of these breeds had an increased risk of developing either type of urolith. Four breeds of cats (British Shorthair, Exotic Shorthair, Havana Brown, Scottish Fold; n = 45) had an increased risk of CaOx urolith formation but were neither predisposed to nor protected from MAP urolith formation. Chartreux (n = 3) had an increased risk of MAP urolith formation but were neither predisposed to nor protected from CaOx urolith formation. Additionally, during the 17-year study period, the magnitude of risk of CaOx urolith formation did not change in Himalayan, Persian, and Siamese cats.

Our inability to find an association between breed, with the exception of Burmese cats, and the reciprocal relationship between prevalences of CaOx and MAP uroliths does not support inbreeding as a putative factor. Our results, however, do suggest that Himalayan cats may be a suitable model to investigate genetic predisposition to CaOx urolithiasis.

Results of the present study did not support the hypothesis that age contributed to the increased prevalence of CaOx uroliths and the decreased prevalence of MAP uroliths from 1981 through 1997. Mean ± SD age of cats with CaOx uroliths increased from 5.0 ± 1.9 years in 1982 to 7.8 ± 3.5 years in 1997. However, rather than a reciprocal decrease, mean age of cats with MAP uroliths also increased from 5.1 ± 3.2 years in 1982 to 6.1 ± 3.2 years in 1997. Furthermore, 95% of cats with uroliths (between 2 and 15 years old) were at increased risk for both CaOx and MAP urolith formation, and the magnitude of increased risk did not change during the 17-year period of study.

The observation that male cats had increased risk (OR, 1.5) for developing CaOx uroliths and a decreased risk (OR, 0.7) for developing MAP uroliths, whereas female cats had an increased risk (OR, 1.4) for developing MAP uroliths and a decreased risk (OR, 0.7) for developing CaOx uroliths supported the hypothesis that sex contributed to the reciprocal relationship between prevalences of CaOx and MAP uroliths during the 17-year period of study. However, when OR were adjusted for the effect of confounders, using multivariate logistic regression, males still had an increased risk of developing CaOx uroliths (OR, 1.3) but no longer had a decreased risk of developing MAP uroliths. Additionally, multiple logistic regression indicated that magnitude of risk that sex contributed to urolith formation was small (OR, 1.3 for both uroliths), compared with risk associated with breed (OR, 5.5 for cats with CaOx uroliths; OR, 2.6 for cats with MAP uroliths), age (OR, 14.6 for cats with CaOx uroliths; OR, 6.8 for cats with MAP uroliths), and reproductive status (OR, 9.5 for cats with CaOx uroliths; OR, 6.7 for cats with MAP uroliths).

Results of the present study suggested that neutered cats were at risk for development of CaOx or MAP urolithiasis, compared with sexually intact cats, and, therefore, do not support the hypothesis that reproductive status contributed to the reciprocal relationship of prevalences of CaOx and MAP uroliths. The percentage of cats with CaOx uroliths that were neutered increased from 71% for 1981 through 1986 to 96% for 1993 through 1997. The percentage of cats with MAP uroliths that were neutered increased from 63% for 1981 through 1986 to 94% for 1993 through 1997.

In conclusion, results of the present study do not support the hypothesis that changes in breed, age, sex, or reproductive status contributed to the apparent reciprocal relationship between prevalences of CaOx and MAP uroliths in cats. However, we found that breed, age, sex, and reproductive status were risk factors for CaOx and MAP urolithiasis in cats. Therefore, future studies of dietary and environmental risk factors associated with CaOx and MAP urolithiasis in cats should be designed to use cats matched for age and reproductive status to minimize confounding effects.

[a]EPI INFO version 6.04b, Centers for Disease Control, Atlanta, Ga.
[b]Winepiscope version 1.0, Frankena K, Noordhuizen J, Blas I, et al. The Netherlands: Wageningen Agricultural University.

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