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Research Article

Spontaneous mammary neoplasms in guinea pigs: 85 cases (2006-2022)

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ABSTRACT

Background: A scoping search of the literature review found 30 clinical or clinical research articles on spontaneous mammary neoplasms in guinea pigs between 1908 and 2023. Despite the many reports, only 4 described tumor biological behavior and/or the presence of metastases. This retrospective study collected data on the tumors found in guinea pigs' mammary/inguinal regions. Both mammary and mesenchymal (lipomatous) neoplasms were seen. Survival time after diagnosis of a neoplasm was evaluated. For mammary neoplasms, risk factors, such as age and sex, and prognostic factors, such as neoplasm malignancy and the effect of surgery on survival, were investigated.

Methods: Medical records of guinea pigs with mammary/inguinal neoplasms between 2006 and 2022 from 3 Parisian veterinary referral hospitals and 1 French diagnostic pathology laboratory were reviewed. Eighty-five (77%) guinea pigs had mammary neoplasms, and 25 (23%) had lipomatous neoplasms. A logistic regression model highlighted that males have significantly increased odds of malignant mammary neoplasms than females, while females (85%) are often found to have benign mammary neoplasms.

Results: Malignancy was significantly associated with aging. Older animals had greater odds of having malignant neoplasms than young animals. The mean age at diagnosis for mammary/inguinal lipomas was 3.0 years, while a benign mammary neoplasm was 3.1 years, and a malignant mammary neoplasm was 4.2 years. The survival prognosis was not influenced by the histopathological diagnosis of malignant versus benign neoplasm or the surgical technique (mastectomy vs lumpectomy) to treat the mammary neoplasm. The median survival time after diagnosis of a mammary neoplasm was 1.2 years, and for an inguinal lipoma was 3.0 years. Twenty-three percent of neoplasms in the mammary/inguinal region are lipomatous. Male guinea pigs usually have a malignant mammary neoplasm, while females mostly have a benign one. Malignancy is typically seen in older animals. In this dataset, survival time was unaffected by malignant versus benign neoplasm diagnosis or surgical treatment.

Conclusions and clinical relevance: The survival analysis results should be considered with caution in light of the small sample size.

Introduction

Guinea pigs have a single pair of mammary glands found just lateral to either side of the midline within the subcutaneous tissue of the caudal abdomen near the inguinal region. In females, mammary glands consist of lobular, pink-tan, soft glandular tissue with ducts draining to the apex of the teat as a single main duct; in males, the mammary glands are rudimentary [1]. Two retrospective studies of 1000 and 1027 pet and laboratory guinea pigs found a 1.3% and 3.6% prevalence of mammary neoplasms [2,3]. The prevalence of mammary neoplasms was significantly higher in older age groups and males.

Numerous reports of mammary neoplasms in guinea pigs are found. A scoping search of the literature (Supplement 1) was performed. The following databases (CAB Abstracts [1910-2023], BIOSIS Previews [1926-2023] and Medline [1946-2023]) were searched on March 6,

2023, with the subject headings and/or keywords guinea pigs, mammary gland neoplasms and mammary tumor for CAB; guinea pig, Cavia porcellus, mammary gland, breast, neoplasia, and/or tumor for BIOSIS; and guinea pigs, mammary neoplasms animal and breast neoplasms for Medline. No language restrictions were enforced. Seventeen reports of original findings were found [4-20]. Nine articles were case reports [4,5,8,9,11,13,14,19,20], and 8 were pathology articles looking at neoplasms in guinea pigs [10,12,16,17] or mammary neoplasia in guinea pigs [6,7,15,18]. A review of references from the 17 reports revealed another 10 reports published between 1908 and 1933 [21-30].

In 2 surveys of guinea pig lesions submitted for pathology (n = 619 [10] and 689 [31]), about half (44%-50%) of the mammary neoplasms were benign, and half (50%-56%) were malignant. Guinea pig mammary neoplasms have been subclassified based on their predominant growth pattern. Adenoma histotypes have included cyst- [6,12], fibro- [12],

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papillary- [11,12], and fibrocystadenomas [12]. Adenocarcinoma histotypes have included papillary- [6,10,11,15] and cyst- [15] adenocarcinoma, although most malignant neoplasms are described as adenocarcinoma [18]. Four reports describe the biological behavior of adenocarcinomas as being locally invasive and locally recurrent after mastectomy [2,6,15,18]. However, metastases of adenocarcinomas appear uncommon, with a 5%-10% reported metastasis rate [6,15].

Two large surveys of cutaneous masses in guinea pigs found lipomas were the most frequently reported neoplasm, accounting for 46.2% [10] and 44.6% [32] of all neoplasms. Although lipomas can occur anywhere on the body, they are often reported in the inguinal area and must be differentiated from mammary gland neoplasms [33]. Of 26 solitary lipomas identified in the second cutaneous masses survey, 16 (62%) were in the inguinal region [32]. Other locations were the trunk, neck, axilla, and head.

A major aim of this retrospective study was to describe the relationship between guinea pig sex, age, and mammary neoplasm histopathology. The second was to compare the prevalence of lipomatous and mammary neoplasms in the inguinal region. A third aim was to perform a survival analysis based on (1) whether the mammary neoplasm was benign or malignant and (2) the effect of surgery.

Materials and methods

Medical records search

The electronic medical records software of three Parisian veterinary referral hospitals was searched independently by authors BC and PR. The search strategy consisted of selecting the species "guinea pig" and combining it with the terms "mammary mass," "mammary tumor," or "inguinal mass," or "inguinal tumor." The terms "mammary mass" and "inguinal" were chosen as tumors involving the mammary region can also include mesenchymal tumors (lipomatous neoplasms such as lipomas or liposarcomas). The hospitals were the French National Veterinary School at Alfort, Fregis Referral Hospital and Advetia Referral Hospital. The medical records searched and the period were: at the French National Veterinary School at Alfort data was searched on Clovis software (Department of Agriculture, France) over the period March 2006 to July 2021; at Fregis Referral Hospital data was searched on Vetup software (Vidauban, France) over the period December 2015 to January 2020; and at Advetia Referral Hospital data was searched on AssistoVet software (Jaunay-Marigny, France) over the period January 2008 to November 2021.

In addition, data on guinea pigs with mammary masses submitted for histopathology was extracted from VetDiagnostics software (Charbonnières-les-Bains, France) at Vet Diagnostics Pathology Laboratory (Charbonnières-les-Bains, France) over the period October 2006 to May 2022. Authors BC and PR searched the pathology laboratory records.

Data extracted from medical records

A spreadsheet was created for data from the 3 hospitals. It included 1 row for each guinea pig mammary/inguinal mass consultation. The following variables were extracted for each consultation: sex, histopathological classification, age at diagnosis, age at time of death, time between diagnosis and death, clinical features of the mass (uni- or bilateral and size at the widest diameter), presence of metastases, and type of surgery performed. A similar spreadsheet was created for data from the pathology laboratory, but it only contained sex, histopathological classification, and age at diagnosis.

For guinea pig sex, only male or female sex was noted, as neuter status was not recorded for most animals. The histological classification of mammary tumors was divided into either benign (e.g., adenoma) or malignant (e.g., adenocarcinoma) neoplasms. When available, clinical features of the mammary/inguinal mass included localization (uni- or bilateral) and size at the widest diameter. For surgery, the removal of

only the tumor and a small rim of normal tissue around was defined as a lumpectomy. Removal of mammary tissue, nipple, and areola from at least one mammary region was defined as a mastectomy.

Guinea pigs were excluded from further analysis if the sex, age at the time of diagnosis, and histopathological diagnosis were unavailable. European board board-certified pathologists (ECVP) diagnosed all mammary masses microscopically. Mammary masses without confirmed mammary epithelial or myoepithelial origin (e.g., lipomatous soft-tissue neoplasms) were excluded from the main study. The prevalence of lipomatous soft-tissue neoplasms and mammary neoplasms was compared.

Statistical analysis

The animal's age and mammary tumor size (determined at the widest diameter) were assessed for normality using a Shapiro-Wilk normality test. The median, first and third quartiles were reported for these parameters since the values were not normally distributed. A binomial logistic regression model was used to evaluate the impact of the guinea pigs' age and sex on the malignancy of the mammary neoplasms. The Box-Tidwell method was used to verify the linearity of the continuous independent variable (age). The presence of outliers was verified using standardized residual standard deviation evaluation.

A Kaplan-Meier survival curve was used to calculate the median survival time of animals from diagnosis to death. Kaplan-Meier survival analysis was also used to evaluate the impact, on the median survival time of animals from diagnosis to death, of the surgical method used (mastectomy versus lumpectomy) and the mammary neoplasm's classification (benign versus malignant). A log-rank test was conducted to determine if there were any differences in the survival distributions.

All statistical analyses were considered significant if $P < 0.05$. All statistical tests and analyses were performed using IBM SPSS Statistics software (IBM SPSS Statistics for Windows, version 25.0, Armonk, NY, USA).

Results

Population summary

From the French National Veterinary School at Alfort, 3212 guinea pigs were identified and 21 (0.65%) were diagnosed with a mammary/inguinal mass; from Fregis Referral Hospital, 780 guinea pigs were identified and 5 (0.64%) were diagnosed with a mammary/inguinal mass; and from Advetia Referral Hospital, 2100 cases and 37 (1.76%) were diagnosed with a mammary/inguinal mass. For the 3 hospitals, 6092 guinea pigs were identified, and 63 (1.03%) were diagnosed with a mammary/inguinal mass. Thirty-three guinea pigs met the inclusion criteria, of which 23 had a mammary neoplasm and 10 had a lipomatous neoplasm. Mammary/inguinal masses without confirmed mammary epithelial or myoepithelial origin were not identified. From the pathology laboratory, 93 guinea pigs were diagnosed with a mammary/inguinal mass and 77 met the inclusion criteria. Sixty-two masses were mammary neoplasms and 15 were lipomatous neoplasms (Table 1).

For data analysis, 85 mammary neoplasms (62 from the pathology laboratory and 23 from the 3 hospitals) were analyzed for histopathological classification, sex, and age at diagnosis. For other variables, 23 mammary neoplasms (from guinea pigs at the three hospitals) were analyzed for the type of surgery performed, and survival analysis (age at time of death and time between diagnosis and death).

Major variables

Association between histopathological diagnosis and survival. Fifty-nine malignant mammary neoplasms (69.4%, 21 females, 38 males) and 26 benign neoplasms (30.6%, 22 females, 4 males) were identified. The neuter status of the guinea pigs was not reported in most medical or pathology records and, consequently, not investigated. Twenty-five

Table 1
Summary of Major Findings in a Retrospective Study of Mammary Neoplasms in Guinea Pigs

Prevalence	
Number of mammary and/or inguinal masses found in guinea pigs presented to a veterinarian (n = 6092)	N = 63 1.03%
Number of guinea pigs presented to a veterinarian that met inclusion criteria	33/63 Mammary tumor = 23 Lipomatous tumor = 10
Number of mammary and/or inguinal masses found in guinea pigs from the pathology laboratory data	N = 93
Number of guinea pigs from the pathology laboratory that met inclusion criteria	77/93 Mammary tumor = 62 Lipomatous tumor = 15
Combined number of mammary and/or inguinal masses	110
Number of lipomatous tumors	25
Number of mammary tumors only	85
Percentage of malignant neoplasms (n = 59)	69.4%
Percentage of benign neoplasms (n = 26)	30.6%
Ratio of tumors	
Mammary tumors: lipomatous tumors	4:1
Malignant mammary tumors: benign mammary tumors	2.3:1
Liposarcomas: lipomas	1:24
Male to female guinea pig ratios	
Malignant mammary tumor	1.8:1
Benign mammary tumor	0.2:1
Age at diagnosis	
Malignant mammary tumor	4.2 y (range 7.3 y)
Benign mammary tumor	3.1 y (range 6.0 y)
Inguinal lipoma	3.0 y (range 6.1 y)
Survival time after tumor diagnosis	
Malignant mammary tumor	0.9 y ^a
Benign mammary tumor	2.0 y ^a
All mammary tumors (benign or malignant)	1.2 y
Survival time after surgery	
Lumpectomy	0.6 y ^b
Mastectomy	1.2 y ^b

^a There was no statistical difference in survival times between malignant and benign mammary tumors.

^b There was no statistical difference in survival times between the 2 types of surgery.

lipomatous neoplasms were identified, comprising 24 lipomas (95.8%, 15 females, 9 males) and 1 liposarcoma (4.2%, 1 male) (Table 1). The histologic descriptions of the malignant mammary neoplasms included 54 adenocarcinomas (92%) and 5 carcinomas (8%). The histologic descriptions of the benign mammary neoplasms included 25 adenomas (96%) and 1 intraductal papilloma (4%).

A Kaplan-Meier survival analysis was also performed on the 23 guinea pigs from the 3 hospitals to compare the survival time with the mammary neoplasm classification (benign versus malignant). A similar percentage of censored (time to survival) cases was present in the benign (42.9%) and malignant (31.3%) groups, and the pattern of censoring was similar. Guinea pigs with benign mammary neoplasms had a median survival time of 715 days (95% CI, 0–1710), while animals with malignant mammary neoplasms had a

median survival time of 312 days (95% CI, 0–665) (Fig. 3). A log-rank test revealed no significant statistical difference ($\chi^2(1) = 0.04$, $P = 0.84$) in survival time between the 2 groups.

Association between malignancy and age or sex. For the 59 malignant mammary neoplasms, the mean age at time of diagnosis was 1545 d (4.2 y) with a range of 2665 d (7.3 y; 248 d (0.7 y) to 2913 d (8.0 y)). For the 26 benign mammary neoplasms, the mean age at time of diagnosis was 1144 d (3.1 y) with a range of 2190 d (6.0 y; 365 d (1.0 y) to 2555 d (7.0 y)) (Table 1). For the 24 animals with lipomas, the mean age at time of diagnosis was 1101 d (3.0 y) with a range of 2226 d (6.1 y; 248 d (0.7 y) to 2474 d (6.8 y)) (Table 1). For the 1 guinea pig with a liposarcoma, the age at diagnosis was 437 d (1.3 y).

A binomial logistic regression model was used to evaluate the impact of age or sex on the malignancy of mammary neoplasms in guinea pigs (Table 2). The Box-Tidwell procedure was performed to assess the linearity of the continuous variable: age. This variable was linearly related to the logit of the dependent variable (tumor malignancy). No outliers were seen when using the standardized residual standard deviation evaluation method. The Hosmer and Lemeshow test were not significant ($\chi^2(7) = 8.5$, $P = 0.29$), suggesting the model is not a poor fit. The model explained 47.2% (Nagelkerke R^2) of the variance in mammary neoplasm malignancy and correctly classified 68.2% of the cases. The 2 predictor variables were statistically significant and highlighted that males had a 20.3 times increased likelihood of exhibiting malignant mammary neoplasms compared to females (OR = 20.3 [5.1: 81.0], $P < 0.001$), and that for each passing year, animals had a 2.1 increased risk of having a malignant rather than benign mammary neoplasm (OR = 2.1 [1.4: 3.2], $P = 0.001$) (Table 2).

Association between surgical procedure and survival time. The surgical procedure was specified for 20 (87%) animals. A lumpectomy was performed in 7 guinea pigs and a mastectomy was performed in 13 animals.

A Kaplan-Meier survival analysis was conducted to compare the survival time of the 20 animals that had surgery. A similar percentage of censoring guinea pig cases was present in the lumpectomy (28.6%) and mastectomy (38.5%) groups, and the pattern of time to death was similar. Guinea pigs that underwent a lumpectomy had a median survival time of 215 days (95% CI, 0–665), while the mastectomy group had a median survival time of 454 days (95% CI, 0–1110) (Fig. 2). When using a log-rank test, no significant statistical difference ($\chi^2(1) = 0.75$, $P = 0.39$) was seen for survival time between the 2 groups.

Survival Analysis. Survival time was defined as the time interval between diagnosis and death of the animal. Of the 23 guinea pigs with mammary neoplasms from the hospitals, 15 died with a known date of death. The remaining 8 were censored (meaning either lost to follow-up or still alive at the time of this analysis). Of these 8 censored animals, 6 were lost to follow-up, and 2 were still alive. The median survival time for the 23 guinea pigs was 454 days (95% CI, [111: 796]) (Fig. 1). There were 34.8% (8/23) of censored guinea pigs in this first survival analysis. The censoring date of the cases lost to follow-up (6/8) corresponds to the date when the latest information was obtained (in consultation or by phone follow-up). For animals still alive (2/8), the censoring date corresponds to the day on which the analysis was carried out, i.e., March 29, 2023.

Table 2
Univariable and Multivariable Analysis of Factors to Determine Association with Mortality in a Cohort of Pet Guinea Pigs

Predictors	Tumor Type		Univariable Logistic Regression		Multivariable Logistic Regression	
	Benign	Malignant	ORs (95%CI)	P-value	ORs (95%CI)	P-value
Age (days)	1154 +/- 507	1547 +/- 597	1.6 (1.1 to 2.3)	0.007	2.1 (1.4 to 3.2)	0.001
Sex						
Male	4 (15%)	23 (85%)	10.1 (3.09 to 33.3)	< 0.001	20.3 (5.1 to 81.0)	< 0.001
Female	37 (64%)	21 (36%)	1		1	

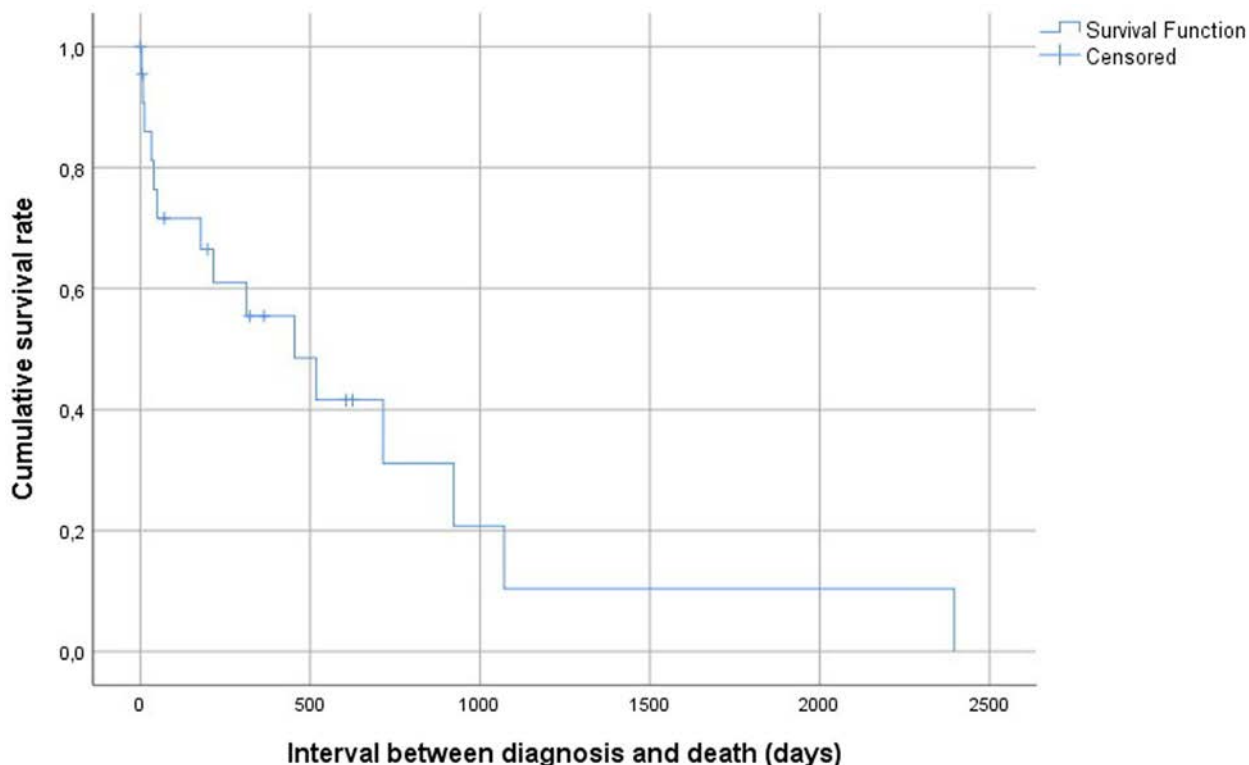


Fig. 1. Survival time in 23 guinea pigs with mammary tumors confirmed histologically. The median overall survival time after diagnosis was 454 days.

Minor variables

Clinical Characteristics. Localization of the mammary neoplasms was available for 23 (100%) animals. Twenty-two guinea pigs had a unilateral tumor, and 1 animal had a bilateral adenoma. The mammary tumor

size was available for 10 (44%) guinea pigs and ranged from 0.5 to 5.0 cm, resulting in median and quartiles of 2.0 cm [1.0: 2.8].

Metastasis Check. Five animals with malignant mammary neoplasms were investigated for metastases. Four guinea pigs had thoracic radiographs, 2 had mammary/inguinal ultrasound, and 1 had thoracic

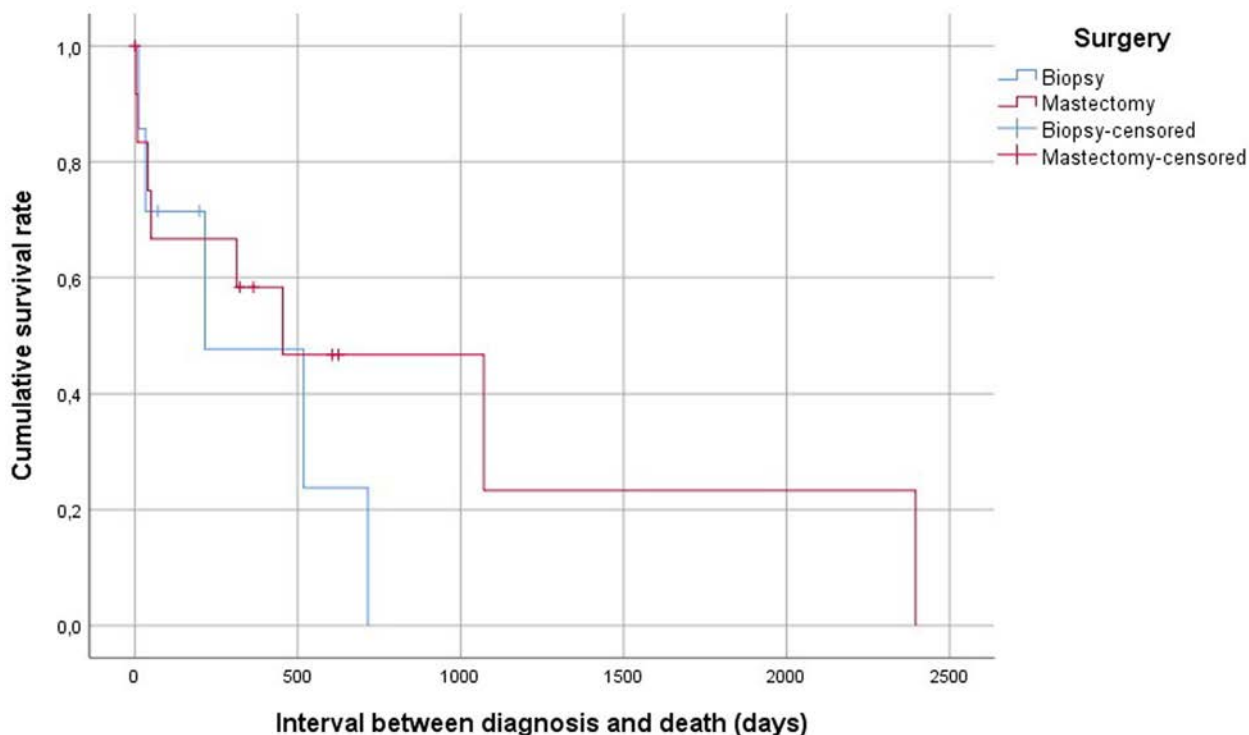


Fig. 2. Comparative survival time in 20 guinea pigs with mammary tumors for which a surgical procedure was performed.

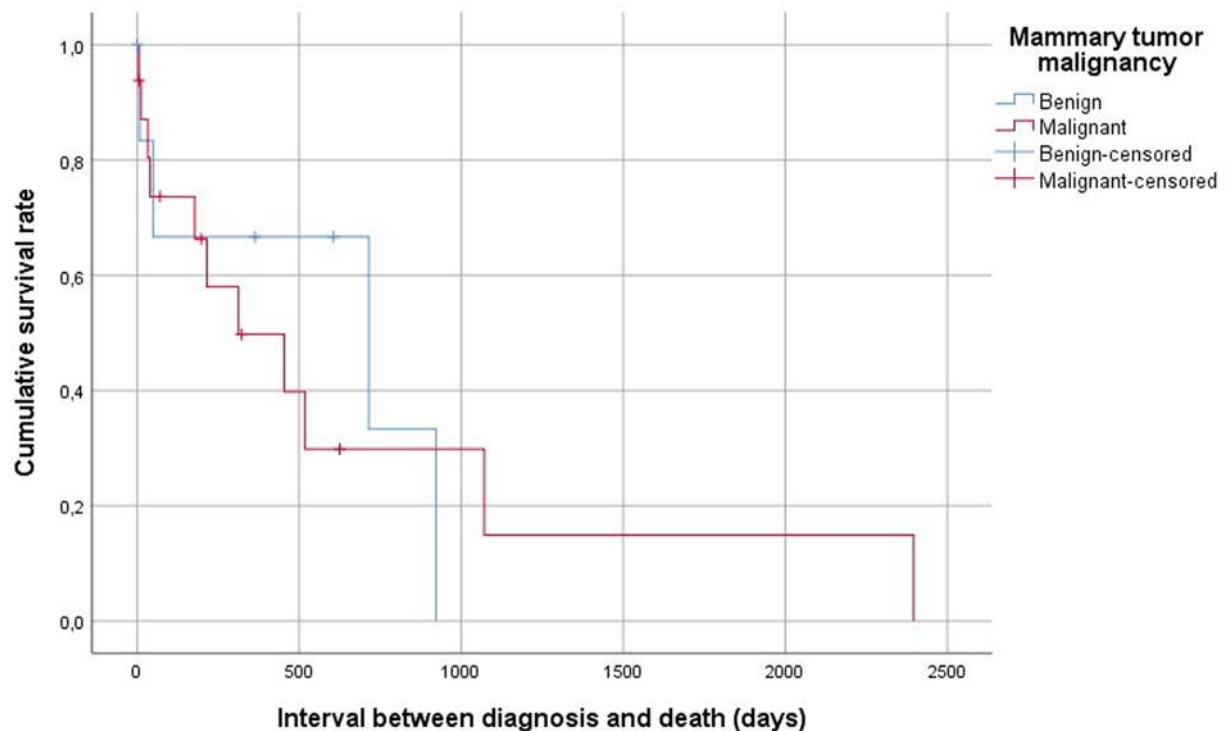


Fig. 3. Comparative survival time in 23 guinea pigs with mammary tumors depending on the tumor histotype (benign versus malignant).

contrast CT. Thoracic radiographs were free of metastases. Presurgical mammary/inguinal ultrasounds that assessed local invasiveness in surrounding tissue or local lymph nodes were free of neoplastic tissue. The presurgical thoracic contrast CT was free of metastases.

Discussion

This retrospective study of guinea pig mammary/inguinal masses was investigated in 110 animals over 16 years. Lipomatous neoplasms accounted for 23% of the tumors. Male guinea pigs usually had a malignant mammary neoplasm, while females typically had a benign one. Malignancy was primarily seen in older animals. The mean age at diagnosis for mammary/inguinal lipomas was 3.0 years, while a benign mammary neoplasm was 3.1 years, and a malignant mammary neoplasm was 4.2 years. The median survival time was 1.2 years after diagnosis of a mammary neoplasm, and survival was not affected by the histological classification of malignant or benign. Survival was also unaffected by surgical treatment.

No specific histopathological classification exists for guinea pig mammary neoplasms compared to dog and cat mammary neoplasms [34]. While veterinary pathologists often start from dog and cat neoplasm classifications to guide their diagnosis of exotic small mammal neoplasms, there are limits to this transposition, and it is seen that the neoplasms of dogs or cats do not resemble those of guinea pigs. However, pathologists can at least make a dichotomy between benign and malignant neoplasms. As the data were collected over 16 years, during which time the histopathological classification of dog and cat mammary tumor classifications changed more than once [35–37], the mammary neoplasms were divided into either benign or malignant neoplasms. No attempt was made to provide a histoprognostic grade from the histopathological classification.

There were 6092 guinea pigs identified from the 3 Parisian veterinary hospitals, and 63 (1.03%) were diagnosed with a mammary/inguinal mass. However, only 33 guinea pigs met the inclusion criteria, of which 23 had a mammary neoplasm and 10 had a lipomatous neoplasm. Our prevalence of 1.03% mammary/inguinal masses is lower than the

1.3% and 3.6% mammary tumor prevalence described in other surveys [2,3]. The report by Kohler [2] of a 1.3% prevalence came from 1027 guinea pigs (900 full necropsies and 127 organs) submitted for histopathology, of which mammary tumors made up 42% ($n = 37$) of the 89 neoplasms diagnosed. Consequently, this prevalence rate is not reflective of the true prevalence of mammary neoplasms seen in guinea pigs presented to veterinarians. The report by Minarikova et al. [3] examined disease prevalence in 1000 guinea pigs presented to the authors' clinics. Malignant mammary neoplasia was seen in 10 animals and benign mammary neoplasia in 3 animals, giving a 1.3% prevalence rate of mammary neoplasia. Using the ratio of 4:1 mammary: lipomatous neoplasms (based on 33/63 guinea pigs that met the inclusion criteria), our prevalence was 0.82% mammary neoplasms.

The report by Minarikova et al. [3] found that the prevalence of mammary neoplasia was significantly higher in animals aged 2-5 years and over 5 years compared to animals aged up to 2 years, and in males. These results are similar to those reported in this paper. Although males (51.6%) and females (49.4%) were equally diagnosed with mammary neoplasia, there was almost a double incidence of malignant mammary neoplasms in male guinea pigs compared with female guinea pigs. In contrast, there was only a 15% incidence of benign mammary neoplasms in male guinea pigs compared to female guinea pigs (85%). The incidence of malignant mammary neoplasms in male guinea pigs also agrees with other reports, which found an equal or greater prevalence in males than in females [5–9,14,18–20].

In humans, male breast cancer occurs in less than 1% of all breast cancers and is almost always positive for hormone receptors [38]. More high-grade malignant neoplasms are seen in men compared to women (85% and 50%, respectively) [39]. In cats, 1%-5% of mammary neoplasms affect males [40], and female dogs are 62 times more likely to develop mammary neoplasia than male dogs [41]. In male dogs, mammary neoplasms are more often benign. However, male cats are mostly diagnosed with malignant neoplasms [40,41]. Mammary neoplasms have been studied in aging rats and mice. Although there are different strain-related incidences of mammary neoplasms, they are rare in male mice not subjected to hormonal manipulations [42]. In rats, benign mammary neoplasms are rarely

found in males of any strain, while malignant mammary neoplasms can occur in up to 2% of male rats of several strains [43].

In this study, 23 guinea pigs (from the 3 hospitals) had a medical record describing the lateralization of the mammary tumor. Twenty-two (95.7%) guinea pigs had a unilateral tumor, and only one had a bilateral (benign) tumor. It suggests that guinea pig mammary neoplasms are likely to be unilateral. Guinea pigs' left and right mammary glands do not have a common blood supply [1]. It makes mastectomy easier and may explain why contralateral tumors are uncommon.

The benefits of early neutering on reducing the incidence of mammary neoplasia have been reported in dogs and rats [44,45], but information is lacking on the prevalence of mammary neoplasia between neutered and intact female guinea pigs, or between neutered and intact male guinea pigs. It is an area that needs further research. Interestingly, while neutered dogs are less likely to have either a single mammary mass or multiple mammary masses diagnosed, they are more likely to have a malignant mammary neoplasm [46].

The median survival time of guinea pigs after diagnosis was 715 days for benign mammary neoplasms and 312 days for malignant mammary neoplasms. The overall median survival time was 454 days. However, Figure 1 shows that about 25% of all guinea pigs diagnosed with a mammary neoplasm died within the first 100 days. The median survival time for guinea pigs after surgery for a mammary neoplasm was 215 days for a lumpectomy and 454 days for a mastectomy. However, no statistical difference is seen in survival between the 2 types of surgery. Figure 2 shows similar survival curves for over 50 % of the cases, but the statistically non-significant result supports the absence of a significant effect from the type of surgery on survival.

Due to its retrospective nature, the main limitation of this study is the lack of information about cases, as many were lost to follow-up, reducing the statistical power. Unfortunately, clinical descriptions of mammary/inguinal masses were poor, with size and clinical features (ulceration, adherence) rarely described. Breed predilection could also not be evaluated as this information was not recorded. Neuter status was not available for most patients. Further studies must determine if neutering decreases male and female guinea pigs' risk of developing mammary neoplasia, especially malignant mammary neoplasms. Additionally, future studies should investigate what is the median survival time for malignant mammary neoplasms and benign mammary neoplasms, and if the type of surgery has a prognostic significance.

Palpation of the mammary region is recommended during any clinical examination of guinea pigs for mammary neoplasms. It is important for males and individuals aged 3 years or older as malignancy is typically seen in males and older animals. However, not all tumors in the mammary region are mammary, and nearly one-quarter are lipomatous.

Declaration of competing interest

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

CRedit authorship contribution statement

Paul Raymond: Writing – review & editing, Writing – original draft, Investigation. **Thomas Coutant:** Writing – review & editing, Writing – original draft, Supervision. **Bertille Chauvaux:** Resources, Investigation, Data curation. **Patricia Muffat-es-Jacques:** Writing – review & editing, Investigation. **Albert Phouratsamay:** Writing – original draft, Investigation. **Thomas M. Donnelly:** Writing – review & editing, Validation, Supervision, Methodology. **Charly Pignon:** Validation, Supervision, Methodology, Conceptualization.

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Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1053/j.jepm.2024.04.002.

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