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ORIGINAL ARTICLE

Total prostatectomy as a treatment for prostatic carcinoma in 25 dogs

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Abstract

Objective: To describe the complications and outcome after total prostatectomy in dogs with histologically confirmed prostatic carcinoma.

Study Design: Multi-institutional retrospective case series.

Animals: 25 client-owned dogs.

Methods: Medical records of dogs undergoing total prostatectomy were reviewed from 2004 to 2016. Data retrieved included signalment, presenting signs, preoperative clinical findings, laboratory data, diagnostic imaging, surgical technique, histologic diagnosis, postoperative complications, occurrence of postoperative metastasis, and survival.

Results: Twenty-five dogs underwent total prostatectomy for prostatic carcinoma. Urinary anastomotic techniques included urethrourethral anastomosis in 14 dogs, cystourethral anastomosis in 9 dogs, ureterocolonic anastomosis in 1 dog, and anastomosis between the bladder neck and penile urethra in 1 dog. All dogs survived to discharge. Fifteen dogs were diagnosed with transitional cell carcinoma, 8 dogs with prostatic adenocarcinoma, 1 with prostatic cystadenocarcinoma, and 1 with an undifferentiated carcinoma. Permanent postoperative urinary incontinence was present in 8 of 23 dogs. The median survival time was shorter in dogs with extracapsular tumor extension compared with those with intracapsular tumors. The overall median survival time was 231 days (range, 24-1255), with 1- and 2-year survival rates equal to 32% and 12%, respectively.

Conclusion and Clinical Significance: Total prostatectomy, combined with adjunct therapies, prolongs survival and lowers complication rates compared to previous reports of dogs with prostatic carcinoma. It should be noted, however, that case selection likely played a significant role in postoperative outcome.

1 | INTRODUCTION

Prostatic neoplasia is relatively rare in dogs,[1,2] with few studies describing treatment outcomes. This limited evidence complicates comparisons among treatment modalities. Dogs are one of the few domestic species known to develop spontaneous prostatic neoplasia, with carcinomas being the most common histologic diagnosis.[3,4] Prostatic carcinomas include transitional cell carcinoma, adenocarcinoma, and squamous cell carcinoma.[5] Efforts have focused on the development of methods more objective than traditional light microscopy to differentiate prostatic adenocarcinoma from transitional cell carcinoma.[5] To the best of the authors' knowledge, these efforts have not led to an established technique, and the distinction between adenocarcinoma and transitional cell carcinoma of the prostate remains controversial.

Prostatic neoplasia carries a poor prognosis in dogs because of its typically late diagnosis, by which time aggressive local invasion is common, with a high rate of regional and distant metastasis.[2,6,7] Hematuria, stranguria, and tenesmus are common clinical signs in dogs with prostatic disease,[2,7] but a diagnosis of prostatic neoplasia is often delayed because these clinical signs are not pathognomonic. A diagnosis of prostatic neoplasia is based on physical examination findings, diagnostic imaging, cytology, and histology.

Treatment options for prostatic neoplasia include nonsteroidal anti-inflammatory drugs (NSAIDs), chemotherapy (maximum tolerated dose [MTD], metronomic, and intra-arterial), radiation therapy, photodynamic therapy, and surgery. Surgical options include curative-intent total prostatectomy and palliative-intent procedures, such as partial prostatectomy, transurethral resection, urethral stenting, and urinary diversion procedures.[8-17]

Survival of dogs with urogenital carcinoma has been improved by NSAIDs alone and combined with chemotherapeutic agents such as mitoxantrone and carboplatin.[18-21] Survival times in dogs with prostatic malignancies vary widely, from 17 to 654 days, depending on the stage at diagnosis and treatment pursued.[7,8,10-12,14,15,21-23] Furthermore, current therapeutic strategies have been associated with poor response and high complication rates. Total prostatectomy involves removal of the entire prostate gland and prostatic urethra with subsequent reconstruction of the lower urinary tract. Case selection for this procedure has been based on criteria, such as small, intracapsular primary lesions, without evidence of metastatic disease.[24] Few reports describe the outcomes of total prostatectomy, most concluding that complication rates are too high and survival times too short to recommend this technique as routine treatment of dogs with prostatic neoplasia.[22,23,25-27] The most common complication consists of urinary incontinence, diagnosed in 33%-100% of cases.[25,28]

This purpose of this retrospective multi-institutional study is to report the signalment, presenting signs, intraoperative and postoperative complications, histologic diagnosis, and outcome of dogs treated with total prostatectomy for prostatic neoplasia. We hypothesized total prostatectomy would be associated with a complication rate and survival time similar to other currently available therapeutic interventions.

2 | MATERIALS AND METHODS

2.1 | Study procedures

This investigation was a multi-institutional retrospective case series approved by the Veterinary Society of Surgical Oncology Research Committee. The study period ranged from October 2004 to August 2016. Medical records from contributing institutions were searched to identify dogs which had undergone total prostatectomy for prostatic neoplasia. Dogs were included if they had undergone total prostatectomy for confirmed prostatic carcinoma. Dogs were excluded if the diagnosis had not been confirmed as carcinoma. Data retrieved included neuter status, breed, age, body weight, presenting clinical signs, dates of presentation and surgery, results of preoperative staging and diagnostic testing, surgical technique, use and duration of postoperative indwelling urethral catheterization, histologic criteria (histologic diagnosis, surgical margin evaluation, and presence of lymphatic and/or vascular invasion), postoperative complications (incidence and severity), use of adjunctive therapy, date and method of detection of recurrent disease, and date and cause of death. Postoperative complications were classified as minor or major. Minor complications were defined as self-limiting or those managed with medical intervention. Major complications were defined as any complication that was expected to cause death without rapid intervention, or that required a second surgical procedure. Postoperative urinary incontinence was graded from 0 to 4 using a scheme modified from that reported by Byron et al[29] (Table 1) based on information recorded in the medical record, from the attending veterinarian, and from the owner.

Disease-free interval (DFI) was defined as the time between total prostatectomy and detection of confirmed or suspected metastasis or local recurrence of neoplasia. Metastasis was suspected based on imaging or clinical examination findings, and was confirmed if cytology or histology results were available. Tumor recurrence was suspected based on recurrence of clinical signs, or if imaging findings were consistent with a recurrent mass in the region of the previous surgical site. Tumor recurrence was confirmed with cytologic or histologic evidence of neoplasia.

Survival time was defined as the time between total prostatectomy and death. Cause of death was classified as either tumor-related or unrelated. Dogs for which the cause of death was unknown were presumed to have died or to have been

TABLE 1 Urinary incontinence scoring system[a]

Score	Incontinence level
0	Dog always continent
1	Dog urine soils where it has been sleeping more than 50% of the time, does not dribble urine or have a wet prepuce/ventrum when awake
2	Dog urine soils where it has been sleeping more than 50% of the time, dribbles urine or has a wet prepuce when awake up to 25% of the time
3	Poorly continent; dog urine soils where it has been sleeping more than 50% of the time and has a wet prepuce/ventrum 25%-75% of the time
4	Dog is never continent, dribbles urine when awake and when sleeping and constantly has a wet prepuce/ventrum and leaves urine when rising from a sitting to standing position

[a]Modified from Byron et al.[29]

euthanized as a result of tumor-related causes. Dogs that died from unrelated causes or were still alive at the time of writing were censored from the survival analysis.

2.2 | Statistical analysis

Descriptive statistics for signalment, historical, preoperative, and postoperative data were generated and reported as the arithmetic mean and range. DFI and survival times were reported as medians with 95% CI. Median survival times (MST) were estimated from Kaplan-Meier survival analysis. A log-rank test was used to compare survival curves of dogs with transitional cell carcinoma and prostatic adenocarcinoma. $P \leq .05$ was considered significant. Statistical software (Medcalc version 16.8.4 for Windows; Medcalc Software, Ostend, Belgium, www.medcalc.org) was used for descriptive statistical modeling and Kaplan-Meier survival analysis.

3 | RESULTS

3.1 | Signalment

Twenty-five dogs met the inclusion criteria. The median age was 9.3 years (range, 4.9-13.0). The median weight was 25.0 kg (range, 6.1-47.4). All dogs were neutered males. Breeds were Labrador Retriever (n = 5), mixed breed (n = 5), German Shepherd (n = 2), and 1 each of West Highland White Terrier, Lhasa Apso, Boxer, Dachshund, Jack Russell Terrier, Australian Cattle Dog, Siberian Husky, American Staffordshire Bull Terrier, Wheaten Terrier, Rhodesian Ridgeback, Shetland Sheepdog, Boston Terrier, and Golden Retriever (Table 2).

3.2 | Clinical findings

The most common clinical signs on presentation were dysuria (n = 12), dyschezia (n = 6), gross hematuria (n = 6), pollakiuria (n = 6), hyporexia (n = 4), and lethargy (n = 4). Prostatic enlargement was detected incidentally on routine digital rectal examination in 4 dogs. Two dogs presented with preexisting urinary incontinence (grade 2, n = 1; grade 4, n = 1). An enlarged prostate palpated on rectal examination was the most common physical examination finding (n = 16). A caudal abdominal mass was detected on abdominal palpation in 2 dogs.

3.3 | Preoperative diagnostic tests

Preoperative serum biochemistry, hematology, and urinalysis results were available for 24, 23, and 24 dogs, respectively. Serum biochemistry abnormalities included increased alkaline phosphatase (n = 4; 227-634 U/L [reference range, 23-212]), increased alanine transferase (n = 2; 189-657 U/L [reference range, 10-125]), and hypertriglyceridemia (n = 1; 539 mg/dL [reference range, 20-112]). Hematologic abnormalities included anemia (n = 1; 4.88 $\times$ 10^{12} cells/L [reference range, 5.65-8.87 $\times$ 10^{12}]), neutrophilia (n = 4; 12.5-24.6 $\times$ 10^{9} cells/L [reference range, 2.95-11.64 $\times$ 10^{9}]), and monocytosis (n = 1; 3.01 $\times$ 10^{9} cells/L [reference range, 0.16-1.12 $\times$ 10^{9}]). Urinalysis results were available for 15 dogs; abnormalities included hematuria (n = 13) and neoplastic epithelial cells on sediment examination (n = 1). Urine was cultured preoperatively in 6 dogs, and 3 of these were positive, including *Streptococcus canis* (n = 1), gram negative rods and gram positive rods and cocci (n = 1), and a positive culture without further information available (n = 1).

Preoperative imaging for clinical staging included 3-projection thoracic radiographs (n = 20), orthogonal abdominal radiography (n = 3), abdominal ultrasonography (n = 19), thoracic and abdominal computed tomography (CT) (n = 8), and abdominal magnetic resonance imaging (MRI) (n = 1). No dog had evidence of pulmonary metastatic disease. Prostatomegaly was detected in all but 1 dog. The prostate was intrapelvic and was not detected on abdominal ultrasonography in this dog. Additional imaging findings included mild internal iliac lymphadenomegaly (n = 3), pyelectasia (n = 1), and ureteral dilation (n = 1).

Preoperative cytology (n = 20) and histopathology (n = 3) reports were available for 23 dogs. Cytology results included carcinoma, not further classified (n = 17), epithelial dysplasia (n = 2), and squamous metaplasia (n = 1). Preoperative histology results were in agreement with the final postoperative diagnosis in all 3 cases with transitional cell carcinoma in 2 dogs and prostatic adenocarcinoma in 1 dog.

TABLE 2 Signalment, diagnosis, surgery details, incontinence, and outcome for dogs undergoing total prostatectomy

Dog	Age, y	Breed	Surgical technique	Postoperative urinary catheter duration, d	Diagnosis	Urinary incontinence score[a]	Adjuvant therapy	Survival times, d	Cause of death
1	10.60	Labrador retriever	CU	2	PA	3	NSAID/mitoxantrone	789	Euthanasia (renal insufficiency)
2	11.30	West Highland terrier	CU	2	TCC	0[b]	NSAID/mitoxantrone	190	Alive
3	4.90	Lhasa apsoa	UU	1	TCC	0	NSAID	628	Euthanasia (suspected metastasis)
4	12.75	Mixed breed	CU	4	TCC	2	NSAID	34	Euthanasia (confirmed pulmonary metastasis)
5	9.30	Boxer	UU	4	TCC	1	NSAID/mitoxantrone	489	Euthanasia (renal insufficiency)
6	10.58	Dachshund	UU	1	TCC	0	NSAID/mitoxantrone	231	Euthanasia (confirmed local recurrence)
7	9.25	Mixed breed	CU	1	TCC	2	NSAID/mitoxantrone	135	Euthanasia (suspected local recurrence)
8	8.50	Jack Russell terrier	CU	2	PA	0	NSAID/mitoxantrone[b]	172	Euthanasia (suspected local recurrence)
9	7.90	Australian cattle dog	UU	2	TCC	4	NSAID/mitoxantrone[b]	134	Euthanasia (suspected local recurrence)
10	8.25	Siberian husky	UU	3	PA	0	NSAID/mitoxantrone[b]/RT	65	Alive
11	11.00	German shepherd	UU	5	PA	0	Metronomic	798	Euthanasia (suspected degenerative myelopathy)
12	8.00	Mixed breed	UU	7	PA	0	Metronomic	1255	Alive
13	7.66	American Staffordshire bull terrier	CU	3	PA	0[b]	Metronomic	169	Euthanasia (suspected metastasis)
14	6.50	Wheaten terrier	UU	n/a	TCC	2	NSAID/mitoxantrone[b]	99	Euthanasia (suspected local recurrence and metastasis)
15	10.00	Golden retriever	UU	n/a	TCC	0[c]	NSAID	189	Unknown
16	10.00	Labrador retriever	CU	n/a	TCC	0[d]	NSAID/mitoxantrone	396	Euthanasia (suspected metastasis)
17	10.00	Labrador retriever	CU	n/a	TCC	4 (preexisting)	NSAID/mitoxantrone	647	Euthanasia (suspected metastasis)

(Continues)

TABLE 2 (Continued)

Dog	Age, y	Breed	Surgical technique	Postoperative urinary catheter duration, d	Diagnosis	Urinary incontinence score[a]	Adjuvant therapy	Survival times, d	Cause of death
18	9.00	Rhodesian ridge back	UU	5	TCC	0	NSAID/carboplatin	664	Euthanasia (confirmed local lymph node metastasis)
19	10.00	Mixed breed	UU	7	PA	0	NSAID/mitoxantrone	248	Euthanasia (suspected local recurrence)
20	9.00	Shetland sheepdog	UU	5	PA	1	None	31	Euthanasia (confirmed multifocal metastatic disease)
21	12.00	Labrador retriever	UU	5	TCC	0	None	88	Euthanasia (suspected metastasis)
22	9.00	Boston terrier	Anastomosis between bladder neck and penile urethra	7	PA	Unknown	None	24	Euthanasia (suspected metastasis)
23	13.00	German shepherd	Ureterocolonic anastomosis	n/a	TCC	n/a	None	138	Euthanasia (melena and lethargy)
24	9.00	Mixed breed	UU	7	TCC	0	NSAID/mitoxantrone	149	Euthanasia (confirmed local recurrence)
25	9.00	Labrador retriever	CU	5	PCA	0	NSAID/mitoxantrone[b]	330	Euthanasia (suspected metastasis)

CU, cystourethral anastomosis; n/a, data not available; NSAID, nonsteroidal anti-inflammatory drug; PA, prostatic carcinoma; PCA, prostatic cystadenocarcinoma; RT, radiation therapy; TCC, transitional cell carcinoma; UU, urethrourethral anastomosis

[a]Modified from Byron et al.[29]

[b]Mitoxantrone course not completed.

[c]Had initial postoperative incontinence that resolved.

[d]No incontinence when on phenylpropanolamine; incontinence recurred 148 days postoperatively, suspected secondary to local recurrence.

3.4 | Total prostatectomy

A retrograde urinary catheter was placed aseptically in all dogs prior to surgery. The prostate was approached via a caudal ventral midline celiotomy in all dogs. Pubic and ischial osteotomies (n = 3) or pubic symphysiotomy (n = 2) were required for further exposure in 5 dogs with an intrapelvic prostate. Enlarged medial iliac lymph nodes were detected intraoperatively and removed for histologic evaluation in 2 dogs. The deferent ducts were ligated and transected. The periprostatic fat was dissected from the prostate, with dissection as close as possible to the prostatic capsule, especially dorsally, to minimize the risk of iatrogenic damage to the neurovascular supply to the urinary bladder and urethra. The prostatic vascular supply was ligated or cauterized as close to the prostate as possible. The urinary catheter was then partially withdrawn to allow for pre- and postprostatic urethral transection before advancing the catheter back into the bladder after completion of the total prostatectomy. Urethrourethral anastomosis was performed in 14 dogs, and cystourethral anastomosis in 9 dogs. One dog had gross disease extending into the bladder and postprostatic urethra. A total cystoprostectomy was performed with bilateral ureterocolonic anastomosis in this dog. Another dog had gross disease involving a large section of the postprostatic urethra, and an anastomosis between the bladder neck and penile urethra was performed. The suture materials and patterns used for anastomosis were recorded for 19 dogs. Anastomosis was performed with a monofilament absorbable suture in all dogs by using either a simple interrupted (n = 11) or a simple interrupted and simple continuous pattern (n = 8). Closure of the celiotomy incision was routine.

3.5 | Postoperative management

A urinary catheter was maintained postoperatively in 20 dogs for a median of 4 days (range, 1-7). All dogs were treated with postoperative analgesia, and protocols were variable, including NSAIDs (n = 22), opioids (n = 20), tramadol (n = 9), ketamine (n = 1), and acetaminophen (n = 1).

3.6 | Surgical complications and outcome

All dogs survived to discharge and no intraoperative or perioperative deaths were recorded. There were 4 major complications in 4 dogs and 16 minor complications in 15 dogs. Major complications included minor incisional dehiscence (n = 2), uroabdomen (n = 1), and prepubic herniation (n = 1). Revision surgery was performed in all dogs with major complications. Uroabdomen was detected 1 day postoperatively in 1 dog, and a 15-mm laceration was found at the bladder neck. This was presumed to be iatrogenic. Prepubic herniation occurred 20 days postoperatively in another dog and was repaired with polypropylene mesh. Minor complications included permanent urinary incontinence (n = 8), urinary tract infection (n = 6), and superficial surgical site infection (n = 2).

The presence or absence of postoperative urinary incontinence was recorded in 23 dogs overall. Eleven dogs had grade 0 urinary incontinence. Urinary incontinence resolved completely in 3 additional dogs within 1-4 weeks postoperatively. In 1 dog, continence was maintained when treated with phenylpropanolamine. Eight dogs exhibited some degree of permanent urinary incontinence: grade 1 (n = 2), grade 2 (n = 3), grade 3 (n = 1), and grade 4 (n = 2). One of the dogs with grade 4 urinary incontinence had preexisting grade 4 urinary incontinence. Fifteen dogs returned to complete urinary continence within 4 weeks, although recurrent urinary incontinence, secondary to suspected local tumor recurrence, was recorded in 1 dog 148 days after surgery (Table 2). Some degree of postoperative urinary incontinence was reported in 4 of 14 dogs with urethrourethral anastomosis and in 4 of 9 dogs with cystourethral anastomosis (1 of which was preexisiting).

3.7 | Histologic diagnosis

Histologic examination of the excised prostate was performed in all dogs, with evaluation of histologic margins, capsular extension, and vascular invasion available for 20 dogs. Diagnoses included transitional cell carcinoma (n = 15), adenocarcinoma (n = 8), undifferentiated carcinoma (n = 1), and papillary cystadenocarcinoma (n = 1). For the 2 dogs with sublumbar lymph node excision, 1 dog had evidence of nodal metastasis, and the other dog had a reactive lymph node.

Of the 20 dogs with histologic margin evaluation, 8 dogs had complete excision and 12 dogs had incomplete excision. Local recurrence was either suspected or confirmed in 3 dogs with complete histologic margins and in 4 dogs with incomplete margins. There was histologically diagnosed extracapsular extension in 11 dogs and no evidence of extracapsular extension in 9 dogs. There was histologic evidence of lymphatic and/or vascular invasion in 13 dogs and no evidence of lymphatic and/or vascular invasion in 7 dogs. Metastatic disease was either confirmed or suspected in 7 dogs with lymphatic and/or vascular invasion and in 2 dogs without lymphatic and/or vascular invasion. The only variable found to be significantly associated with outcome was the presence of extracapsular extension, with the MST being significantly shorter in these dogs compared to those with intracapsular tumors ($P = .02$; Table 3).

3.8 | Adjuvant therapy

Twenty-one dogs received adjunctive therapy, including mitoxantrone and NSAIDs (n = 14); NSAIDs alone (n = 3);

TABLE 3 Comparison of MST with and without lymphatic/vascular invasion, extracapsular extension, complete histologic margins, and MTD chemotherapy

MST	With lymphatic/vascular invasion (n = 13)	Without lymphatic/vascular invasion (n = 7)	With extracapsular extension (n = 11)	Without extracapsular extension (n = 9)	With complete histologic margins (n = 12)	Without complete histologic margins (n = 8)	With MTD chemotherapy (n=15)	Without MTD chemotherapy (n = 10)
MST, d	149	248	138	248	248	172	248	138
95% CI	99-189	135-664	88-169	172-628	99-628	134-396	149-647	34-628
P-value	.12		.02		.23		.76	

MST, median survival time; MTD, maximum tolerated dose

metronomic thalidomide, cyclophosphamide, and piroxicam (n = 3); and carboplatin and deracoxib (n = 1). Dosing and protocols were variable, but of the 15 dogs treated with curative-intent chemotherapy protocols, 10 dogs completed their targeted chemotherapy protocols. Of the 5 dogs that did not complete their protocols, reasons for termination of the protocol were available for 3 dogs, and all were terminated because of the development of metastatic disease. Adverse effects were recorded for 2 dogs, both of which had episodes of neutropenia during treatment with mitoxantrone and piroxicam that resolved with dose reduction of mitoxantrone. There was no significant difference in MST for dogs that received MTD chemotherapy and those that did not ($P = .76$; Table 3). One dog was treated with adjunctive radiation therapy to the local surgical site (27 Gy divided into 10 fractions of 2.7 Gy daily, Monday through Friday), starting 20 days after total prostatectomy and bilateral medial iliac lymphadenectomy.

3.9 | Clinical outcome

Local tumor recurrence was confirmed in 3 dogs and suspected in 5 dogs. Metastatic disease was confirmed in 4 dogs and suspected in 9 dogs. Confirmed metastatic sites included lungs (n = 1); sublumbar lymph nodes (n = 1); sublumbar lymph nodes and pelvis (n = 1); and lungs, pelvis, vertebrae, adrenal glands, and sublumbar lymph nodes (n = 1). Sites of suspected metastasis included lungs (n = 6), skin (n = 1), bone (n = 1), and sublumbar lymph nodes (n = 1).

Data to calculate the DFI were available for 14 dogs. The median DFI was 81.5 days (range, 11.0-630; 95% CI 48.4-263). Data to calculate the median DFI were available for 5 dogs with suspected or confirmed local recurrence (median DFI 85.0 days [range, 76-247], 95% CI 27.7-208.7) and for 9 dogs with suspected or confirmed metastatic disease (median DFI 76.0 days [range, 24.0-630], 95% CI 31.4-305). Two dogs with recurrent disease were still alive at the time of writing, 65 and 190 days postoperatively.

Death was attributed to tumor-related causes in 19 dogs: local recurrence in 7 dogs (confirmed in 2 and suspected in 5) and metastasis in 12 dogs (confirmed in 3 and suspected in 9). Three dogs were euthanized for reasons unrelated to prostatic neoplasia. Two dogs were euthanized for clinical progression of chronic kidney disease, and 1 dog was euthanized for suspected degenerative myelopathy. Three dogs were still alive at the time of writing, ranging from 65-1255 days postoperatively.

The MST for all dogs was 231 days (range, 24-1255; 95% CI 138-628). The MST for dogs with prostatic transitional cell carcinoma was 189 days (range, 34.0-664; 95% CI 135-628), and the MST for dogs with prostatic adenocarcinoma was 248 days (range, 24-1255; 95% CI 169-789). There was no significant difference in MST between dogs with transitional cell carcinoma and those with adenocarcinoma ($P = .27$). The 1- and 2-year survival rates after total prostatectomy were 32% and 12% of dogs, respectively.

4 | DISCUSSION

This study describes a population of dogs with prostatic carcinoma and their outcome after total prostatectomy. The signalment and clinical presentation of dogs in the present study was similar to previous reports of dogs with prostatic tumors.[7,30] Total prostatectomy has been associated with an unacceptably high complication rate in previous studies in dogs.[22,24-28] However, the majority of these studies included total prostatectomy for treatment of various prostatic diseases, and only 1 publication, specifically focused on prostatic neoplasia,[22] reported short survival times (range, 5-45 days). Although this study did not disclose the incidence of postoperative urinary incontinence,[22] other studies have identified this condition as the most common complication after total prostatectomy, affecting 33%-100% of operated dogs.[25,27,28] Permanent postoperative urinary incontinence was recorded in 34.8% of dogs in the present study. The severity of urinary incontinence was subjectively graded on

the basis of owner and veterinary assessment. Of the dogs (8/23) with permanent urinary incontinence, 5 had grade 1 or 2 urinary incontinence. A previous study classified the severity of urinary incontinence after total prostatectomy as minor if it occurred only with excitement or activity, and major if it was permanent.[28] A grading system to describe the severity of urinary incontinence may assist owners in determining whether the postoperative outcome will be compatible with their expectations. Permanent urinary incontinence may be associated with secondary complications such as recurrent urinary tract infection, pyelonephritis, and urine scalding; owners should be aware of these possible sequalae.

Urinary incontinence has been assessed in both normal dogs and dogs with prostatic disease undergoing total prostatectomy.[25,31] Total prostatectomy does not result in urinary incontinence in dogs free of prostatic disease.[31] However, in study by the same authors, 93% of dogs with prostatic disease experienced urinary incontinence after total prostatectomy, 54% of these dogs having permanent incontinence.[25] This finding suggests that the surgical procedure itself cannot account for urinary incontinence and that, instead, the disease process contributes to the pathogenesis of this complication. This concept is further supported by the report of 3 dogs who underwent inadvertent prostatectomy during cryptorchidectomy but did not show postoperative signs of urinary incontinence.[32] Normal dogs undergoing total prostatectomy sustained minimal changes in urinary function.[31] Their maximal urethral closing pressure decreased, but remained high enough to resist intravesicular pressure.[31] By contrast, dogs with prostatic disease have abnormally low external urethral sphincter pressures.[25] This reduced external urethral sphincter pressure is likely exacerbated by the total prostatectomy, predisposing dogs operated for prostatic disease to urinary incontinence.

Surgical technique may also influence the development of urinary incontinence posttotal prostatectomy. The neurovascular supply to the bladder neck and prostatic urethra courses along the dorsal aspect of the prostate, and disruption of this neurovascular supply during total prostatectomy may result in urinary incontinence postoperatively.[28] Dissection in this region was performed with extra care in all dogs of our study, to minimize the risk of disrupting the innervation to the bladder neck and proximal urethra.

The comparatively low rate of urinary incontinence in the present study could also reflect the primary pathology. However, total prostatectomy in dogs with prostatic neoplasia has been proposed to increase the incidence of postoperative incontinence compared with other causes of prostatic pathology.[28] The numbers in that study were small, with only 3 of 9 dogs being diagnosed with prostatic neoplasia, 2 of which were carcinomas. Finally, case selection in our study may also have limited the rate of postoperative urinary incontinence because dogs with gross disease extending beyond the prostatic capsule may not have been deemed appropriate surgical candidates. This selection may have minimized the amount of dissection required to excise the prostate, thus limiting collateral damage to the surrounding neurovascular structures. In that regard, advanced imaging may also influence case selection, its superior sensitivity improving the delineation of local disease and detection of metastasis. Preoperative detection of more advanced disease may improve the selection of candidates with better postoperative prognosis for total prostatectomy and exclusion of less suitable candidates, who may not have been identified as such without advanced imaging.

Metastatic disease was either suspected or confirmed in 13 of 25 dogs (52.0%). This rate is comparable to previous reports in which metastasis to sublumbar lymph nodes, bone, and lungs was reported in 63%–89% of dogs at the time of diagnosis.[9] However, no association was found in our study between lymphatic or vascular tumor invasion and metastatic disease. The population of dogs in this study, however, differed from previous reports in that only 1 dog was confirmed with metastatic disease at the time of diagnosis. No difference in survival time was detected between dogs with transitional cell carcinoma or adenocarcinoma. Some authors have referred to prostatic neoplasia with various morphologic features, such as glandular and urothelial differentiation, collectively as prostatic carcinoma,[7] as we have done in the present study. This may be reasonable given the lack of a proven objective means of differentiation. Prostatic adenocarcinoma may be difficult to differentiate from transitional cell carcinoma by using light microscopy, given their similar morphologic features.[5] Immunohistochemical methods have been investigated for this purpose, but a valid method has not yet been found.[5] Accurate classification of prostatic epithelial neoplasia may be significant from a prognostic perspective, although currently this remains controversial.

The MST for dogs undergoing total prostatectomy for prostatic carcinoma in this study was 231 days (Figure 1).

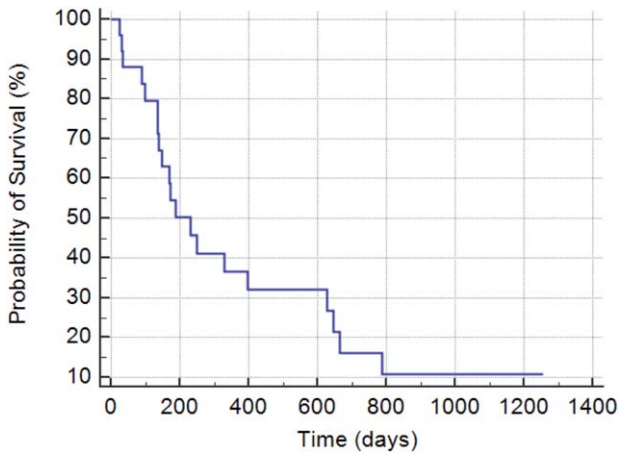

FIGURE 1 Kaplan-Meier survival curve for 25 dogs with prostatic carcinoma that underwent total prostatectomy. Dogs were censored from analysis if they were still alive at the time of writing or if they had died from causes unrelated to prostatic neoplasia

TABLE 4 Published survival times in dogs with prostatic carcinoma

Reference	Treatment	No. of dogs	MST (range)
Vlasin et al[22]	Total prostatectomy	10	17 d (5-45)
Vlasin et al[22]	Subtotal intracapsular prostatectomy	11	130 d (2-220)
Liptak et al[9]	Transurethral resection	3	32, 74, 264 d
L'Epplattenier et al[23]	Partial prostatectomy with Nd:YAG laser	8	103 d (5-239)[a]
Weisse et al[12]	Urethral stenting	12	20 d (6-105)[b]
L'Epplattenier et al[15]	Photodynamic therapy with 5-aminolevulinic acid	6	41 d (10-68)
Turrel et al[10]	Intraoperative radiation therapy	10	114 d (41-750)
Nolan et al[33]	Intensity modulated and image guided radiation therapy	21	654 d[c]
Sorenmo et al[8]	NSAID	16	6.9 mo
Sorenmo et al[8]	Untreated	16	21 d

MST, median survival time; NSAID, nonsteroidal anti-inflammatory drug.
[a]Excluding the 3 dogs that died within 16 days, MST =183 (range, 91-239).
[b]Survival time for all 12 dogs in this study (survival for cases with prostatic carcinoma were not reported separately).
[c]Survival time for all 21 dogs in this study (survival for cases with prostatic carcinoma were not reported separately).

All dogs survived to discharge, and almost one-third of dogs survived longer than 1 year after surgery. The only other study of total prostatectomy in dogs reported an MST of 17 days.[22] This study consisted of a randomized prospective trial, thereby preventing case selection. Various other treatments have resulted in survival times ranging from 17 to 654 days (Table 4).[8-10,12,15,22,23,33] However, a number of these studies included in their analyses cases with urogenital carcinomas arising from locations other than the prostate.[12,19,33] By contrast, the retrospective nature of our report may have resulted in reporting of cases deemed more suitable for total prostatectomy by the surgeon. While no reported effort was made to select cases with primary lesions under a certain size and without extracapsular extension or preexisting metastatic disease, it is reasonable to assume that these factors played a role in case selection. Only 1 case in the present study had documented metastatic disease prior to total prostatectomy. Our prolonged survival time should therefore be considered in light of our population, which consisted of dogs deemed good surgical candidates if their tumors were smaller and of lower stage.

Extracapsular extension of prostatic carcinoma may have a prognostic value because dogs with extracapsular extension experienced shorter survival times than those with intracapsular tumors. However, no association was detected between extracapsular extension and local recurrence, nor between local recurrence and MST. It is therefore unlikely that extracapsular extension contributed to the difference in MST as a consequence of an increased rate of local recurrence. Adjunctive treatment was administered in 21 of 25 dogs after total prostatectomy. While no conclusion can be drawn regarding the protocol of choice, adjunctive treatment is still recommended for dogs with prostatic carcinoma because of the high risk of metastatic disease. No difference in MST was detected between dogs treated with MTD chemotherapy and those that were not. The low number of dogs treated with surgery alone, combined with variations between adjunct treatment protocols used, precludes meaningful comparisons.

The limitations of this study are inherent to multi-institutional retrospective studies. Medical records can be inaccurate or incomplete. There was no standardization of perioperative or adjunctive treatments, and the surgeons performing the procedure differed. The cause of death was confirmed by postmortem evaluation in only 4 dogs. Retrospective inference of the degree of postoperative urinary incontinence from owner and veterinarian descriptions may be inaccurate. Also, the power of statistical analyses performed was likely limited by the small sample, which may have led to type II errors with regard to variables found to be statistically insignificant.

Based on our findings, total prostatectomy may be considered as a viable treatment option in dogs with prostatic neoplasia, particularly if presenting with urethral obstruction. Based on the outcomes of our population, the incidence and severity of urinary incontinence in dogs with prostatic carcinoma treated with total prostatectomy may be lower and survival times longer than previously reported. However, these encouraging results likely reflect our case selection. Dogs with tumors confined to the prostate or prostatic urethra, without evidence

of metastasis at the time of total prostatectomy, may have better postoperative outcomes. Prognostic factors and criteria guiding case selection warrant further investigation in prospective studies of total prostatectomy in dogs.

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CONFLICT OF INTEREST

The authors have no conflicts of interest related to this report.

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