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Total prostatectomy as a treatment for prostatic carcinoma in 25 dogs

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**Total Prostatectomy as a Treatment for Prostatic Carcinoma
in 25 Dogs**

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Review

Total Prostatectomy for Prostatic Carcinoma In Dogs

1 **Total Prostatectomy as a Treatment for Prostatic Carcinoma in 25 Dogs**

2

3 **ABSTRACT**

4 **Objective:** To describe the complications and outcome following total prostatectomy in
5 dogs with histologically-confirmed prostatic carcinoma.

6 **Study Design:** Multi-institutional retrospective case series

7 **Animals:** Twenty-five client-owned dogs

8 **Methods:** Medical records of dogs undergoing total prostatectomy were reviewed from
9 20014-2016. Data retrieved included signalment, presenting signs, preoperative clinical
10 findings, including laboratory data, diagnostic imaging, surgical technique, histologic
11 diagnosis, postoperative complications, occurrence of postoperative metastasis, and
12 survival.

13 **Results:** Twenty-five dogs underwent total prostatectomy for prostatic carcinoma.
14 Urinary anastomotic techniques included urethrourethral anastomosis in 14 dogs,
15 cystourethral anastomosis in 9 dogs, ureterocolonic anastomosis in 1 dog, and
16 anastomosis between the bladder neck and penile urethra in 1 dog. All dogs survived to
17 discharge. Fifteen dogs were diagnosed with transitional cell carcinoma, 8 dogs with
18 prostatic adenocarcinoma, 1 dog with prostatic cystadenocarcinoma, and 1 dog with an
19 undifferentiated carcinoma. Permanent postoperative urinary incontinence was present in
20 8 dogs. The median survival time was significantly shorter in dogs with extracapsular
21 tumor extension compared to those with intracapsular tumors. The overall median
22 survival time was 231 days (range, 24-1255 days) and the 1- and 2-year survival rates
23 were 32% and 12%, respectively.

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24 **Conclusions:** Based on information from this study, the median survival time for dogs
25 with prostatic carcinoma undergoing total prostatectomy is longer and complication rates
26 lower than previously reported.

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For Peer Review

Total Prostatectomy for Prostatic Carcinoma In Dogs

47 **INTRODUCTION**

48 Prostatic neoplasia is relatively rare in dogs¹ making evaluation of various therapeutic
49 interventions difficult. Despite the uncommon occurrence in dogs, they are one of the few
50 domestic species known to develop spontaneous prostatic neoplasia, with carcinomas
51 being the most common histologic diagnosis.^{2,3} Prostatic carcinomas include transitional
52 cell carcinoma, adenocarcinoma, and squamous cell carcinoma⁴. Attempts have been
53 made to develop more objective methods than traditional light microscopy for
54 differentiating prostatic adenocarcinoma and transitional cell carcinoma⁴. To the authors'
55 knowledge there is not yet a well accepted objective method of differentiation and the
56 distinction between adenocarcinoma and transitional cell carcinoma of the prostate
57 remains controversial.

58 Prostatic neoplasia carries a poor prognosis in dogs because of aggressive local invasion
59 and a high rate of regional and distant metastasis.⁵ Hematuria, stranguria and tenesmus
60 are common clinical signs in dogs with prostatic disease,^{1,6} but a diagnosis of prostatic
61 neoplasia is often delayed because these clinical signs are not pathognomonic for
62 prostatic tumors. A diagnosis of prostatic neoplasia is made based on physical
63 examination findings, diagnostic imaging, cytology, and histology. Metastatic disease is
64 often present at the time of initial diagnosis.^{1,6}

65 Various treatments have been described for prostatic neoplasia including non-steroidal
66 anti-inflammatory drugs (NSAIDs), chemotherapy, radiation therapy, photodynamic
67 therapy, and surgery. Surgical options include curative-intent total prostatectomy and
68 palliative-intent procedures such as partial prostatectomy, transurethral resection,

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69 radiation therapy, photodynamic therapy, urethral stenting, and urinary diversion
70 procedures.⁷⁻¹⁶

71 Improved survival in dogs with urogenital carcinoma has been shown with the use of
72 non-steroidal anti-inflammatory drugs (NSAIDs) alone and in combination with
73 chemotherapeutic agents such as mitoxantrone and carboplatin.¹⁷⁻²⁰ Reported survival
74 times in dogs with prostatic malignancies vary widely, depending on the stage at
75 diagnosis and treatment pursued.^{6,7,9-11,13,14, 20-22} Furthermore current therapeutic strategies
76 have been associated with poor response and high complication rates.

77 Total prostatectomy involves removal of the entire prostate gland and prostatic urethra
78 with subsequent reconstruction of the lower urinary tract. Criteria for appropriate case
79 selection for total prostatectomy in dogs have been previously suggested to include small,
80 intracapsular primary lesions, without evidence of metastatic disease.²³ There have been
81 few reports evaluating total prostatectomy with most concluding that complication rates
82 are too high and survival times are too short to routinely recommend this technique for
83 treatment of dogs with prostatic neoplasia.^{21,22,24-26} The most common complication
84 reported following total prostatectomy is urinary incontinence, which has been reported
85 in 33-100% of cases.^{24,27}

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

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92 **MATERIALS AND METHODS**

93 This investigation was a multi-institutional retrospective case series approved by the
94 Veterinary Society of Surgical Oncology Research Committee. The study period ranged
95 from October 2004 to August 2016. Medical records from contributing institutions were
96 searched to identify dogs which had undergone total prostatectomy for prostatic
97 neoplasia. Dogs were included if they had undergone total prostatectomy for confirmed
98 prostatic carcinoma. Dogs were excluded where the diagnosis was not confirmed to be
99 carcinoma. Data retrieved included neuter status, breed, age, body weight, presenting
100 clinical signs, dates of presentation and surgery, results of preoperative staging and
101 diagnostic testing, surgical technique, use and duration of postoperative indwelling
102 urethral catheterization, histologic criteria (histologic diagnosis, surgical margin
103 evaluation, and presence of lymphatic and/or vascular invasion), postoperative
104 complications (incidence and severity), use of adjunctive therapy, date and method of
105 detection of recurrent disease, and date and cause of death. Postoperative complications
106 were classified as minor or major. Minor complications were defined as self-limiting or
107 those managed with medical intervention. Major complications were defined as any
108 complication that was expected to cause death without rapid intervention or those
109 requiring a second surgical procedure. Postoperative urinary incontinence was graded
110 from 0-4 using a scheme modified from that reported by Byron et al. (Table 1)²⁸ with
111 information recorded from veterinarian assessment and owner reporting in the medical
112 history.

113 Disease-free interval (DFI) was defined as the time between total prostatectomy and
114 detection of confirmed or suspected metastasis or local recurrence of neoplasia.

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115 Metastasis was suspected if there were consistent imaging or clinical examination
116 findings and was confirmed with cytology or histology. Tumor recurrence was suspected
117 if there was a recurrence of clinical signs or if imaging findings were consistent with a
118 recurrent mass in the region of the previous surgical site; and tumor recurrence was
119 confirmed with cytologic or histologic evidence of neoplasia.

120 Survival time was defined as the time between total prostatectomy and death. Cause of
121 death was classified as either tumor-related or unrelated. Dogs for which the cause of
122 death was unknown were presumed to have died or been euthanized as a result of tumor-
123 related causes. Dogs that died from unrelated causes or were still alive at the time of
124 writing were censored from the survival analysis.

125

126 Statistical Analysis

127 Descriptive statistics for signalment, historical, preoperative, and postoperative data were
128 generated and reported as the arithmetic mean and range. Disease-free intervals and
129 survival times were reported as medians with 95% confidence intervals. Median survival
130 times (MST) were estimated from Kaplan-Meier survival analysis. A log-rank test was
131 used to compare survival curves of dogs with transitional cell carcinoma and prostatic
132 adenocarcinoma. $P \leq 0.05$ was considered significant. Statistical software (Medcalc
133 version 16.8.4 for Windows, Medcalc Software, Ostend, Belgium, www.medcalc.org)
134 was used for descriptive statistical modelling and Kaplan-Meier survival analysis.

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138 **RESULTS**139 *Signalment*

140 Twenty-five dogs met the inclusion criteria. The median age was 9.3 years (range 4.9-
141 13.0 years). The median weight was 25.0 kg (range 6.1-47.4 kg). All dogs were neutered
142 males. Breeds were Labrador retriever (n=5), mixed breed (5), German shepherd (2), and
143 1 each of West Highland White Terrier, Lhasa Apso, Boxer, Dachshund, Jack Russell
144 Terrier, Australian Cattle Dog, Siberian Husky, American Staffordshire Bull Terrier,
145 Wheaten Terrier, Rhodesian Ridgeback, Shetland Sheepdog, Boston Terrier, and Golden
146 Retriever (Table 2).

147

148 *Clinical Findings*

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

156

157 *Preoperative Diagnostic Tests*

158 Preoperative serum biochemistry, hematology and urinalysis results were available for
159 24, 23, and 24 dogs, respectively. Serum biochemistry abnormalities included increased
160 alkaline phosphatase (n=4; 227-634 U/L [reference range, 23-212 U/L]), increased

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161 alanine transferase (2; 189-657 U/L [reference range, 10-125 U/L]), and
162 hypertriglyceridemia (1; 539 mg/dL [reference range, 20-112 mg/dL]). Hematologic
163 abnormalities included anemia (1; 4.88×10^{12} cells/L [reference range, 5.65-8.87
164 $\times 10^{12}$ /L]), neutrophilia (4; 12.5 - 24.6×10^9 /L [reference range, 2.95 - 11.64×10^9 /L]) and
165 monocytosis (1; 3.01×10^9 /L [reference range, 0.16 - 1.12×10^9 /L]). Urinalysis
166 abnormalities included hematuria (13) and neoplastic epithelial cells on sediment
167 examination (1). Urine was cultured preoperatively in 6 dogs and 3 of these were
168 positive, including *Streptococcus canis* (1), Gram negative rods and Gram positive rods
169 and cocci (1), and a positive culture without further information available (1).
170 Preoperative imaging for clinical staging included three-projection thoracic radiographs
171 (n=20), orthogonal abdominal radiography (3), abdominal ultrasonography (19), thoracic
172 and abdominal computed tomography (CT) (8), and abdominal magnetic resonance
173 imaging (MRI) (1). No dog had evidence of pulmonary metastatic disease.
174 Prostatomegaly was detected in all but one dog. The prostate was intrapelvic and not
175 detected on abdominal ultrasonography in this dog. Additional imaging findings included
176 mild internal iliac lymphadenomegaly (3), pyelectasia (1), and ureteral dilation (1).
177 Preoperative cytology (20) and histopathology (3), reports were available for 23 dogs.
178 Cytology results included carcinoma, not further classified in (17), epithelial dysplasia
179 (2) and squamous metaplasia (1). Histology results were in agreement with the final post-
180 operative diagnosis in all three cases with transitional cell carcinoma in 2 dogs and
181 prostatic adenocarcinoma in 1 dog.

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184 *Total Prostatectomy*

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

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207 *Postoperative Management*

208 A urinary catheter was maintained postoperatively in 20 dogs for a median of 4 days
209 (range, 1-7).

210 All dogs were treated with postoperative analgesia and protocols were variable including
211 NSAIDs (n=22), opioids (20), tramadol (9), ketamine (1), and acetaminophen (1).

212

213 *Surgical Complications and Outcome*

214 All dogs survived to discharge and no intraoperative or perioperative deaths were
215 recorded. There were 4 major complications in 4 dogs and 16 minor complications in 15
216 dogs.

217 Major complications included minor incisional dehiscence (n=2), uroabdomen (1), and
218 prepubic herniation (1). Revision surgery was performed in all dogs with major
219 complications. Uroabdomen was detected 1 day post-operatively in 1 dog and a 15 mm
220 laceration was found at the bladder neck. This was presumed to be iatrogenic. Prepubic
221 herniation occurred 20 days post-operatively in another dog and was repaired with
222 polypropylene mesh.

223 Minor complications included permanent urinary incontinence (n=8), urinary tract
224 infection (6), and superficial surgical site infection (2).

225 Postoperative urinary incontinence was recorded in 23 dogs overall. Eleven dogs had
226 grade 0 urinary incontinence. Urinary incontinence resolved completely in 3 additional
227 dogs within 1-4 weeks postoperatively. In 1 dog, continence was maintained when treated
228 with phenylpropanolamine. Eight dogs exhibited some degree of permanent urinary
229 incontinence: grade 1 (n=2), grade 2 (3), grade 3 (1) and grade 4 (2). One of the dogs

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230 with grade 4 urinary incontinence had pre-existing grade 4 urinary incontinence. Fifteen
231 dogs returned to complete urinary continence within 4 weeks; although recurrent urinary
232 incontinence, secondary to suspected local tumor recurrence, was recorded in 1 dog 148
233 days after surgery (Table 2). Some degree of post-operative urinary incontinence was
234 seen in 4 of 9 dogs with cystourethral anastomosis (one of which was pre-existing) and 4
235 of 11 dogs with urethrourethral anastomosis.

236

237 *Histologic Diagnosis*

238 Histologic examination of the excised prostate was performed in all dogs, with a report
239 available in 20 dogs. Diagnoses included transitional cell carcinoma (n=15),
240 adenocarcinoma (8), undifferentiated carcinoma (1), and papillary cystadenocarcinoma
241 (1). For the two dogs with sublumbar lymph node excision, one dog had evidence of
242 nodal metastasis and the other dog had a reactive lymph node.

243 Of the 20 dogs with histologic margin evaluation, 8 dogs had complete excision and 12
244 dogs had incomplete excision. Local recurrence was either suspected or confirmed in 3
245 dogs with complete histologic margins and in 4 dogs with incomplete margins. There was
246 no significant difference in the rate of local recurrence between dogs with complete
247 histologic margins compared to those with incomplete margins ($P = 0.84$). There was
248 histologically diagnosed extracapsular extension in 11 dogs and no evidence of
249 extracapsular extension in 9 dogs. There was no significant difference in the rate of local
250 recurrence between dogs with extracapsular extension and those without extracapsular
251 extension ($P = 0.44$). There was histologic evidence of lymphatic and/or vascular
252 invasion in 13 dogs and no evidence of lymphatic and/or vascular invasion in 7 dogs.

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253 Metastatic disease was either confirmed or suspected in 7 dogs with lymphatic and/or
254 vascular invasion and in 2 dogs without lymphatic and/or vascular invasion. There was
255 no significant difference in the rate of metastasis between dogs with lymphatic and/or
256 vascular invasion compared to those without lymphatic and/or vascular invasion ($P =$
257 0.29).

258 There was no significant difference in MSTs between dogs with and without complete
259 histologic margins or dogs with and without lymphatic and/or vascular invasion ($P = 0.23$
260 and 0.11, respectively). The MST was significantly shorter in dogs with extracapsular
261 extension compared to those with intracapsular tumors ($P = 0.02$) (Table 3).

262
263 *Adjuvant Therapy*

264 Twenty-one dogs received adjunctive therapy, including mitoxantrone and NSAIDs
265 ($n=14$); NSAIDs alone (3); metronomic thalidomide, cyclophosphamide, and piroxicam
266 (3); and carboplatin and deracoxib (1). Dosing and protocols were variable, but of the 15
267 dogs treated with curative-intent chemotherapy protocols, 10 dogs completed their
268 targeted chemotherapy protocols. Of the five dogs that did not complete their protocols
269 reasons for termination of the protocol were available for 3 dogs and were all due to the
270 development of metastatic disease. Adverse effects were recorded for 2 dogs both of
271 which were episodes of neutropenia during treatment with mitoxantrone and piroxicam
272 which resolved with dose reduction of mitoxantrone.

273 One dog was treated with adjunctive radiation therapy to the local surgical site (27 Gy
274 divided into 10 fractions of 2.7 Gy daily, Monday through Friday), starting 20 days
275 following total prostatectomy and bilateral medial iliac lymphadenectomy.

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276 *Clinical Outcome*

277 Local tumor recurrence was confirmed in 3 dogs and suspected in 5 dogs. Metastatic
278 disease was confirmed in 4 dogs and suspected in 9 dogs. Confirmed metastatic sites
279 included lungs (n=1), sublumbar lymph nodes (1), sublumbar lymph nodes and pelvis (1),
280 and lungs, pelvis, vertebrae, adrenal glands and sublumbar lymph nodes (1). Sites of
281 suspected metastasis included lungs (6), skin (1), bone (1) and sublumbar lymph nodes
282 (1).

283 Data to calculate the DFI was available for 14 dogs. The median DFI was 81.5 days (95%
284 confidence interval (CI) 48.4-263, range 11.0-630 days). Data to calculate the median
285 DFI was available for 5 dogs with suspected or confirmed local recurrence (median DFI
286 85.0 days, 95% CI 27.7-208.7, range 76-247) and 9 dogs with suspected or confirmed
287 metastatic disease (median DFI 76.0 days, 95% CI 31.4-305, range 24.0-630). Two dogs
288 with recurrent disease were still alive at the time of writing 65 and 190 days post-
289 operatively.

290

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

297 The MST for all dogs was 231 days (95% CI 138-628, range 24-1255 days). The MST
298 for dogs with prostatic transitional cell carcinoma was 189 days (95% CI 135-628, range

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299 34.0-664) and the MST for dogs with prostatic adenocarcinoma was 248 days (95% CI
300 169-789 days, range 24-1255 days). There was no significant difference in MSTs
301 between dogs with transitional cell carcinoma and adenocarcinoma ($P = 0.27$). The 1- and
302 2-year survival rates following total prostatectomy were 32% and 12% of dogs,
303 respectively.

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322 **DISCUSSION**

323 This report describes the surgical technique and outcome of dogs undergoing total
324 prostatectomy for the treatment of prostatic carcinoma. The signalment and clinical
325 presentation of dogs in the present study was similar to previous reports of dogs with
326 prostatic tumors.^{6,29}

327 Total prostatectomy has been associated with an unacceptably high complication rate in
328 previous studies in dogs.^{21, 23, 24-27} However, the majority of these studies included total
329 prostatectomy for treatment of various prostatic diseases and only one specifically
330 investigated total prostatectomy for treatment of prostatic neoplasia.²¹ In this study,
331 survival times were short (range, 5-45 days) and the incidence of urinary incontinence
332 was not described.²¹ However, urinary incontinence was the most common postoperative
333 complication in other studies of total prostatectomy for dogs with prostatic diseases, with
334 an incidence ranging from 33%-100%.^{24,26, 27} Permanent postoperative urinary
335 incontinence was recorded in 34.8% of dogs in the present study. The severity of urinary
336 incontinence was subjectively graded based on owner and veterinary assessment. Of the 8
337 dogs with permanent urinary incontinence, 5 dogs had grade 1 or 2 urinary incontinence.
338 A previous study classified the severity of urinary incontinence following total
339 prostatectomy as minor if it only occurred with excitement or activity, and major if it was
340 permanent.²⁷ If this classification were used in the present study then only 17.4% of dogs
341 (4/23) would have been assessed to have major urinary incontinence. A grading system to
342 describe the severity of urinary incontinence may assist owners in determining whether
343 the postoperative outcome will be compatible with their expectations. Permanent urinary
344 incontinence may lead to secondary complications such as recurrent urinary tract

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345 infection, pyelonephritis, and urine scalding; and owners should be aware of these
346 possible sequelae.

347 Urinary incontinence has been assessed in both normal dogs and dogs with prostatic
348 disease undergoing total prostatectomy.^{24,31} For dogs without prostatic disease, total
349 prostatectomy does not result in urinary incontinence.³¹ However, in another study by the
350 same authors, 93% of dogs with prostatic disease had urinary incontinence following
351 total prostatectomy with 54% of these dogs having permanent incontinence.²⁴ This
352 suggests that the disease process itself may play a role in the development of urinary
353 incontinence, and urinary incontinence may not solely be a consequence of the surgical
354 technique. This is further supported by a study in which the surviving 3 dogs that
355 underwent inadvertent prostatectomy during cryptorchidectomy did not have urinary
356 incontinence following surgical correction.³² In normal dogs treated with total
357 prostatectomy, there were minimal functional changes to the urinary tract, but there was a
358 decrease in the maximal urethral closing pressure in these dogs.³¹ However, this decrease
359 in maximal urethral closing pressure was not sufficient for urethral sphincter pressure to
360 be overcome by intravesicular pressure.³¹ Dogs with prostatic disease have abnormally
361 low external urethral sphincter pressures.²⁴ This reduced external urethral sphincter
362 pressure, in combination with a decrease in maximal urethral closing pressure following
363 total prostatectomy, likely predisposes to urinary incontinence in dogs with prostatic
364 disease.

365 Surgical technique may also influence the development of urinary incontinence post-total
366 prostatectomy. The neurovascular supply to the bladder neck and prostatic urethra
367 courses along the dorsal aspect of the prostate and disruption of this neurovascular supply

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368 during total prostatectomy may result in urinary incontinence postoperatively.²⁷ Total
369 prostatectomy was performed in all dogs in the present study with close attention to the
370 dorsal dissection technique to minimize the risk of disrupting the innervation to the
371 bladder neck and proximal urethra.

372 It is possible that the comparatively low rate of urinary incontinence in the present study
373 is related to the primary pathology. However, it has been suggested that total
374 prostatectomy in dogs with prostatic neoplasia may be associated with a higher incidence
375 postoperative incontinence compared to other causes of prostatic pathology.²⁷ The
376 numbers in that study were small with only 3 of 9 dogs being diagnosed with prostatic
377 neoplasia, two of which were carcinomas. Case selection may also have played in role in
378 the lower rate of urinary incontinence in the present study as dogs may not have been
379 deemed appropriate surgical candidates if there was gross disease extending beyond the
380 prostatic capsule. This may have contributed to less aggressive dissection being required
381 to excise the prostate thus limiting collateral damage to the surrounding neurovascular
382 structures.

383 Adjunctive treatment was used in the majority of the dogs in this study, with 21 dogs
384 receiving some form of adjunctive therapy following total prostatectomy. While no
385 comment can be made on the adjunctive treatment protocol of choice, adjunctive
386 treatment is still recommended for dogs with prostatic carcinoma because of the high risk
387 of metastatic disease. Additionally, because very few dogs in this study were treated with
388 total prostatectomy alone, no comparison of outcome for surgical intervention with and
389 without adjunctive therapy can be made from this population.

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390 There was no significant difference found between completeness of histologic margins or
391 the presence extracapsular extension and local recurrence of prostatic carcinoma. There
392 was no significant difference in MST between dogs with local recurrence of prostatic
393 carcinoma compared to those without local recurrence; however the MST was
394 significantly shorter for dogs with extracapsular extension compared to those with
395 intracapsular tumors. The reason for this difference is unclear. Since there was no
396 association found between extracapsular extension and local recurrence; or local
397 recurrence and MST, it is unlikely that extracapsular extension contributed to the
398 significant difference in MST as a consequence of an increased rate of local recurrence.
399 Nonetheless the significantly shorter survival time of dogs with extracapsular extension
400 indicates that this information may be of prognostic value.

401 There was no association found between the presence of lymphatic and/or vascular
402 invasion at the time of surgery and the occurrence of metastatic disease. Likewise there
403 was no association found between the presence of lymphatic and/or vascular invasion and
404 MST. Overall metastatic disease was either suspected or confirmed in 13 of 25 dogs
405 (52.0%). This is comparable to previous reports where metastasis to sublumbar
406 lymph nodes, bone, and lungs was reported in 63–89% of dogs at the time of diagnosis.⁸

407 There was no significant difference in survival time between dogs with transitional cell
408 carcinoma or adenocarcinoma. Some authors have referred to prostatic neoplasia with
409 various morphologic features, such as glandular and urothelial differentiation,
410 collectively as prostatic carcinoma⁶ as we have done in the present study. This may be
411 reasonable given the lack of a proven objective means of differentiation. Given the
412 similar morphologic features of prostatic adenocarcinoma and transitional cell carcinoma

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413 when assessed using light microscopy it may be difficult to distinguish the precise cell
414 origin.⁴ Immunohistochemical methods have been investigated for the purpose of
415 differentiating prostatic adenocarcinoma from transitional cell carcinoma but as yet a
416 valid method has not been found.⁴ Accurate classification of prostatic epithelial neoplasia
417 may be significant from a prognostic perspective though currently this remains
418 controversial.

419 The MST time for dogs undergoing total prostatectomy for prostatic carcinoma in this
420 study was 231 days (Figure 1). All dogs survived to discharge and almost one-third of
421 dogs survived longer than one year following total prostatectomy. A MST of 17 days was
422 reported in the only other study to report a MST following total prostatectomy in dogs
423 with prostatic neoplasia²¹ Published survival times for prostatic carcinoma including
424 various other treatments range from 17 to 654 days (Table 4).^{7-9,11,14,21,22,30,33} However a
425 number of these studies included cases with urogenital carcinomas arising from locations
426 other than the prostate and did not provide separate analysis of survival for patients with
427 prostatic carcinoma alone.^{11,18,33}

428 The MST in this study population is markedly longer than that previously published for
429 dogs with prostatic carcinoma following total prostatectomy. The study by Vlasin, et al.²¹
430 reporting a MST of 17 days in dogs was prospective and randomised. This study design
431 may have contributed, in part, to the poor overall survival of those dogs as randomization
432 may have prevented selection of cases most appropriate for total prostatectomy. In
433 contrast the retrospective nature of our report may have resulted in reporting of cases
434 deemed more suitable for total prostatectomy by the surgeon. While no reported effort
435 was made to select cases with primary lesions under a certain size and without

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436 extracapsular extension or pre-existing metastatic disease, it is reasonable to assume that
437 these factors played a role in case selection. Only one case in this study had documented
438 metastatic disease prior to total prostatectomy.

439 The limitations of this study are shared with other multi-institutional retrospective
440 studies. Medical records can be inaccurate or incomplete. There was no standardization
441 of perioperative or adjunctive treatments, and the surgeons performing the procedure
442 differed. The cause of death was only confirmed by post-mortem evaluation in 4 dogs.
443 Retrospective inference of the degree of post-operative urinary incontinence from owner
444 and veterinarian descriptions may be inaccurate. Also, the power of statistical analyses
445 performed was likely limited by the small sample size.

446 Based on our findings, total prostatectomy may be considered as a viable treatment
447 option in dogs with prostatic neoplasia, particularly if presenting with urethral
448 obstruction. However, we propose that case selection is likely to play an important role in
449 postoperative complications and survival. Our study suggests that the incidence and
450 severity of urinary incontinence in dogs with prostatic carcinoma treated with total
451 prostatectomy may be lower and survival times longer than previously reported. Further
452 prospective evaluation of risk factors for post-operative complications and outcome
453 following total prostatectomy in dogs is necessary to determine appropriate case selection
454 criteria.

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Total Prostatectomy for Prostatic Carcinoma In Dogs

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460 **DISCLOSURE**

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

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Table 1 Urinary Incontinence Scoring System*

0	Dog always continent
1	Dog urine soils where is 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. Constantly has a wet prepuce/ventrum and leaves urine when rising from a sitting to standing position.

*Modified from Byron, et al.²⁸

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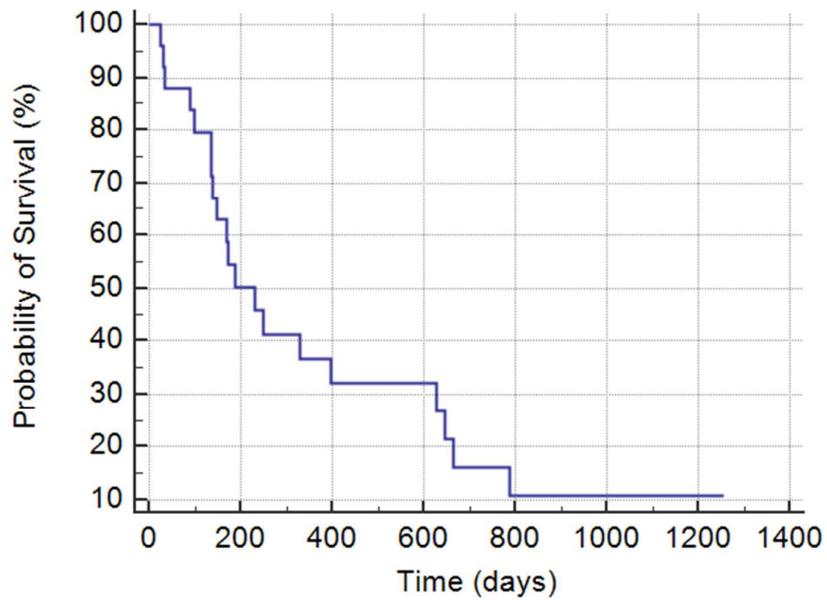


Figure 1 Kaplan-Meier survival curve for 25 dogs with prostatic carcinoma that underwent total prostatectomy. Dogs were censored from analysis if they were still alive at the time of writing or if they had died from causes unrelated to prostatic neoplasia.

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

Dog	Age (years)	Breed	Surgical Technique	Postoperative urinary catheter duration (days)	Diagnosis [†]	Urinary Incontinence Score [‡]	Survival Times (days)	Cause of death
1	10.6	Labrador retriever	CU	2	PA	3	789	Euthanasia (renal insufficiency)
2	11.3	West-Highland terrier	CU	2	TCC	0 [§]	190	Alive
3	4.9	Lhasa apsoa	UU	1	TCC	0	628	Euthanasia (suspected metastasis)
4	12.75	mixed breed	CU	4	TCC	2	34	Euthanasia (confirmed pulmonary metastasis)
5	9.3	boxer	UU	4	TCC	1	489	Euthanasia (renal insufficiency)
6	10.58	dachshund	UU	1	TCC	0	231	Euthanasia (confirmed local recurrence)
7	9.25	mixed breed	CU	1	TCC	2	135	Euthanasia (suspected local recurrence)
8	8.5	Jack Russell terrier	CU	2	PA	0	172	Euthanasia (suspected local recurrence)
9	7.9	Australian cattle dog	UU	2	TCC	4	134	Euthanasia (suspected local recurrence)
10	8.25	Siberian husky	UU	3	PA	0	65	Alive
11	11	German shepherd	UU	5	PA	0	798	Euthanasia (suspected degenerative myelopathy)
12	8	mixed breed	UU	7	PA	0	1255	Alive
13	7.66	American Staffordshire bull terrier	CU	3	PA	0 [§]	169	Euthanasia (suspected metastasis)
14	6.5	wheaten terrier	UU	n/a	TCC	2	99	Euthanasia (suspected local recurrence and metastasis)
15	10	golden retriever	UU	n/a	TCC	0 [¶]	189	Unknown
16	10	Labrador retriever	CU	n/a	TCC	0 [§]	396	Euthanasia (suspected metastasis)
17	10	Labrador retriever	CU	n/a	TCC	4 (pre-existing)	647	Euthanasia (suspected metastasis)
18	9	Rhodesian ridge back	UU	5	TCC	0	664	Euthanasia (confirmed local lymph node metastasis)
19	10	mixed breed	UU	7	PA	0	248	Euthanasia (suspected local recurrence)
20	9	Shetland sheepdog	UU	5	PA	1	31	Euthanasia (confirmed multifocal metastatic disease)
21	12	Labrador retriever	UU	5	TCC	0	88	Euthanasia (suspected metastasis)
22	9	Boston terrier	Anastomosis between bladder neck and penile urethra	7	PA	Unknown	24	Euthanasia (suspected metastasis)
23	13	German shepherd	Ureterocolonic anastomosis	n/a	TCC	n/a	138	Euthanasia (melena and lethargy)
24	9	mixed breed	UU	7	TCC	0	149	Euthanasia (confirmed local recurrence)
25	9	Labrador retriever	CU	5	PCA	0	330	Euthanasia (suspected metastasis)

*Urethrourethral anastomosis (UU), cystourethral anastomosis (CC)

† Prostatic carcinoma (PA), transitional cell carcinoma (TCC), prostatic cystadenocarcinoma (PCA)

‡ Modified from Byron et al²⁸

§ Had initial post-operative incontinence which resolve

¶ No incontinence when on phenylpropanolamine. Incontinence recurred 148 days post-operatively, suspected secondary to local recurrence

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

MST	With Lymphatic/vascular Invasion	Without Lymphatic/vascular Invasion	With Extracapsular Extension	Without Extracapsular Extension	With Complete Histologic Margins	Without Complete Histologic Margins
MST	149	248	138	248	248	172
95% CI	99.0-189	135-664	88.0-169	172-628	99.0-628	134-396
P value		0.12		0.02		0.23

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Table 4 Published Survival Times in Dogs with Prostatic Carcinoma

Reference	Treatment	MST (range)
Vlasin et al ²¹	Total prostatectomy	17 days (5-45)
Vlasin et al ²¹	Subtotal intracapsular prostatectomy	130 days (2-220)
Liptak et al ⁸	Transurethral resection	32, 74, and 264 days
L'Epplattienier et al ³⁰	Partial prostatectomy with Nd:YAG laser	103 days (5-239)*
Weisse et al ¹¹	Urethral stenting	20 days (6-105) †
L'Epplattienier et al ¹⁴	Photodynamic therapy with 5-aminolevulinic acid	41 days (10-68)
Turrel et al ⁹	Intraoperative radiation therapy	114 days (41-750)
Nolan et al ³³	Intensity modulated and image guided radiation therapy	654 days ‡
Sorenmo et al ¹⁸	NSAIDS	6.9months
Sorenmo et al ¹⁸	Untreated	21 days

*Excluding the three dogs that died within 16 days MST=183 (91-239)

†Survival time for all 12 dogs in this study (survival for cases with prostatic carcinoma not reported separately).

‡ Survival time for all 21 dogs in this study (survival for cases with prostatic carcinoma were not reported separately).

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