Pakistan Veterinary Journal

ISSN: 0253-8318 (PRINT), 2074-7764 (ONLINE)
Accessible at: www.pvj.com.pk

RESEARCH ARTICLE

Sonographic Determination of Residual Bladder Volume after Application of Different Cystotomy Closure Techniques in Dogs

IU Khan[1*], MA Khan[2], SG Bokhari[2], A Safdar[2], M Shoaib[1], H Akbar[2], S Aslam[2], MA Khan[2] and A Noor[2]

[1]Gomal College of Veterinary Sciences, Gomal University, D.I. Khan, Pakistan; [2]University of Veterinary and Animal Sciences, Abdul Qadir Jilani Road, Lahore, Pakistan
*Corresponding author: imdadsaifi@gmail.com

ARTICLE HISTORY (15-167)

Received: April 01, 2015
Revised: May 22, 2016
Accepted: July 18, 2016
Published online: September 05, 2016

Key words:
B-Mode Sonography
Cystotomy
Dogs
Residual bladder volume
Suturing patterns

ABSTRACT

Residual urine volume is measured to diagnose various neurogenic and obstructive disorders of the urinary bladder. However, it is hypothesized that cystotomy closure using inverting patterns decreases intraluminal diameter of urinary bladder which consequently reduce residual bladder volume. This study aimed to investigate the ideal suturing style for cystotomy incision closure which would exert the least effect on residual bladder volume. The effect of various suturing styles on residual bladder volume was studied sonographically. Residual Bladder Volume (RBV) was calculated by the formula, i.e. RBV=L×W×(DL+DT)/2×0.625, where L=longitudinal diameter, W=transverse diameter, DL= depth at longitudinal diameter, DT=depth at transverse diameter. 24 healthy mongrel dogs were selected and randomly divided into four equal groups A, B, C and D (n=6). In groups A, B and C, the cystotomy incision was subsequently closed by two-layered appositional suturing pattern, two-layered inverting pattern and three layers (using a combination of appositional and inverting styles), respectively. Group-D remained as sham-operated Control. The results clearly showed that the three-layered closure technique using a combination of appositional and inverting patterns (Group-C), significantly reduced the bladder volume ($P<0.01$). Two-layered inverting patterns (Group B), also reduced the bladder volume but not up to a significant level, whereas, the appositional suturing technique (group-A) exerted the least effect on residual bladder volume. Conclusively, it was inferred that a two-layered appositional suturing pattern should be preferred for closure of cystotomy incision to avoid significant changes in residual bladder volume.

To Cite This Article: Khan IU, Khan MA, Bokhari SG, Safdar A, Shoaib M, Akbar H, Aslam S, Khan MA and Noor A, 2016. Sonographic determination of residual bladder volume after application of different cystotomy closure techniques in dogs. Pak Vet J, 36(4): 431-434.

INTRODUCTION

Residual urine volume, also called residual bladder volume, refers to the urine left in the urinary bladder when the act of micturition is completed. Measurement of the residual bladder volume can help in the diagnosis of various micturition disorders (Kelly, 2004). Bladder volume is increased in various neurogenic disorders, e.g. prolapsed inter-vertebral disc, neoplasia of spinal cord, myotonia and encephalitis; obstruction and stenosis of the urinary tract e.g. urethral calculi, urethral stricture, neoplasms, and prostatic hyperplasia, and inflammation of the urethra e.g. urethritis and traumatic injury (Selius and Subedi, 2008).

The residual bladder volume can be estimated by catheterization (Kelly, 2004), contrast radiography and ultrasonography (Dudley *et al*., 2014). However, ultrasonography supervenes as a simple, safe and accurate method for the estimation of residual bladder volume (Park *et al*., 2011), because catheters may cause physical injury or infection (Wyndaele *et al*., 2012).

Cystotomy procedure is indicated for the treatment of various obstructive conditions of the urinary bladder due to stones, tumors, stricture (Brown, 2011) and foreign bodies (Kopp *et al*., 2011). The suturing patterns which have been used for cystotomy closure include the single-layered appositional suturing patterns, i.e. simple interrupted and simple continuous suturing patterns

(Stephen *et al*., 2009), double-layered using a combination of appositional and inverting patterns, i.e. simple continuous sutures followed by cushing suture pattern, and the double-layered inverting suturing patterns, i.e. cushing sutures followed by lembert suture pattern (Waldron, 2003). Three-layered closure is preferred in case of excessive hemorrhage from the bladder mucosa. Intraluminal diameter may be compromised by two-layered inverting suturing pattern which may reduce the residual bladder volume (Khan *et al*., 2013). Bladder wound requires 14-21 days to obtain 100% of normal tissue strength and usually complete re-epithelialization occurs as early as 14 days till 30 days, maximally (Abass *et al*., 2011).

In the present project two-layered appositional, two-layered inverting and three-layered (i.e. one layer of appositional plus two layers of inverting sutures) closure techniques for cystotomy were evaluated sonographically for their effect on residual bladder volume. We hypothesize that appositional and two-layered suturing patterns do not significantly affect the intraluminal diameter and the residual bladder volume.

MATERIALS AND METHODS

Preparation of animals: The study protocol was approved by the Animal Ethical Committee (Reference No. 891, dated 24.12.2011). 24 healthy mongrel dogs were selected and randomly divided into four groups A, B, C and D, comprising 6-dogs each. The mean age and weight of all the dogs was 1.48±0.43 years and 19.79±3.6 kg, respectively.

All the dogs were acclimatized, vaccinated and dewormed 1-week before surgery. Urinary bladders of all dogs were scanned through B-mode sonography to rule out the presence of cysts, tumors and cystoliths.

Experimental cystotomy surgeries: Under general anesthesia, a caudal midline celiotomy was performed and urinary bladders were manually exteriorized. A 4-cm long cystotomy incision was given on the dorsal aspect (Thilagar, 2012) and thereafter closure of the cystotomy incision was done with catgut-2/0 (Appel *et al*., 2012) in three different styles (i.e. double-layered appositional, two-layered inverting and three-layered patterns) as described below.

In group-A dogs, the cystotomy incision was closed in two-layers by appositional suturing patterns, viz. simple continuous suturing pattern for the mucosa and simple interrupted pattern for the sero-muscular layer (Gourgiotis *et al*., 2008).

In group-B dogs, the cystotomy wound was closed in two layers of inverting sutures, viz. cushing suturing pattern for the sero-muscular layer, overlapped by a lembert pattern (Waldron, 2003). In group-C dogs, the cystotomy incision was sutured in three layers, i.e. simple continuous pattern for the mucosa, followed by cushing pattern, oversewn by lembert pattern for the sero-muscular layer (Waldron, 2003). Group-D dogs remained sham-operated and were kept as control. However, normal bladder dimensions and residual bladder volume were ascertained sonographically in this group. All the dogs were kept for an experimental period of 6-weeks.

Ultrasonography: B-mode sonography, using a curvilinear transducer 3.5 MHz (U.S. Machine, Falco-100), was conducted to examine the effects of suturing patterns on residual bladder volume. In each group, sonography was conducted 1-day prior to surgery and 1-week post-surgically, respectively. Prior to surgery, the urinary bladders were scanned three times a day, preferably and immediately after the act of urination. Mean bladder volume was thus calculated for each dog pre- and post-surgically.

For sonography, the dogs were restrained in dorsal recumbency with the probe placed in caudal abdominal area adjacent to the pubic bone. Both longitudinal and transverse planes were used to scan the maximum size of the urinary bladder and the corresponding parameters of length, width and depth were measured using electronic calipers. Residual urine volume was calculated by the formula (Atalan *et al*., 1998a; 1998b):

$$\text{Residual Bladder Volume} = L \times W \times (DL+DT)/2 \times 0.625$$

where L=longitudinal diameter, W=transverse diameter, DL=depth at longitudinal diameter, DT=depth at transverse diameter). Normal residual urine volume in dogs ranges from 0.1-3.4 mL/kg (Atalan *et al*., 1999).

Frequency of urination: The dogs were released from their kennels in the morning at 8am; they were allowed to walk around and simultaneously observed for 20 minutes to record the number of successful attempts of urination. The attempts were recorded for three consecutive days before surgery and three consecutive days post-surgically. Mean values were recorded for each dog in a group before and after surgery (Atalan *et al*., 1999).

Statistical analysis: Paired-t test was applied to detect significant changes in bladder volume and frequency of urination resulting from the application of suturing techniques for cystotomy closure (Hedberg and Ayers, 2015).

RESULTS

Sonographic findings indicating changes in residual bladder volume: Changes in residual urinary bladder volume in each dog were determined using B-mode ultrasonography (Table 1). In group-A dogs in which the appositional two-layered pattern was used, mean residual bladder volume was 5.43±2.64cm^3 before surgery, while after the surgery it was reduced to 5.22±2.46cm^3, with a slight insignificant mean difference of 0.215±0.73cm^3 (Table 1). Likewise, in group-B dogs, in which two-layered inverting suturing pattern had been used, the mean residual bladder volume was recorded as 6.22±3.94cm^3 before surgery, while after the surgery it was decreased to 5.77±4.41cm^3, showing an insignificant difference of 0.44±1.21cm^3 (Table 1). However, in group-C dogs which were operated upon using a three-layered closure, the mean residual bladder volume before the surgery was 12.82±6.30cm^3 whereas after the surgery it was reduced to 11.49±5.88 cm^3 (Table 1) depicting a significant difference of 1.32±0.8cm^3 ($P<0.01$; $\alpha=0.05$), Table 1. The sham operated group-D dogs represented no change in

Table 1: Mean Bladder Volumes recorded Pre- and Post-Operatively in each group

Groups	Mean±SD (Pre-operatively) cm^3	Mean±SD (Post-operatively) cm^3	Mean difference (Pre-Op−Post-operative value) cm^3	P-value
Group-A (n=6)	5.43±2.64	5.22±2.46	0.215±0.73	0.520
Group-B (n=6)	6.22±3.94	5.78±4.41	0.44±1.21	0.409
Group-C (n=6)	12.82±6.30	11.49±5.88	1.33±0.8	0.010**
Group-D (n=6)	4.28±2.05	4.25±2.07	0.03±0.02	0.118

Group A: cystotomy closure using two-layered appositional pattern; Group B: cystotomy closure using two-layered inverting pattern; Group C: cystotomy closure using three-layered pattern (appositional in first layer, and inverting in second and third layers, respectively); ** depicts a significant decrease in bladder volume (Group C), given that α=0.050; Group-D: control group, sham operated, without cystotomy operation.

Table 2: Alterations in frequency of urination resulting from different suturing techniques used for cystotomy closure

	Before and after surgery (group 1–group 2)	Mean±SD	P-value (2-tailed)
Group-A (n=6)	groupA1–groupA2	-0.33±0.81	0.36
Group-B (n=6)	groupB1–groupB2	-0.33±0.51	0.17
Group-C (n=6)	groupC1–groupC2	-1.00±0.63	0.01**
Group-D (n=6)	groupD1–groupD2	2.0±0.02	0.19

**depicts a significant increase in frequency of urination (Group C) at α= 0.050.

bladder volume with insignificant difference of 0.03±0.02 (Table-1). Therefore, it was concluded that among the three patterns, the two-layered appositional suturing pattern did not affect the bladder volume, whereas, the three-layered cystotomy closure markedly reduced the bladder volume.

Frequency of urination: The frequency of urination was not statistically altered in group-A, B and D (control) dogs ($P<0.36$, $P<0.17$, $P\leq0.19$ respectively, at α=0.05). However, in group-C, the frequency of urination was significantly increased ($P<0.01$ at α=0.05) (Table 2).

DISCUSSION

Residual bladder volume is measured for the diagnosis of various micturition disorders which may be either due to neurogenic abnormalities in the urinary tract or various kinds of obstructive uropathies (Selius and Subedi, 2008). Many authors suggest that the residual bladder volume should be in the range of 0.2 to 0.4mL/kg, usually <10mL total (Fingeroth and Thomas, 2015). In human beings residual bladder volume has been ascertained to be 6-7mL (on average) of catheter studies (Krebs *et al*., 2013).

Residual urine volume is increased in various diseased conditions of the urinary bladder like displacement of inter-vertebral disc, neoplasia of the spinal cord, urethral stones, urethral stricture, neoplasms, prostatic hyperplasia, urethritis and traumatic injury (Selius and Subedi, 2008). In dogs, normal residual bladder volume ranges from 0.1-3.4mL/kg, on average being 0.2mL/kg, <10mL total ((Fingeroth and Thomas, 2015). Residual urine volume can conveniently and non-invasively be measured by different methods using ultrasonography (Hwang *et al*., 2004). However, in this study, residual urine volume was calculated by measuring the cross-sectional areas of the bladder, both in sagittal and transverse scan planes; the values were then used in the formula= $L\times W\times(DL+DT)/2\times0.625$ (Atalan *et al*., 2002).

There is no data available which indicates the effect of different suturing patterns on residual urine volume. In the present study, the effects of different suturing patterns on residual urine volume were evaluated sonographically. Results were relatively insignificant for group A & B ($P<0.52$, $P<0.40$, respectively) indicating that the suturing patterns (two-layered appositional and two-layered inverting type) do not significantly alter the bladder volume. In group-C dogs, however, the difference was statistically significant ($P<0.01$) indicating that the three-layered suturing technique for cystotomy closure, in which a combination of appositional and inverting sutures are used, significantly reduces the bladder volume, intraluminal diameter and thus increases frequency of urination.

One important point of differential diagnosis was the Group C pre-surgery residual volume values which were higher than the other groups. It is worthwhile to mention that the data range of 0.2-0.4mL/kg represents the range of average values which vary among the dogs of different body weights and age. Different authors have reported slightly different range of normal values for residual bladder volume. According to one author the normal residual volume counts to about 0.1-3.4mL/kg with an average of 0.2 mL/kg, <10mL total (Fingeroth and Thomas, 2015). The residual bladder volume values increase in case of neurological disorders. However, in the present study all the dogs were healthy, and not having any neurological disorders. Hence, the pre-operative bladder volumes represented the normal values which, otherwise significantly decreased with the application of a three-layered suturing pattern as in Group C.

It has also been postulated that about 75% of the bladder wall can be respected by keeping the trigone and proximal urethra preserved. However, after partial cystectomy, the bladder is seen to enlarge due to a combination of processes such as epithelial regeneration, synthesis and remodeling of the scar tissue, hypertrophy, proliferation of smooth muscles and stretching of bladder remnants. Thus, normal evacuation volumes are ultimately regained in several months (Dorsher and McIntosh, 2012).

Conclusions: Conclusively, keeping in view the above-mentioned facts, it can be predicted from the present study that different suturing styles temporarily compromise the intraluminal diameter of the urinary bladder for some time, and that through a course of several months, the residual bladder volume may be restored with normal voiding. However, amongst various suturing patterns used for closure of cystotomy incision, three-layered closure techniques significantly compromise the intraluminal diameter, which consequently decreases the residual bladder volume, simultaneously, increasing the frequency of urination. To minimize these complications, we suggest that the appositional pattern may be preferred for

cystotomy incision closure, since it produces the least sonographic and functional changes in the bladder wall and residual bladder volume, importantly.

Acknowledgements: The authors pay special thanks to Professor Dr. Atalan G. (Bristol University), Drs. Zellmer Katja and James F. Borin (Assistant Professors Urology, Maryland Medical Center) for providing valuable literature; and Prof. Dr. Naseem Ahmad (Former Dean, Faculty of Veterinary Science, University of Veterinary & Animal Sciences, Pakistan) for giving the author free access to the use of Ultrasound Machine.

Authors' contributions: IUK and MAK conceived the idea. IUK, SGB and MAK launched the initial surgical experiments and assessed the efficacy of the techniques in experimental animals. SGB, AS, MS, HA, SA, MAK and AN assisted in all subsequent surgeries and post-operative care. MAK assisted in compilation and editing of the various chapters in the thesis. IUK and MAK analyzed the data. All authors interpreted the data. Finally, all authors modified and critically revised the manuscript for important intellectual contents and approved the final version.

REFERENCES

Abass BT, Amin DMTM and Hassan AH, 2011. Cystotomy closure using a single-layer simple continuous versus continuous cushing suture patterns in dogs. Al-Anbar J Vet Sci, 4: 58-66.

Appel S, Otto SJ and Weese JS, 2012. Cystotomy practices and complications among general small animal practitioners in Ontario, Canada. Can Vet J, 53: 303-310.

Atalan G, Barr FJ and Holt PE, 1998a. Estimation of bladder volume using ultrasonographic determination of cross-sectional areas and linear measurements. Vet Rad Ultrasound, 35: 446-450.

Atalan G, Barr FJ and Holt PE, 1998b. The assessment of bladder volume by means of linear ultrasonographic measurements. Am J Vet Res, 59: 10-15.

Atalan G, Barr FJ and Holt PE, 1999. Frequency of urination and ultrasonographic estimation of residual urine in normal and dysuric dogs. Res Vet Sci, 67: 295-299.

Atalan G, Parkinson TJ, Barr FJ, Innes JF and Holt PE, 2002. Urine volume estimations in dogs recovering from intervertebral disc prolapse surgery. Berl Munch Tierarztl Wochenschr, 115: 303-305.

Brown C, 2011. Urolithiasis and cystotomy in the rabbit. Lab Anim, 40: 73-74.

Dorsher PT and McIntosh PM, 2012. Neurogenic Bladder. Adv in Urol, volume 2012: pp. 1-16.

Dudley NJ, Kirkland M, Lovett J and Watson AR, 2014. Clinical agreement between automated and calculated ultrasound measurements of bladder volume. Brit J Urol, 76: 761-762.

Fingeroth JM and Thomas WB, 2015. Medical management and nursing care for the paralyzed patient. In: Fingeroth JM and WB Thomas (Eds.), Advances in intervertebral disc disease in dogs and cats. 1st ed, Wiley Blackwell, USA, pp: 210.

Gourgiotis S, Rothkegel S and Germanos S, 2008. Combined diaphragmatic and urinary bladder rupture after minor motorcycle accident. Turk J Trauma & Emerg Surg, 14: 163-166.

Hedberg EC and Ayers S, 2015. The power of a paired *t*-test with a covariate. Soc Sci Res, 50: 277-291.

Hwang JY, Byun SS, Oh SJ and Kim HC, 2004. Novel algorithm for improving accuracy of ultrasound measurement of residual urine volume according to bladder shape. Urology, 64: 887-891.

Kelly CE, 2004. Evaluation of Voiding Dysfunction and Measurement of Bladder Volume Rev Urol, 6: S32–S37.

Khan IU, Khan MA, Chaudhry AS, Ali MM, Imran M, *et al*., 2013. Evaluation of different suturing techniques for cystotomy closure in canines. The JAPS, 23: 981-985.

Kopp RP, Dato PE and Sur RL, 2011. Bladder perforation associated with hot tub. J Sex Med, 8: 321-324.

Krebs J, Bartel P and Pannek J, 2013. Residual urine volumes after intermittent catheterization in men with spinal cord injury. Spinal Cord, 51: 776-9.

Park YH, JaHyeon K and Oh Seung-June, 2011. Accuracy of post-void residual urine volume measurement using a portable ultrasound bladder scanner with real-time pre-scan imaging. Neurourol and Urodynamics, 30: 335-338.

Selius BA and Subedi R, 2008. Urinary retention in adults: diagnosis and initial management. Am Fam Physician, 77: 643-650.

Stephen JO, Harty MS, Hollis AR, Yeomans JM and Corley KTT, 2009. A non-invasive technique for standing surgical repair of urinary bladder ruptures in a post-partum mare: a case report. Irish Vet J, 62: 734-736.

Thilagar S, 2012. Management of urinary bladder surgery in dogs. Ind J Canine Pract, 121: 121-123.

Waldron DR, 2003. Urinary Bladder. Ch 111 In: Slatter DH (ed). Textbook of Small Animal Surgery. 3rd ed, Saunders, USA, pp: 1635.

Wyndaele JJ, Brauner A, Geerlings SE, Bela K, Peter T, *et al*., 2012. Clean intermittent catheterization and urinary tract infection: review and guide for future research, Brit J Urol Int, 110: E910–E917.