PATHOGENIC BACTERIA, ANTIMICROBIAL SUSCEPTIBILITY AND ULTRASONOGRAPHIC FEATURES OF FELINE LOWER URINARY TRACT DISEASE

By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Veterinary Science

August 2022

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Feline lower urinary tract disease (FLUTD) is a common condition affecting cats urinary bladder and urethra with varying prevalence globally. The condition is caused by uroliths, urethral plugs, bacterial infections or neoplasia. Internationally, there has been an increase in the rate of FLUTD caused by urinary tract infections (UTI). This study aimed to characterise clinical features, diagnostic imaging and laboratory findings in cats with FLUTD, both retrospectively and prospectively. History, signalment and physical examination information of the cats were obtained. Laboratory findings including haematology, biochemistry, urinalysis, bacterial identification, antibiotic sensitivity testing and diagnostic imaging findings were analysed. In addition of this, the prospective study analysed temporal ultrasonographic changes in the bladder at 3-day intervals during the hospitalisation period. In both studies, results showed that most cats were male and belonged to multi-cat households with no access to outdoors. In both studies common clinical signs were stranguria and inappetence. Neutrophilia and hyperkalemia were common clinicopathological abnormalities recorded along with elevated blood urea nitrogen and creatinine. The retrospective study included 61 cases which reported the most common bacterial pathogens of FLUTD were *Staphylococcus* spp. (23.2%), *Enterococcus* spp. (17.9%)*, and Escherichia coli* (16.1%)*.* It was also found that *Escherichia coli* and *Klebsiella pneumoane* recorded high level of antibiotic resistance. The impact factor calculated was found highest for cephalexin (31.14) and amoxicillin / clavulanic acid (30.82). Uroliths and emphysemateous cystitis were diagnosed by radiography, while bladder leakage and urethral stenosis were found on contrast cystography. Ultrasonography was used to diagnose pseudomembraneous cystitis, emphysemateous cystitis, cystitis and evaluate kidney size. In the prospective study, temporal ultrasonographic changes were recorded at 3-day intervals for 13 cats diagnosed with FLUTD. This led to change in treatment protocol of two

cases from medical to surgical management. This prospective study also documented the first occurrences of *Enterobacter cloacae* in a case of emphysematous cystitis and *Pasteurella* spp. in a case of pseudomembraneous cystitis. *Proteus mirabilis* was the most common urinary bacterial pathogen found in the prospective study. This study contributed to the understanding of the clinical manifestation of FLUTD, the bacterial pathogens and the temporal ultrasonographic changes.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Veterinar Sains

BAKTERIA PATOGENIK, KERENDAHAN ANTIMIKROB DAN CIRI-CIRI ULTRASONOGRAFI PENYAKIT SALURAN KENCING BAWAH FELINE

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Penyakit saluran kencing bawah kucing (FLUTD) ialah adalah keadaan biasa yang menjejaskan pundi kencing dan uretra kucing dengan kelaziman yang berbeza-beza di seluruh dunia. Keadaan ini disebabkan oleh urolit, palam uretra, jangkitan bakteria atau neoplasia. Di peringkat antarabangsa, terdapat peningkatan dalam kadar FLUTD yang disebabkan oleh jangkitan saluran kencing (UTI). Kajian ini Kajian bertujuan untuk mencirikan mengkategorikan ciri-ciri klinikal, pengimejan diagnostik dan penemuan makmal dalam kucing dengan FLUTD, secara retrospektif dan prospektif. Maklumat sejarah, isyarat dan pemeriksaan fizikal kucing diperolehi. Penemuan makmal termasuk hematologi, biokimia, urinalisis, pengenalpastian bakteria, ujian sensitiviti antibiotik dan penemuan pengimejan diagnostik telah dianalisis. Di samping itu, kajian prospektif menganalisis perubahan ultrasonografi temporal dalam pundi kencing pada selang 3 hari semasa tempoh kemasukan ke hospital. Dalam kedua-dua kajian, keputusan menunjukkan bahawa kebanyakan kucing adalah jantan dan tergolong berada di dalam rumah berbilang kucing tanpa akses ke luar. Dalam kedua-dua kajian, tanda-tanda klinikal yang biasa adalah stranguria dan ketidakupayaan. Neutrophilia dan hiperkalemia adalah keabnormalan klinikopatologi yang biasa direkodkan bersama dengan peningkatan nitrogen urea darah dan kreatinin. Kajian retrospektif termasuk 61 kes yang melaporkan patogen bakteria FLUTD yang paling biasa ialah Staphylococcus spp., Enterococcus spp., dan Escherichia coli. Juga didapati bahawa Escherichia coli dan Klebsiella pneumoane mencatatkan tahap rintangan antibiotik yang tinggi. Faktor impak yang dikira didapati paling tinggi adalah untuk cephalexin dan amoxicillin / asid klavulanat. Uroliths dan cystitis emfisemateous telah didiagnosis melalui radiografi, manakala kebocoran pundi kencing dan stenosis uretra didapati pada cystography kontras. Ultrasonografi digunakan untuk mendiagnosis cystitis pseudomembraneous, cystitis emfisemateous, cystitis dan menilai saiz buah pinggang. Dalam kajian prospektif, perubahan ultrasonografi temporal direkodkan pada selang 3 hari untuk 13 kucing yang

didiagnosis dengan FLUTD. Ini membawa kepada perubahan dalam protokol rawatan dua kes daripada pengurusan perubatan kepada pembedahan. Kajian prospektif ini juga mendokumentasikan kejadian pertama Enterobacter cloacae dalam kes cystitis emfisematous dan Pasteurella spp. dalam kes cystitis pseudomembraneous. Proteus mirabilis adalah patogen bakteria kencing yang paling biasa ditemui dalam kajian prospektif. Kajian ini menyumbang kepada pemahaman tentang penemuan klinikal FLUTD, patogen bakteria dan perubahan ultrasonografi temporal.

ACKNOWLEDGEMENTS

I thank God for giving me the focus, patience, strength and faith during this time.

I thank my family for their support throughout this master's degree.
My grandfather without whose support I would have never begun my studies overseas.

I'm extremely grateful for my supervisor Assoc. Prof. Dr. Lau Seng Fong who has given me never ending support, guidance and encouragement. She has been a driving force and never gave up on me.

I would also like to thank Dr. Sharina Omar for her guidance, expertise and encouragement.

I would not have been able to deal with the stress of this degree if it wasn't for the support from my friends and colleagues; Dr. Phoebe and Dr. Dylan.

Other friends who helped me through this journey include Dr. Ikhwan, Dr. Sim JJ, Dr. Bryan, Dr Joash, Dr Ph'ng, Dr Waseem.

I am also grateful to all the AVOs and staff at the radiology unit, cat medicine ward and bacteriology lab for their patience, support and guidance.

Finally, I would also like to thank my friends back from India; Aman, Utkarsh Rahul and Sneha, for providing long distance support and encouragement virtually whenever needed.

This thesis was submitted to the Senate of the Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Veterinary Science. The members of the Supervisory Committee were as follows:

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LIST OF ABBREVIATIONS

A:G	albumin : globulin
ALP	alkaline phosphatase
ALT	alanine aminotransferase
AMR	antimicrobial resistance
BID	bis in die
BUN	blood urea nitrogen
CFU	colony forming unit
DSH	Domestic Short Hair
EC	emphysematous cystitis
FIC	feline idiopathic cystitis
FLUTD	feline lower urinary tract disease
FPC	feline pseudomembranous cystitis
IF	impact factor
IV	intravenous
hpf	high power field
n	number
NA	not applicable
pH	potential Hydrogen
PO	Per Os
PU	perineal urethrostomy
SG	specific gravity
spp.	species
UK	United Kingdom
USA	United States of America
UTI	urinary tract infection

CHAPTER 1

INTRODUCTION

Feline lower urinary tract disease (FLUTD) describes a collection of conditions that affect a cats' urinary bladder and urethra. This includes conditions like uroliths, bacterial infections, urethral plugs, neoplasia, and idiopathic cystitis (Martinez-Ruzafa et al., 2012; Sævik et al., 2011). Globally 1.6 to 6% of cats presented to veterinary practices are diagnosed with FLUTD. (Dorsch et al., 2014; Eggertsdóttir et al., 2007; Gerber et al., 2005; Lew-Kojrys et al., 2017; Sævik et al., 2011). FLUTD is presented with clinical signs such as haematuria, stranguria, dysuria, periuria and/or pollakiuria, with or without obstructions (Gerber et al., 2005). Feline idiopathic cystitis (FIC) is currently the leading cause of FLUTD and accounting for 55 to 60% of FLUTD cases, followed by urolithiasis in 12 to 22% cases and 1.5 to 20% involving bacterial infections (Dorsch et al., 2014; Eggertsdóttir et al., 2007; Gerber et al., 2005; Lew-Kojrys et al., 2017; Sævik et al., 2011). Bacterial urinary tract infections were diagnosed in only 1 to 3% of FLUTD cases in the USA while in Europe, a higher occurrence was reported from 8 to 25% (Eggertsdóttir et al., 2007; Gerber et al., 2005).

Diagnostic workup of FLUTD includes urinalysis, haematology, serum biochemistry, diagnostic imaging techniques such as radiography, ultrasonography, urine culture and antibiotic sensitivity testing (Buffington, 2011; Forrester et al., 2015; Sævik et al., 2011). Ultrasonography plays an important role not only in diagnosing but also monitoring the progression of FLUTD. Common ultrasonography findings in FLUTD include irregular thickening of the urinary bladder wall and presence of calculi, necrotic debris, or blood clots within the bladder lumen. Ultrasonography allows recording of the bladder lumen in real time which is vital in such conditions with rapidly occurring changes. This enables clinicians to monitor the effectiveness of the treatment administered and modify treatments accordingly. Often ultrasonography is not performed on uncomplicated cases, which can result in misdiagnosis or underdiagnosis of conditions. A diagnosis of FIC is made only when no other cause can be found after performing a thorough diagnostic workup (Buffington et al., 2011).

Quantitative urine culture and antibiotic sensitivity testing is performed to identity bacteria present in the bladder and to assist in deciding the antibiotic of choice. The common bacterial pathogens isolated in cats with FLUTD were *Escherichia. coli, Staphylococcus* spp. *and Enterococcus* spp. (Dorsch et al., 2014; Dorsch et al., 2015; Eggertsdóttir et al., 2007; Litster et al., 2009). There is limited data regarding feline urinary pathogens currently available in Malaysia. A case report by Hemasri et al., 2018, reported presence of *Escherichia coli* concurrent with hemotropic mycoplasmosis in a domestic short hair cat.

Treatment and management of FLUTD is case specific. Generally, treatment includes anti-inflammatory drugs, anti-spasmodic drugs and catheterization in blocked cats, paired with appropriate pain management (Black, 2018). A change

in diet from dry kibbles to wet food is also advised, such as to increase the animals water intake. Antibiotics should be prescribed only in cases with evidence of bacterial urinary tract infections based on urine culture and sensitivity results. Periodic monitoring of urinary pathogens and their susceptibility patterns help in selection of empirical antibiotic therapy and monitor presence of resistant bacteria within the country's feline population. Currently, no records of such data exist in Malaysia. Empirical treatment choices currently are based on global data which may differ from local findings. Increasing levels of antibiotic resistance is a global concern. It complicates therapy, can result in therapeutic failure, increased patient mortality and morbidity, and overall treatment costs. It also presents a public health concern as some of these pathogens are potentially zoonotic.

Cats are common household pets in Malaysia, with pet numbers increasing in today's world, more effort and attention is devoted to animal welfare, leading to more treatments for sick animals, and thus more frequent use of antibiotics. The proportion of FLUTD cases that are caused by bacterial pathogens in Malaysia is currently unknown. Antimicrobial resistance (AMR) is a consequence of indiscriminate use of antimicrobials, resulting in development of drug resistant pathogenic bacteria. This is often seen where cats are prescribed antibiotics without evidence of a bacterial infection due to pressure from owners or their refusal of diagnostic tests. A critical aspect of AMR in pets is their proximity and physical contact to humans (Guardabassi et al., 2004), that results in higher risk of infection and cross transmission of AMR traits (Klous et al., 2016; Messenger et al., 2014). The World Health Organization has reported that an increasing resistance to critical antibiotics is likely to lead to increased mortality (Antibiotic resistance., 2020).

This preliminary study clinically investigated FLUTD cases presented to the University Veterinary Hospital, Faculty of Veterinary Medicine, Universiti Putra Malaysia from 2018 to 2021. It analysed the clinical manifestation of cats with FLUTD, the bacterial pathogents and their antibiotic sensitivity results. Based on these results, impact factor of these antibiotics was calculated to guide empirical treatment. It further highlighted the importance of positive urine culture results in decision to administer antibiotics, as not all cases diagnosed with FLUTD had evidence of bacteriuria. It also recorded and described temporal ultrasonographic changes in cats diagnosed with FLUTD. The progression of the condition and response to treatment was observed through these changes, and in some cases treatment protocol was changed.

1.1 Problem statement

Feline lower urinary tract disease is a common disease presented to veterinary practices. Currently there is limited data regarding the clinical manifestation, diagnosis and treatment of cats diagnosed with feline lower urinary tract disease in Malaysia. There is a lack of data about the bacterial pathogens responsible for feline urinary tract infections in Malaysia, the antibiotics used to treat these infections and the impact factor of the antibiotics. Furthermore there is also a lack of data reporting temporal ultrasonographic changes seen in cases with FLUTD during hospitalisation.

This study gives a better understanding of the clinical manifestation, diagnostic features and the bacterial pathogens that cause FLUTD. This study can improve our understanding of FLUTD caused by bacterial pathogens, improving the diagnosis and treatment outcomes of future patients. This study also highlights the current antibiotic resistance amongst the bacterial pathogens and reports on the temporal ultrasonographic changes seen in cases of FLUTD.

1.2 Objectives

The objectives of this study are:

1. To investigate the clinical appearance, common bacterial causes and diagnostic imaging findings of cats diagnosed with feline lower urinary tract disease in University Veterinary Hospital, UPM, Malaysia from 2018-2019.
2. To identify common pathogenic bacteria, antibiogram and impact factor of antibiotics prescribed to cats with lower urinary tract infections. To describe ultrasonographic features of the bladder of cats diagnosed with FLUTD, at University Veterinary Hospital from 2020-2021.

REFERENCES

Ackerman, N. (1991). *Radiology and ultrasound of urogenital diseases in dogs and cats*. Ames (IA): Iowa State University Press; (32-35).

Ackerman, N., Wingfield, W. E., & Corley, E. A. (1972). Fatal air embolism associated with pneumourethrography and pneumocystography in a dog. *Journal of the American Veterinary Medical Association*, *160*(12), 1616–1618.

Aisyah, J (2017 Pattern of clinicopathological parameters of cats with lower urinary tract disease presented to University Veterinary Hospital, UPM, Universiti Putra Malaysia (thesis). http://psasir.upm.edu.my/id/eprint/78293/1/FPV%202017%2027%20-%20IR.pdf

Aizenberg, I., & Aroch, I. (2003). Emphysematous Cystitis due to Escherichia coli Associated with Prolonged Chemotherapy in a Non-Diabetic Dog. *Journal of Veterinary Medicine, Series B*, *50*(8), 396–398.

Alashraf, A. R., Lau, S. F., Khor, K. H., Khairani-Bejo, S., Bahaman, A. R., Roslan, M. A., Rahman, M. S. A., Goh, S. H., & Radzi, R. (2019). Serological Detection of Anti-Leptospira Antibodies in Shelter Cats in Malaysia. *Topics in Companion Animal Medicine*, *34*, 10–13.

Alleman, R., & Wamsley, H. (2017). Complete urinalysis. In *BSAVA Manual of Canine and Feline Nephrology and Urology* (3rd ed., pp. 60–83). British Small Animal Veterinary Association.

Allstadt, S. D., Lee, N., & Scruggs, J. L. (2014). Clinical rounds-transitional cell carcinoma. *Vet Med*, *109*(10), 327–333.

Amano, M., & Shimizu, T. (2014). Emphysematous cystitis: A review of the literature. In *Internal Medicine* (Vol. 53, Issue 2, pp. 79–82).

Antibiotic resistance. (2020, July 31). https://www.who.int/news-room/fact-sheets/detail/antibiotic-resistance

Armbruster, C. E., & Mobley, H. L. T. (2012). Merging mythology and morphology: the multifaceted lifestyle of Proteus mirabilis. *Nature Reviews Microbiology*, *10*(11), 743–754.

Astuty, A. T. J. E., Tjahajati, I., & Nugroho, W. S. (2020). Detection of feline idiopathic cystitis as the cause of feline lower urinary tract disease in Sleman Regency, Indonesia. *Veterinary World*, *13*(6), 1108–1112.

Bailiff, N. L., Westropp, J. L., Nelson, R. W., Sykes, J. E., Owens, S. D., & Kass, P. H. (2008). Evaluation of urine specific gravity and urine sediment as risk factors for urinary tract infections in cats. *Veterinary Clinical Pathology*, *37*(3), 317–322.

Barrett, E. (2011). Bladder and urethra. In *BSAVA manual of canine and feline ultrasonography* (pp. 155–164). BSAVA Library.

Barsanti, J. A., Crowell, W., Losonsky, J., & Talkington, F. D. (1981). Complications of bladder distension during retrograde urethrography. *American Journal of Veterinary Research*, *42*(5), 819–821.

Bartges, J. W. (1997). Lower urinary tract disease in geriatric cats. *Proceedings of the 15th American College of Veterinary Internal Medicine Forum*, 322–324.

Barthez, P. Y., Léveillé, R., & Scrivani, P. v. (1997). Side lobes and grating lobes artifacts in ultrasound imaging. *Veterinary Radiology and Ultrasound*, *38*(5), 387–393.

Bischoff, M. G. (2003). Radiographic techniques and interpretation of the acute abdomen. *Clinical Techniques in Small Animal Practice*, *18*(1), 7–19.

Boost, M. v, So, S. Y. C., & Perreten, V. (2011). Low Rate of Methicillin-resistant Coagulase-positive Staphylococcal Colonization of Veterinary Personnel in Hong Kong. *Zoonoses and Public Health*, *58*(1), 36–40.

Breton, L., Pennock, P. W., & Valli, V. E. (1978). The effects of hypaque 25% and sodium iodide 10% in the canine urinary bladder. *Veterinary Radiology*, *19*(4), 116–124.

Buffington, C. A., Chew, D. J., Kendall, M. S., Scrivani, P. v, Thompson, S. B., Blaisdell, J. L., & Woodworth, B. E. (1997). Clinical evaluation of cats with nonobstructive urinary tract diseases. *Journal of the American Veterinary Medical Association*, *210*(1), 46–50.

Buffington, C. A. T. (2011). Idiopathic cystitis in domestic cats--beyond the lower urinary tract. *Journal of Veterinary Internal Medicine*, *25*(4), 784–796.

Byl, K. M., Kruger, J. M., Kinns, J., Nelson, N. C., Hauptman, J. G., & Johnson, C. A. (2010). In vitro comparison of plain radiography, double-contrast cystography, ultrasonography, and computed tomography for estimation of cystolith size. *American Journal of Veterinary Research*, *71*(3), 374–380.

Cameron, M. E., Casey, R. A., Bradshaw, J. W. S., Waran, N. K., & Gunn-Moore, D. A. (2004). A study of environmental and behavioural factors that may be associated with feline idiopathic cystitis. *Journal of Small Animal Practice*, *45*(3), 144–147.

Chew, R., Thomas, S., Mantha, M., Killen, J., Cho, Y., & Baer, R. (2012). Large urate cystolith associated with Proteus urinary tract infection. *Kidney International*, *81*, 802.

CLSI (2012) Performance Standards for Antimicrobial Disk Susceptibility Tests; Approved Standard—Eleventh Edition. CLSI Document M02-A11. Clinical and Laboratory Standards Institute, Wayne, 32(1).

Cohn, L. A., Gary, A. T., Fales, W. H., & Madsen, R. W. (2003). Trends in Fluoroquinolone Resistance of Bacteria Isolated from Canine Urinary Tracts. *Journal of Veterinary Diagnostic Investigation*, *15*(4), 338–343.

Côté, E., Carroll, M. C., Beck, K. A., Good, L., & Gannon, K. (2002). Diagnosis of urinary bladder rupture using ultrasound contrast cystography: In vitro model and two case-history reports. *Veterinary Radiology and Ultrasound*, *43*(3), 281–286.

Dawson, P., Becker, A., & Holton, J. M. (1983). The effect of contrast media on the growth of bacteria. *The British journal of radiology*, *56*(671), 809–815.

Dorsch, R., Remer, C., Sauter-Louis, C., & Hartmann, K. (2014). Feline lower urinary tract disease in a German cat population: A retrospective analysis of demographic data, causes and clinical signs. *Tierarztliche Praxis Ausgabe K: Kleintiere - Heimtiere*, *42*(4), 231–239.

Dorsch, R., von Vopelius-Feldt, C., Wolf, G., Straubinger, R. K., & Hartmann, K. (2015). Feline urinary tract pathogens: prevalence of bacterial species and antimicrobial resistance over a 10-year period. *Veterinary Record*, *176*(8), 201–201.

Douglass, J. P. (1993). Bladder wall mass effect caused by the intramural portion of the canine ureter. *Veterinary Radiology and Ultrasound: The Official Journal of the American College of Veterinary Radiology and the International Veterinary Radiology Association (USA)*.

Douglass, J. P., & Kremkau, F. W. (1993). Ultrasound corner- the urinary bladder wall hypoechoic pseudolesion. *Veterinary Radiology & Ultrasound*, *34*(1), 45–46.

Eggertsdóttir, A. v., Lund, H. S., Krontveit, R., & Sørum, H. (2007). Bacteriuria in cats with feline lower urinary tract disease: a clinical study of 134 cases in Norway. *Journal of Feline Medicine and Surgery*, *9*(6), 458–465.

Ellis, J. J., McGowan, R. T. S., & Martin, F. (2017). Does previous use affect litter box appeal in multi-cat households? *Behavioural Processes*, *141*, 284–290.

Essman, S. C. (2005). Contrast cystography. *Clinical Techniques in Small Animal Practice*, *20*(1), 46–51.

Ettinger, S. J., Feldman, E. C., & Cote, E. (2017). *Textbook of Veterinary Internal Medicine-eBook*. Elsevier health sciences. 1992-1996

Farrow, C. S. (1981). Exercise in diagnostic radiology: intimal dissection and luminal involution secondary to double contrast cystography. *The Canadian Veterinary Journal= La Revue Veterinaire Canadienne*, *22*(8), 260–261.

Feeney, D. A., & Anderson, K. L. (2010). Radiographic imaging in urinary tract disease. In *Nephrology and urology of small animals* (pp. 97–127). Wiley.

Feeney, D. A., & Johnston, G. R. (1986). Urogenital imaging: A practical update. *Seminars in Veterinary Medicine and Surgery (Small Animal) 1(2), 144-164*.

Feeney, D. A., Osborne, C. A., & Jessen, C. R. (1980). Effects of radiographic contrast media on results of urinalysis, with emphasis on alteration in specific gravity. *Journal of the American Veterinary Medical Association*, *176*(12), 1378–1381.

Finn-Bodner ST (1995) The urinary bladder. In: Cartee RE, Selcer BA, Hudson JA et al., eds. Practical Veterinary Ultra- sound. Philadelphia: Lea and Febiger, pp 210–235.

Flores-Mireles, A. L., Walker, J. N., Caparon, M., & Hultgren, S. J. (2015). Urinary tract infections: epidemiology, mechanisms of infection and treatment options. *Nature Reviews. Microbiology*, *13*(5), 269–284.

Forrester, S. D., & Towell, T. L. (2015). Feline Idiopathic Cystitis. In *Veterinary Clinics of North America - Small Animal Practice* (Vol. 45, Issue 4, pp. 783–806).

Forrester, S. D., Troy, G. C., Dalton, M. N., Huffman, J. W., & Holtzman, G. (1999). Retrospective evaluation of urinary tract infection in 42 dogs with hyperadrenocorticism or diabetes mellitus or both. *Journal of Veterinary Internal Medicine / American College of Veterinary Internal Medicine*, *13*(6), 557–560.

Foxman, B. (2002). Epidemiology of urinary tract infections: incidence, morbidity, and economic costs. *The American Journal of Medicine*, *113*(1), 5–13.

Foxman, B., & Brown, P. (2003). Epidemiology of urinary tract infections: transmission and risk factors, incidence, and costs. *Infectious Disease Clinics*, *17*(2), 227–241.

Freitag, T., Squires, R. A., Schmid, J., Elliott, J., & Rycroft, A. N. (2006). Antibiotic Sensitivity Profiles Do Not Reliably Distinguish Relapsing or Persisting Infections from Reinfections in Cats with Chronic Renal Failure and Multiple Diagnoses *of Escherichia coli* Urinary Tract Infection. *Journal of Veterinary Internal Medicine*, *20*(2), 245–249.

Fumeo, M., Manfredi, S., & Volta, A. (2019). Emphysematous cystitis: review of current literature, diagnosis and management challenges. *Veterinary Medicine: Research and Reports*, *Volume 10*, 77–83.

Geisse, A. L., Lowry, J. E., Schaeffer, D. J., & Smith, C. W. (1997). Sonographic evaluation of urinary bladder wall thickness in normal dogs. *Veterinary Radiology & Ultrasound*, *38*(2), 132–137.

Gerber, B., Boretti, F. S., Kley, S., Laluha, P., Müller, C., Sieber, N., Unterer, S., Wenger, M., Flückiger, M., & Glaus, T. (2005). Evaluation of clinical signs

and causes of lower urinary tract disease in European cats. *Journal of Small Animal Practice*, *46*(12), 571–577.

Gerber, B., Boretti, F. S., Kley, S., Laluha, P., Müller, C., Sieber, N., Unterer, S., Wenger, M., Flückiger, M., Glaus, T., & Reusch, C. E. (2005). Evaluation of clinical signs and causes of lower urinary tract disease in European cats. *Journal of Small Animal Practice*, *46*(12), 571–577.

Gerber, B., Eichenberger, S., & Reusch, C. E. (2008). Guarded long-term prognosis in male cats with urethral obstruction. *Journal of Feline Medicine and Surgery*, *10*(1), 16–23.

Grauer, G. F. (2015). Feline struvite & calcium oxalate urolithiasis. *Todays Vet Pract*, *5*(5), 14–20.

Griffith, D., Musher, D., & Itin, C. (1976). Urease. The primary cause of infection-induced urinary stones. *Investigative Urology*, *13 5*, 346–350.

Grupper, M., Kravtsov, A., & Potasman, I. (2007). Emphysematous cystitis: Illustrative case report and review of the literature. In *Medicine* (Vol. 86, Issue 1, pp. 47–53).

Guardabassi, L., Loeber, M. E., & Jacobson, A. (2004). Transmission of multiple antimicrobial-resistant Staphylococcus intermedius between dogs affected by deep pyoderma and their owners. *Veterinary Microbiology*, *98*(1), 23–27.

Gunn-Moore, D. A. (2003). Feline lower urinary tract disease. *Journal of Feline Medicine and Surgery*, *5*(2), 133–138.

Hall, J. L., Holmes, M. A., & Baines, S. J. (2013). Prevalence and antimicrobial resistance of canine urinary tract pathogens. *Veterinary Record*, *173*(22), 549.

Hanazono, K., Fukumoto, S., Endo, Y., Ueno, H., Kadosawa, T., & Uchide, T. (2014). Ultrasonographic findings related to prognosis in canine transitional cell carcinoma. *Veterinary Radiology and Ultrasound*, *55*(1), 79–84.

Hanson, J. A., & Tidwell, A. S. (1996). Ultrasonographic appearance of urethral transitional cell carcinoma in ten dogs. *Veterinary Radiology and Ultrasound*, *37*(4), 293–299.

Hardefeldt, L. Y., Holloway, S., Trott, D. J., Shipstone, M., Barrs, V. R., Malik, R., Burrows, M., Armstrong, S., Browning, G. F., & Stevenson, M. (2017). Antimicrobial Prescribing in Dogs and Cats in Australia: Results of the Australasian Infectious Disease Advisory Panel Survey. *Journal of Veterinary Internal Medicine*, *31*(4), 1100–1107.

Hardefeldt, L. Y., Selinger, J., Stevenson, M. A., Gilkerson, J. R., Crabb, H., Billman-Jacobe, H., Thursky, K., Bailey, K. E., Awad, M., & Browning, G. F. (2018). Population wide assessment of antimicrobial use in dogs and

cats using a novel data source–a cohort study using pet insurance data. *Veterinary Microbiology*, *225*, 34–39.

Hecht, S. (2014). Applications of ultrasound in diagnosis and management of urinary disease. *Kirk's Current Veterinary Therapy XV*, 840–845.

Hecht, S. (2015). Diagnostic Imaging of Lower Urinary Tract Disease. In *Veterinary Clinics of North America - Small Animal Practice* 45 (4), 639–663.

Hecht, S., & Henry, G. A. (2011). Ultrasonography of the urinary tract. *Nephrology and Urology of Small Animals*, 128–145.

Hemasri, S., Okene, I. A., & Goni, M. D. (2018). Feline hemotropic mycoplasmosis concurrent with bacterial cystitis in a domestic shorthair cat. Journal of advanced veterinary and animal research, 5(4), 490–495

Hollenbeck, B. L., & Rice, L. B. (2012). Intrinsic and acquired resistance mechanisms in enterococcus. *Virulence*, *3*(5), 421–433. https://doi.org/10.4161/viru.21282

Hostutler, R. A., Chew, D. J., & DiBartola, S. P. (2005). Recent concepts in feline lower urinary tract disease. In *Veterinary Clinics of North America - Small Animal Practice* Vol. 35(1), 147–170

Jee, H., Pakhrin, B., Bae, I. H., Shin, N. S., Lee, S. I., Yoo, H. S., & Kim, D. Y. (2007). Pyelonephritis associated with Staphylococcus intermedius in a Siberian tiger (Panthera tigris altaica). *The Journal of veterinary medical science*, *69*(8), 851–852.

Johnston, G. R., Daniel, A. F., William, J. R., & Ralph, W. (1996). Diagnostic imaging of the feline lower urinary tract. *Veterinary Clinics: Small Animal Practice*, *26*(2), 401–415.

Johnston, G. R., & Feeney, D. A. (1984). Comparative organ imaging lower urinary tract. *Veterinary Radiology*, *25*(4), 146–153.

Johnston, G. R., Feeney, D. A., & Osborne, C. A. (1982). Urethrography and cystography in cats. 1. Techniques, normal radiographic anatomy, and artifacts. *Compendium On Continuing Education For The Practicing Veterinarian*, *4*(10), 823.

Johnston, G. R., Osborne, C. A., & Jessen, C. R. (1985). Effects of urinary bladder distension on the length of the dog and cat urethra. *American Journal of Veterinary Research*, *46*(2), 509–512.

Johnston, G. R., Osborne, C. A., Jessen, C. R., & Feeney, D. A. (1986). Effects of urinary bladder distention on location of the urinary bladder and urethra of healthy dogs and cats. *American Journal of Veterinary Research*, *47*(2), 404–415.

Johnston, G. R., Stevens, J. B., Jessen, C. R., & Osborne, C. A. (1983). Complications of retrograde contrast urethrography in dogs and cats. *American Journal of Veterinary Research*, *44*(7), 1248–1256.

Jones, B., Mahenthiralingam, E., Sabbuba, N. A., & Stickler, D. (2005). Role of swarming in the formation of crystalline Proteus mirabilis biofilms on urinary catheters. *Journal of Medical Microbiology*, *54*, 807–813.

Kass, E. H. (2002). Asymptomatic infections of the urinary tract. *The Journal of Urology*, *167*(2), 1016–1020.

Kaul, E., Hartmann, K., Reese, S., & Dorsch, R. (2020). Recurrence rate and long-term course of cats with feline lower urinary tract disease. *Journal of Feline Medicine and Surgery*, *22*(6), 544–556.

Kim, B., Kim, N. J., Kim, M., Kim, Y. S., Woo, J., & Ryu, J. (2003). Bacteraemia due to tribe Proteeae: a review of 132 cases during a decade (1991–2000). *Scandinavian Journal of Infectious Diseases*, *35*(2), 98–103.

Kirberger, R. M. (1995). Imaging artifacts in diagnostic ultrasound—a review. *Veterinary Radiology & Ultrasound*, *36*(4), 297–306

Kirk, C. A., Lund, E., Armstrong, P., & Kolar, L. M. (2001). Prevalence of lower urinary tract disorders of dogs and cats in the United States. *Proceedings, Waltham International Symposium*, *61*, l.

Klahr, S., Harris, K., & Purkerson, M. L. (1988). Effects of obstruction on renal functions. *Pediatric Nephrology*, *2*(1), 34-42

Klous, G., Huss, A., Heederik, D. J. J., & Coutinho, R. A. (2016). Human–livestock contacts and their relationship to transmission of zoonotic pathogens, a systematic review of literature. *One Health*, *2*, 65–76. https://doi.org/https://doi.org/10.1016/j.onehlt.2016.03.001

Kmieciak, W., & Szewczyk, E. M. (2019). Coagulase-positive species of the genus Staphylococcus–taxonomy, pathogenicity. *Postępy Mikrobiologii-Advancements of Microbiology*, *56*(2).

Knapp, D. W. (2007). Tumors of the urinary system. In *Withrow & MacEwen's Small Animal Clinical Oncology*,4 649–658.

Kruger, J. M., Osborne, C. A., Goyal, S. M., Wickstrom, S. L., Johnston, G. R., Fletcher, T. F., & Brown, P. A. (1991). Clinical evaluation of cats with lower urinary tract disease. *Journal of the American Veterinary Medical Association*, *199*(2), 211–216.

KuKanich, K. S., & Lubbers, B. V. (2015). Review of Enterococci Isolated from Canine and Feline Urine Specimens from 2006 to 2011. *Journal of the American Animal Hospital Association*, *51*(3), 148–154.

Lacy, M. K., Klutman, N. E., Horvat, R. T., & Zapantis, A. (2004). Antibiograms: New NCCLS Guidelines, Development, and Clinical Application. *Hospital Pharmacy*, *39*(6), 542–553.

le Boedec, K., Pastor, M. L., Lavoué, R., & Reynolds, B. S. (2011). Pseudomembranous cystitis, an unusual condition associated with feline urine outflow obstruction: Four cases. *Journal of Feline Medicine and Surgery*, *13*(8), 588–593.

Lekcharoensuk, C., Osborne, C. A., & Lulich, J. P. (2001). Epidemiologic study of risk factors for lower urinary tract diseases in cats. *Journal of the American Veterinary Medical Association*, *218*(9), 1429–1435.

Léveillé, R. (1998). Ultrasonography of urinary bladder disorders. *The Veterinary Clinics of North America. Small Animal Practice*, *28*(4), 799–821.

Léveillé, R., Biller, D. S., Partington, B. P., & Miyabayashi, T. (1992). Sonographic investigation of transitional cell carcinoma of the urinary bladder in small animals. *Veterinary Radiology & Ultrasound*, *33*(2), 103–107.

Lew-Kojrys, S., Mikulska-Skupien, E., Snarska, A., Krystkiewicz, W., & Pomianowski, A. (2017). Evaluation of clinical signs and causes of lower urinary tract disease in Polish cats. *Veterinarni Medicina*, *62*(7), 386–393

Li, X., Zhao, H., Lockatell, C. V., Drachenberg, C. B., Johnson, D. E., & Mobley, H. L. T. (2002). Visualization of Proteus mirabilis within the matrix of urease-induced bladder stones during experimental urinary tract infection. *Infection and Immunity*, *70*(1), 389–394.

Lippi, I., Mannucci, T., Santa, D. della, Barella, G., Oranges, M., & Citi, S. (2019). Article Emphysematous cystitis: Retrospective evaluation of predisposing factors and ultrasound features in 36 dogs and 2 cats. *The Canadian Veterinary Journal = La Revue Veterinaire Canadienne*, *60*(5), 514–518.

Litster, A., Moss, S. M., Honnery, M., Rees, B., & Trott, D. J. (2007). Prevalence of bacterial species in cats with clinical signs of lower urinary tract disease: Recognition of Staphylococcus felis as a possible feline urinary tract pathogen. *Veterinary Microbiology*, *121*(1–2), 182–188. https://doi.org/10.1016/j.vetmic.2006.11.025

Litster, A., Moss, S., Platell, J., & Trott, D. J. (2009). Occult bacterial lower urinary tract infections in cats-urinalysis and culture findings. *Veterinary Microbiology*, *136*(1–2), 130–134. https://doi.org/10.1016/j.vetmic.2008.10.019

Louvet, A. (2006). Twinkling artifact in small animal color-Doppler sonography. *Veterinary Radiology and Ultrasound*, *47*(4), 384–390.

Lulich, J. P., Berent, A. C., Adams, L. G., Westropp, J. L., Bartges, J. W., & Osborne, C. A. (2016). ACVIM Small Animal Consensus

Recommendations on the Treatment and Prevention of Uroliths in Dogs and Cats. *Journal of Veterinary Internal Medicine*, *30*(5), 1564–1574

Lund, H. S., Skogtun, G., Sørum, H., & Eggertsdóttir, A. V. (2014). Antimicrobial susceptibility in bacterial isolates from Norwegian cats with lower urinary tract disease. *Journal of Feline Medicine and Surgery*, *17*(6), 507–515.

Magruder, M., Sholi, A. N., Gong, C., Zhang, L., Edusei, E., Huang, J., Albakry, S., Satlin, M. J., Westblade, L. F., Crawford, C., Dadhania, D. M., Lubetzky, M., Taur, Y., Littman, E., Ling, L., Burnham, P., de Vlaminck, I., Pamer, E., Suthanthiran, M., & Lee, J. R. (2019). Gut uropathogen abundance is a risk factor for development of bacteriuria and urinary tract infection. *Nature Communications*, *10*(1), 5521.

Mahaffey, M. B., Barber, D. L., Barsanti, J. A., & Crowell, W. A. (1984). Simultaneous double-contrast cystography and cystometry in dogs. *Veterinary Radiology*, *25*(6), 254–259.

Mahaffey, M. B., Barsanti, J. A., Crowell, W. A., Shotts, E., & Barber, D. L. (1989). Cystography: Effect of technique on diagnosis of cystitis in dogs. *Veterinary Radiology*, *30*(6), 261–267.

Manges, A. R., Johnson, J. R., Foxman, B., O'Bryan, T. T., Fullerton, K. E., & Riley, L. W. (2001). Widespread distribution of urinary tract infections caused by a multidrug-resistant Escherichia coli clonal group. *New England Journal of Medicine*, *345*(14),

Marolf, A. J. (2018). Urinary bladder. In *Textbook of veterinary diagnostic radiology* . (7), 846–864.

Marques, C., Gama, L. T., Belas, A., Bergström, K., Beurlet, S., Briend-Marchal, A., Broens, E. M., Costa, M., Criel, D., Damborg, P., van Dijk, M. A., van Dongen, A. M., Dorsch, R., Espada, C. M., Gerber, B., Kritsepi-Konstantinou, M., Loncaric, I., Mion, D., Misic, D., Movilla, R., Pomba, C. (2016). European multicenter study on antimicrobial resistance in bacteria isolated from companion animal urinary tract infections. BMC veterinary research, 12(1), 213

Martinez-Ruzafa, I., Kruger, J. M., Miller, R. A., Swenson, C. L., Bolin, C. A., & Kaneene, J. B. (2012). Clinical features and risk factors for development of urinary tract infections in cats. *Journal of Feline Medicine and Surgery*, *14*(10), 729–740.

Mayer-Roenne, B., Goldstein, R. E., & Erb, H. N. (2007). Urinary tract infections in cats with hyperthyroidism, diabetes mellitus and chronic kidney disease. *Journal of Feline Medicine and Surgery*, *9*(2), 124–132.

McGuire, N. C., Schulman, R., Ridgway, M. D., & Bollero, G. (2002). Detection of Occult Urinary Tract Infections in Dogs With Diabetes Mellitus. *Journal of the American Animal Hospital Association*, *38*(6), 541–544.

Merkel, L. K., Lulich, J., Polzin, D., Ober, C., Westropp, J., & Sykes, J. (2017). Clinicopathologic and microbiologic findings associated with emphysematous cystitis in 27 dogs. *Journal of the American Animal Hospital Association*, *53*(6), 313–320.

Messenger, A. M., Barnes, A. N., & Gray, G. C. (2014). Reverse Zoonotic Disease Transmission (Zooanthroponosis): A Systematic Review of Seldom-Documented Human Biological Threats to Animals. *PLOS ONE*, *9*(2), e89055-.

Middleton, D. J., & Lomas, G. R. (1979). Emphysematous cystitis due to Clostridium perfringens in a non-diabetic dog. *Journal of Small Animal Practice*, *20*(7), 433–438.

Międzobrodzki, J., Kasprowicz, A., Białecka, A., Jaworska, O., Polakowska, K., Władyka, B., & Dubin, A. (2010). The first case of a Staphylococcus pseudintermedius infection after joint prosthesis implantation in a dog. *Polish Journal of Microbiology*, *59*(2).

Moon, R., Biller, D., & Smee, N. (2014). Emphysematous cystitis and pyelonephritis in a nondiabetic dog and a diabetic cat. *Journal of the American Animal Hospital Association*, *50*(2), 124-129

Mulvey, M. A., Schilling, J. D., & Hultgren, S. J. (2001). Establishment of a persistent Escherichia coli reservoir during the acute phase of a bladder infection. *Infection and Immunity*, *69*(7), 4572–4579.

Munns, J., & Amawi, F. (2010). A large urinary bladder stone: An unusual cause of rectal prolapse. *Archives of Disease in Childhood*, *95*, 1026.

Nevins JR, Mai W, Thomas E. Associations between ultrasound and clinical findings in 87 cats with urethral obstruction. Vet Radiol Ultrasound. 2015; 56: 439-447.

Nicolle, L. E. (2006). Asymptomatic bacteriuria: review and discussion of the IDSA guidelines. *International Journal of Antimicrobial Agents*, *28*, 42–48.

Norris, A. M., Laing, E. J., Valli, V. E. O., Withrow, S. J., Macy, D. W., Ogilvie, G. K., Tomlinson, J., McCaw, D., Pidgeon, G., & Jacobs, R. M. (1992). Canine bladder and urethral tumors: a retrospective study of 115 cases (1980–1985). *Journal of Veterinary Internal Medicine*, *6*(3), 145–153.

Nururrozi, A., Yanuartono, Y., Sivananthan, P., & Indarjulianto, S. (2020). Evaluation of lower urinary tract disease in the Yogyakarta cat population, Indonesia. *Veterinary World*, *13*(6), 1182–1186.

O'Neill, D. G., Church, D. B., McGreevy, P. D., Thomson, P. C., & Brodbelt, D. C. (2014). Prevalence of disorders recorded in cats attending primary-care veterinary practices in England. *Veterinary Journal*, *202*(2), 286–291.

Orabi, H., Aboushwareb, T., Tan, J., Yoo, J. J., & Atala, A. (2014). Can computed tomography - Assisted virtual endoscopy be an innovative tool for detecting urethral tissue pathologies? *Urology*, *83*(4), 930–938.

Osborne, C. A., & Jessen, C. R. (1971). Double-contrast cystography in the dog. *Journal of American Veterinary Medecidine Association*. 159(11),1400–4.

Osuna, D. J., Stone, E. A., & Metcalf, M. R. (1989). A urethrorectal fistula with concurrent urolithiasis in a dog. *The Journal of the American Animal Hospital Association.* 25(1), 35-9

Papich, M. G. (2013). Antibiotic Treatment of Resistant Infections in Small Animals. In *Veterinary Clinics of North America - Small Animal Practice*.4(5), 1091–1107.

Petite, A., Busoni, V., Heinen, M.-P., Billen, F., & Snaps, F. (2006). Radiographic and ultrasonographic findings of emphysematous cystitis in four nondiabetic female dogs. *Veterinary Radiology and Ultrasound*, *47*(1), 90–93.

Philippon, A., Labia, R., & Jacoby, G. (1989). Extended-spectrum beta-lactamases. *Antimicrobial Agents and Chemotherapy*, *33*(8), 1131–1136.

Piyarungsri, K., Tangtrongsup, S., Thitaram, N., Lekklar, P., & Kittinuntasilp, A. (2020). Prevalence and risk factors of feline lower urinary tract disease in Chiang Mai, Thailand. *Scientific Reports*, *10*(1).

Pomba, C., Couto, N., & Moodley, A. (2010). Treatment of a lower urinary tract infection in a cat caused by a multi-drug methicillin-resistant Staphylococcus pseudintermedius and Enterococcus faecalis. *Journal of Feline Medicine and Surgery*, *12*(10), 802–806.

Puchot, M. L., Cook, A. K., & Pohlit, C. (2017). Subclinical bacteriuria in cats: prevalence, findings on contemporaneous urinalyses and clinical risk factors. *Journal of Feline Medicine and Surgery*, *19*(12), 1238–1244.

Pugh, C. R., Rhodes, W. H., & Biery, D. N. (1993). Contrast studies of the urogenital system. *Veterinary Clinics of North America: Small Animal Practice*, *23*(2), 281–306.

Root, C. R., & Scott, R. C. (1971). Emphysematous cystitis and other radiographic manifestations of diabetes mellitus in dogs and cats. *Journal of the American Veterinary Medical Association*, *158*(6), 721–728.

Ruby, A. L., Ling, G. v, & Ackerman, N. (1983). Effect of sodium diatrizoate on the in vitro growth of three common canine urinary bacterial species. *Veterinary Radiology*, *24*(5), 222–225.

Russo, T. A., & Johnson, J. R. (2003). Medical and economic impact of extraintestinal infections due to Escherichia coli: focus on an increasingly important endemic problem. *Microbes and Infection*, *5*(5), 449–456.

Sævik, B. K., Trangerud, C., Ottesen, N., Sørum, H., & Eggertsdóttir, A. v. (2011). Causes of lower urinary tract disease in Norwegian cats. *Journal of Feline Medicine and Surgery*, *13*(6), 410–417

Sandle, T., 2016. Microbial identification. *Pharmaceutical Microbiology*, pp.103-113

Sam, S., & Craig, D. L. (2000). The diagnosis of urinary incontinence and abnormal urination in dogs and cats. *Veterinary Clinics of North America: Small Animal Practice*, *30*(2), 427–448.

Savini, V., Paparella, A., Serio, A., Marrollo, R., Carretto, E., & Fazii, P. (2014). Staphylococcus pseudintermedius for CAMP-test. *International journal of clinical and experimental pathology*, *7*(4), 1733–1734.

Scrivani, P. v, Chew, D. J., Buffington, C. A., Kendall, M., & Léveillé, R. (1997). Results of retrograde urethrography in cats with idiopathic, nonobstructive lower urinary tract disease and their association with pathogenesis: 53 cases (1993-1995). *Journal of the American Veterinary Medical Association*, *211*(6), 741–748.

Scrivani, P. v, Chew, D. J., Buffington, C. A. T., & Kendall, M. (1998). Results of double-contrast cystography in cats with idiopathic cystitis: 45 Cases (1993-1995). *Journal of the American Veterinary Medical Association*, *212*(12), 1907–1909. 0032525477&partnerID=40&md5=cd99aa4993154e1880eafded97ae0244

Scrivani, P. v, Léveillé, R., & Collins, R. L. (1997). The effect of patient positioning on mural filling defects during double contrast cystography. *Veterinary Radiology & Ultrasound*, *38*(5), 355–359.

Seo S, Na H, Choi S, Choi H, Lee Y, Lee K. (2021) Ultrasonographic and Clinical Findings in Cats with Feline Lower Urinary Tract Disease. *Journal of Veterinary Clinics*, 38:63-68.

Silverstone, A. M., & Adams, W. M. (2001). Radiographic diagnosis of a rectourethral fistula in a dog. *Journal of the American Animal Hospital Association*, *37*(6), 573–576.

Sivagurunathan, A., Atwa, A. M., & Lobetti, R. (2018). Prevalence of feline immunodeficiency virus and feline leukaemia virus infection in Malaysia: a retrospective study. *Journal of Feline Medicine and Surgery Open Reports*, *4*(1), 2055116917752587.

Song, W., Kim, J., Bae, I. K., Jeong, S. H., Seo, Y. H., Shin, J. H., Jang, S. J., Uh, Y., Shin, J. H., Lee, M.-K., & Lee, K. (2011). Chromosome-encoded AmpC and CTX-M extended-spectrum β-lactamases in clinical isolates of Proteus mirabilis from Korea. *Antimicrobial Agents and Chemotherapy*, *55*(4), 1414–1419.

Stafford, J. R., & Bartges, J. W. (2013). A clinical review of pathophysiology, diagnosis, and treatment of uroabdomen in the dog and cat. *Journal of Veterinary Emergency and Critical Care*, *23*(2), 216–229.

Stickler, D. (2008). Bacterial biofilms in patiens with indwelling urinary catheters. *Nature Clinical Practice. Urology*, *5*, 598–608.

Stock, I. (2003). Natural Antibiotic Susceptibility of Proteus spp., with Special Reference to P. mirabilis and P. penneri Strains. *Journal of Chemotherapy*, *15*(1), 12–26.

Sutherland-Smith, J., & Penninck, D. (2008). Bladder and urethra. *Atlas of small animal ultrasonography.* Blackwell publishing. *(2)*, 365–384.

Teichmann-Knorrn, S., Reese, S., Wolf, G., Hartmann, K., & Dorsch, R. (2018). Prevalence of feline urinary tract pathogens and antimicrobial resistance over five years. *Veterinary Record*, *183*(1), 21.

van Duijkeren, E., Kamphuis, M., van der Mije, I. C., Laarhoven, L. M., Duim, B., Wagenaar, J. A., & Houwers, D. J. (2011). Transmission of methicillin-resistant Staphylococcus pseudintermedius between infected dogs and cats and contact pets, humans and the environment in households and veterinary clinics. *Veterinary Microbiology*, *150*(3), 338–343.

Vila, A., Movilla, R., Castro, J., Mallol, C., Novellas, R., Espada, Y., & Roura, X. (2018). Successful medical management of pseudomembranous cystitis in three cats with lower urinary tract obstruction. *Australian Veterinary Journal*, *96*(1–2), 33–38.

Viswanathan, S., Rajan, R. P., Iqbal, N., Subramani, J., & Muthu, V. (2012). Enterococcus faecium related emphysematous cystitis and bladder rupture. *The Australasian Medical Journal*, *5*(11), 581–584

Voros, K., Wladar, S., Vrabely, T., & Fenyves, B. (1993). Ultrasonographic diagnosis of urinary bladder calculi in dogs. *Canine Practice (USA)*.

Waknitz, D., & Greer, D. H. (1983). Urethrorectal fistula in a cat. *Veterinary Medicine & Small Animal Clinician*, *78*(10), 1551–1553.

Watanakunakorn, C., & Perni, S. C. (1994). Proteus mirabilis bacteremia: a review of 176 cases during 1980–1992. *Scandinavian Journal of Infectious Diseases*, *26*(4), 361–367.

Weese, J. (2008). Investigation of Enterobacter cloacae infections at a small animal veterinary teaching hospital. *Veterinary Microbiology*, *130*, 426–428.

Weese, J. S., Blondeau, J., Boothe, D., Guardabassi, L. G., Gumley, N., Papich, M., Jessen, L. R., Lappin, M., Rankin, S., Westropp, J. L., & Sykes, J. (2019). International Society for Companion Animal Infectious Diseases (ISCAID) guidelines for the diagnosis and management of bacterial

urinary tract infections in dogs and cats. *Veterinary Journal*, *247*, 8–25. https://doi.org/10.1016/j.tvjl.2019.02.008

Weese, J. S., Blondeau, J. M., Boothe, D., Breitschwerdt, E. B., Guardabassi, L., Hillier, A., Lloyd, D. H., Papich, M. G., Rankin, S. C., Turnidge, J. D., & Sykes, J. E. (2011). Antimicrobial use guidelines for treatment of urinary tract disease in dogs and cats: Antimicrobial guidelines working group of the international society for companion animal infectious diseases. *Veterinary Medicine International*, *2011*, 263768.

Weichselbaum, R. C., Feeney, D. A., Jessen, C. R., Osborne, C. A., Dreytser, V., & Holte, J. (1999). Urocystolith detection: comparison of survey, contrast radiographic and ultrasonographic techniques in an in vitro bladder phantom. *Veterinary Radiology & Ultrasound*, *40*(4), 386–400.

Weichselbaum, R. C., Feeney, D. A., Jessen, C. R., Osborne, C. A., Dreytser, V., & Holte, J. (2000). Relevance of sonographic artifacts observed during in vitro characterization of urocystolith mineral composition. *Veterinary Radiology and Ultrasound*, *41*(5), 438–446.

Wenner, J. J., & Rettger, L. F. (1919). A systematic study of the Proteus group of bacteria. *Journal of Bacteriology*, *4*(4), 331–353.

White, J. D., Cave, N. J., Grinberg, A., Thomas, D. G., & Heuer, C. (2016). Subclinical Bacteriuria in Older Cats and its Association with Survival. *Journal of Veterinary Internal Medicine*, *30*(6), 1824–1829.

Zontine, W. J., & Andrews, L. K. (1978). Fatal air embolization as a complication of pneumocystography in two cats. *Veterinary Radiology*, *19*(1), 8–11.

Zotti, A., Fant, P., de Zan, G., Mollo, A., & Busetto, R. (2007). Chronic cystitis with ossification of the bladder wall in a 6-month-old German shepherd dog. *Canadian Veterinary Journal*, *48*(9), 935–938.