UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL

FACULDADE DE VETERINÁRIA

PROGRAMA DE PÓS-GRADUAÇÃO EM CIÊNCIAS VETERINÁRIAS

AVALIAÇÃO CLÍNICO-LABORATORIAL DA OBSTRUÇÃO URETRAL EM FELINOS DOMÉSTICOS

Gabriela da Cruz Schaefer

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Dissertação apresentada ao Programa de Pós-Graduação em Ciências Veterinárias – UFRGS, como requisito parcial da obtenção do título de Mestre em Ciências Veterinárias

Orientador: Félix Hilario Diaz González

Co-orientadora: Fernanda Vieira Amorim da Costa

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AVALIAÇÃO CLÍNICO-LABORATORIAL DA OBSTRUÇÃO URETRAL EM FELINOS DOMÉSTICOS

Autor: Gabriela da Cruz Schaefer

Orientador: Félix Hilario Diaz González

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RESUMO

A obstrução uretral é uma condição clínica comum em gatos, caracterizada por alterações metabólicas e do equilíbrio hidroeletrolítico e ácido-básico que são potencialmente fatais. Dentre as causas de obstrução uretral, a cistite idiopática é a mais frequentemente observada em diversos estudos. Outras causas incluem urolitíase, tampões uretrais e infecção do trato urinário. Em muitos casos, os gatos encontram-se em estado crítico e a morte pode ocorrer em decorrência de alterações metabólicas, como estado urêmico avançado e hipercalemia. As principais alterações eletrolíticas e do equilíbrio ácido-básico relatadas são hipercalemia, acidose metabólica, hiponatremia e hipocalcemia ionizada. Embora a obstrução uretral seja muito frequente na rotina clínica, estudos para caracterizar a população de gatos acometida ainda são escassos no Brasil. Características relacionadas ao manejo, dieta e perfil dos tutores podem influenciar na manifestação da doença. Os objetivos do presente estudo foram avaliar os parâmetros clínicos e as alterações hematológicas, bioquímicas, urinárias, eletrolíticas e ácido-básicas presentes em gatos com obstrução uretral e a associação entre estas variáveis. Além disso, objetivou-se conhecer as principais causas de obstrução uretral nos gatos atendidos no Hospital de Clínicas Veterinárias da Universidade Federal do Rio Grande do Sul. Para isso, foram incluídos no estudo 28 gatos com diagnóstico de obstrução uretral no período de dezembro de 2015 a dezembro de 2016. Foram obtidos dados referentes ao histórico, exame físico, coletados sangue e urina, além da realização de exames de imagem (radiografia e ultrassonografia abdominal). Em todos os gatos foram realizados hemograma, bioquímica sérica, análise de pH, gases e eletrólitos sanguíneos, urinálise e urocultura. Após, todos os pacientes foram tratados de acordo com um protocolo pré-estabelecido. A causa mais comum de obstrução uretral neste estudo foi a cistite idiopática, que ocorreu em mais de 60% dos casos, seguida de tampões uretrais e infecção do trato urinário. Nenhum caso de urolitíase foi diagnosticado, o que pode ser explicado por fatores como idade, ambiente e estilo de vida dos animais. A maioria dos gatos obstruídos apresentou múltiplos sinais sistêmicos, assim como alterações metabólicas, eletrolíticas e do equilíbrio ácido-básico, principalmente azotemia, hiperlactatemia, acidose metabólica, hipercalemia e hipocalcemia ionizada. Hipotermia, depressão do estado mental, bradicardia e desidratação foram os parâmetros clínicos que tiveram maior quantidade de associação com as alterações metabólicas e podem ser considerados bons preditores clínicos destas desordens. Por outro lado, o lactato não foi considerado um bom preditor de alterações clínicas e laboratoriais neste estudo.

Palavras-chave: doença do trato urinário inferior dos felinos; cistite idiopática; desequilíbrio ácido-básico; hipercalemia; acidose metabólica.

CLINICAL AND LABORATORY EVALUATION OF URETHRAL OBSTRUCTION IN CATS

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ABSTRACT

Urethral obstruction is a common and potentially life-threatening condition, characterized by severe metabolic, electrolyte and acid-base disturbances. Among the causes of urethral obstruction, idiopathic cystitis is the most frequent in several studies. Other causes include urolithiasis, urethral plugs and urinary tract infection. In many cases, cats are critically ill and death may occur due to metabolic alterations, such as advanced uremic status and hyperkalemia. The main electrolyte and acid-base balance disorders reported are hyperkalemia, metabolic acidosis, hyponatremia and ionized hypocalcemia. Although urethral obstruction is a very common condition, there are few studies characterizing the population affected by the disease in Brazil. Characteristics related to management, diet and owner's profile can influence the manifestation of the disease. The aim of the present study was to evaluate the association of clinical, haematological, biochemical, urinary, hydroelectrolyte and acid-base parameters in male cats with urethral obstruction. In addition, the objective was to determine the causes of urethral obstruction in male cats admitted to the Veterinary Teaching Hospital of Federal University of Rio Grande do Sul. Twenty-eight cats diagnosed with urethral obstruction were included in the study between December 2015 and December 2016. Data regarding medical history and physical examination were obtained. Blood and urine were collected, and imaging tests were performed (abdominal radiography and ultrasonography). Complete blood count, serum chemistry, blood pH, gas and electrolyte, urinalysis and urine culture were performed. All patients were treated accordingly to a previous established protocol. The most common cause of urethral obstruction in this study was idiopathic cystitis, which occurred in more than 60% of cases, followed by urethral plugs and urinary tract infection. No diagnosis of urolithiasis was achieved, which could be explained by factors like age, environment and life style of cats. Most of obstructed cats presented with multiple systemic clinical signs, as well as, metabolic, electrolyte and acid-base alterations. The main disorders found were azotemia, hyperlactatemia, metabolic acidosis, hyperkalemia and ionized hypocalcemia. Hypothermia, depressed mental status, bradycardia and dehydration were the clinical parameters with the greatest amount of associations with the metabolic alterations and can be considered as good predictors of metabolic disorders. On the other hand, lactate was not considered a good predictor of clinical and laboratory abnormalities in this study.

Keywords: *feline lower urinary tract disease; idiopathic cystitis, acid-base disorders; hyperkalemia; metabolic acidosis.*

SUMÁRIO

1 INTRODUÇÃO

A obstrução uretral é uma condição clínica frequentemente presente em gatos atendidos em clínicas e hospitais veterinários, caracterizada por alterações metabólicas e do equilíbrio hidroeletrolítico e ácido-básico que são potencialmente fatais (COOPER, 2015; RIESER, 2005). É comum a ocorrência de sinais sistêmicos, e, em casos graves e dependendo do tempo de obstrução, colapso circulatório e morte podem ocorrer (BALAKRISHNAN, 2013).

Dentre as causas de obstrução uretral, a cistite idiopática é a mais frequente em diversos estudos, sendo diagnosticada em mais de 50% dos casos. Outras causas incluem urolitíase, tampões uretrais e infecção do trato urinário, com incidências variando em diferentes populações (GERBER *et al.*, 2005; LEKCHAROENSUK; OSBORNE; LULICH, 2001; TRANGERUD; OTTESEN; EGGERTSDO, 2011).

Em muitos casos, principalmente quando a obstrução já vem ocorrendo por mais de 24 horas, os gatos encontram-se em estado crítico e a morte pode ocorrer em decorrência de alterações metabólicas, como estado urêmico avançado e hipercalemia (SCHAER, 1977). As principais alterações eletrolíticas e do equilíbrio ácido-básico relatadas em gatos com obstrução uretral são hipercalemia, acidose metabólica, hiponatremia e hipocalcemia ionizada (EISENBERG *et al.*, 2013; FULTS; HEROLD, 2012; HALL; HALL; POWELL, 2015; LEE; DROBATZ, 2006).

Embora a obstrução uretral seja muito frequente na rotina, estudos para caracterizar a população de gatos acometida ainda são escassos no Brasil (FERREIRA; CARVALHO; AVANTE, 2014; MARTINS *et al.*, 2013; NERI *et al.*, 2016; RECHE; HAGIWARA; MAMIZUKA, 1998). Além disso, é necessário conhecer as causas de obstrução uretral na nossa população para poder instituir medidas de prevenção. É importante que sejam realizados estudos regionais, visto que características relacionadas ao manejo, dieta e perfil dos tutores podem influenciar na manifestação da doença. Em vários estudos, não foi possível determinar a causa da obstrução de todos os animais da população avaliada, devido à falta de padronização na realização de exames, principalmente nos estudos retrospectivos ou multicêntricos (EISENBERG *et al.*, 2013; RECHE; HAGIWARA; MAMIZUKA, 1998; SEGEV *et al.*, 2011). Espera-se encontrar uma maior frequência de urolitíase, que pode estar relacionada com a dieta e o manejo dos felinos atendidos na nossa rotina.

2 OBJETIVOS

- Avaliar os parâmetros clínicos e as alterações hematológicas, bioquímicas, urinárias, eletrolíticas e ácido-básicas presentes em gatos com obstrução uretral e a associação entre estas variáveis;

- Conhecer as principais causas de obstrução uretral nos gatos atendidos no Hospital de Clínicas Veterinárias da Universidade Federal do Rio Grande do Sul (HCV-UFRGS);

- Correlacionar os parâmetros clínico-laboratoriais com a taxa de mortalidade dos pacientes.

3 REVISÃO BIBLIOGRÁFICA

3.1 Caracterização da obstrução uretral

O termo "doença do trato urinário inferior dos felinos" (DTUIF) é utilizado para descrever uma série de sinais clínicos relacionados com a dificuldade de micção sem determinar uma causa específica. Os sinais clínicos observados incluem disúria, estrangúria, hematúria, polaquiúria, periúria e lambedura excessiva do períneo (HOSTUTLER; CHEW; DIBARTOLA, 2005). Vocalização e relutância em andar podem se manifestar como sinais de dor associada (MARSHALL, 2011). A DTUIF pode se apresentar na forma obstrutiva ou não obstrutiva.

A obstrução uretral é uma manifestação comum e potencialmente fatal da DTUIF, caracterizada por alterações metabólicas e do equilíbrio hidroeletrolítico e ácido-básico (COOPER, 2015; RIESER, 2005). Nestes casos, é comum a ocorrência de sinais sistêmicos, como vômito, anorexia e prostração. Em casos graves e, dependendo do tempo de obstrução, colapso circulatório e morte podem ocorrer (BALAKRISHNAN, 2013). Os principais sinais clínicos relacionados às alterações metabólicas são desidratação, hipovolemia, bradicardia, hipotermia, pulso fraco e choque (LEE; DROBATZ, 2003, 2006). Clinicamente, o diagnóstico de obstrução uretral é dado pela presença de uma bexiga firme e distendida à palpação não passível de compressão, associada ao histórico de sinais de DTUIF e de incapacidade de urinar (BALAKRISHNAN, 2013; MARSHALL, 2011).

Em um estudo epidemiológico realizado na Europa, Austrália e Estados Unidos, a taxa de morbidade de DTUIF variou de 1 a 6% na população felina atendida em clínicas veterinárias e hospitais de referência, sendo que a proporção dos casos na forma obstrutiva chegou a aproximadamente 70% (WILLEBERG, 1984). Em outra pesquisa, realizada nos Estados Unidos, em hospitais de referência, entre os anos 1980 e 1999, a prevalência de obstrução uretral foi de 15,4% na população atendida (LEKCHAROENSUK; OSBORNE; JODY, 2002). Um estudo na Europa demonstrou uma taxa de 58% de obstrução uretral dentre os gatos atendidos com DTUIF (GERBER *et al.*, 2005). A taxa de mortalidade a curto prazo relatada é de 4,9 a 22% (FULTS; HEROLD, 2012; GERBER; EICHENBERGER; REUSCH, 2008; LEE; DROBATZ, 2003; SEGEV *et al.*, 2011; WALKER *et al.*, 1977).

3.2 Fatores predisponentes

A DTUIF ocorre principalmente em gatos de dois a seis anos de idade, sendo incomum em animais com menos de um e mais de dez anos (HOSTUTLER; CHEW; DIBARTOLA, 2005). Obstrução uretral é rara em fêmeas e ocorre principalmente nos machos, devido ao diâmetro reduzido da uretra, sendo que os machos castrados são mais predispostos (WILLEBERG, 1984). Com relação ao manejo, a doença se manifesta mais em gatos sem acesso à rua ou que convivem com outros gatos (HOSTUTLER; CHEW; DIBARTOLA, 2005). Peso corporal e a dieta também são considerados fatores de risco, sendo que obesidade e sedentarismo estão relacionados com maior risco de desenvolver DTUIF, assim como a alimentação exclusiva com ração seca ou de forma intermitente durante o dia. Com relação a variações sazonais, alguns estudos mostraram maior frequência da doença no inverno, outros na primavera e outros não observaram sazonalidade (WILLEBERG, 1984). Também não foi observada diferença significativa entre meses chuvosos e secos (SEGEV *et al.*, 2011).

3.3 Etiologia, epidemiologia, patogenia e diagnóstico

O diagnóstico da causa da obstrução uretral baseia-se principalmente em exames de imagem e de urina. Indica-se a associação de mais de uma modalidade de exame de imagem para aumentar a sensibilidade. O exame radiográfico deve incluir toda a extensão da uretra e é útil para a pesquisa de urolitíase. A radiografia contrastada é indicada em casos de suspeita de neoplasia, defeitos congênitos, urólitos radioluscentes ou estenose de uretra. Já a ultrassonografia abdominal é utilizada para avaliar a bexiga, porém não permite a avaliação de toda a extensão da uretra. Por meio desta, é possível detectar urólitos pequenos e radioluscentes, além de neoplasias, pólipos e/ou coágulos (HOSTUTLER; CHEW; DIBARTOLA, 2005; MARSHALL, 2011).

Na urinálise, é especialmente importante a avaliação da densidade urinária e do pH, considerando que as características químicas da urina estão relacionadas com a formação de determinados tipos de urólitos. Uma densidade urinária alta sugere aumento na concentração de precursores litogênicos. A análise do sedimento urinário pode indicar presença de inflamação e/ou infecção, além de cristalúria. Esta última apenas sugere a precipitação de substâncias litogênicas, não confirmando a presença de um urólito (BARTGES; CALLENS, 2015; HOSTUTLER; CHEW; DIBARTOLA, 2005).

Dentre as causas de obstrução uretral, a cistite idiopática é a mais frequente, sendo diagnosticada em 53% dos casos, seguida por urolitíase (29%) e tampões uretrais (18%) (GERBER *et al.*, 2005). Um estudo epidemiológico de gatos com DTUIF, em uma população hospitalar, demonstrou que 10% destes tinham como causa a urolitíase ou a presença de tampões uretrais, e que gatos entre quatro e sete anos e entre dez e 15 anos tiveram maior risco de desenvolvimento dos mesmos. Cistite idiopática foi diagnosticada em 63% dos casos, sendo que gatos entre dois e sete anos tiveram maior risco. Infecção do trato urinário foi diagnosticada em 12% dos casos e gatos acima de dez anos tiveram risco aumentado. Outras causas como neoplasia, alterações congênitas e iatrogenia foram diagnosticados em 1,6% dos gatos avaliados (LEKCHAROENSUK; OSBORNE; LULICH, 2001). Um estudo mostrou uma frequência de apenas 5,7% de urolitíase em gatos com obstrução uretral que foram avaliados mediante exame radiográfico e ultrassonográfico (HALL; HALL; POWELL, 2015). Outra pesquisa europeia com gatos com DTUIF verificou que 55,5% destes apresentaram cistite idiopática, 21% tinham tampões uretrais, 11,8% infecção do trato urinário e 11,8% urolitíase (TRANGERUD; OTTESEN; EGGERTSDO, 2011).

Estudos regionais das causas de obstrução uretral em felinos são escassos. Um estudo de necropsia realizado com 13 gatos com obstrução uretral, detectou a presença de urolitíase em apenas dois deles. Sinais de pielonefrite foram relatados em três gatos, porém só foi realizado exame bacteriológico em um deles (WOUTERS *et al.*, 1998). Em outro estudo realizado em São Paulo, em uma população hospitalar com 50 gatos com DTUIF, 36 apresentaram obstrução uretral. Destes, 67% tinham tampão uretral, 11% infecção do trato urinário e 22% não apresentaram causa específica (RECHE; HAGIWARA; MAMIZUKA, 1998).

3.3.1 Urolitíase

A fisiopatogenia da formação dos urólitos é complexa e envolve diversos mecanismos. De um modo geral, ocorre a supersaturação da urina com substâncias litogênicas, resultando na formação de cristais. Estes podem precipitar e sua agregação resultar na formação de um urólito. Outros fatores associados são o pH urinário, infecção do trato urinário concomitante, a presença de promotores e a ausência de inibidores da cristalização. O diagnóstico de urolitíase é dado pela observação dos mesmos em exames de imagem ou durante procedimentos para sua remoção. Todos os urólitos devem ser analisados por meio de análise quantitativa para que sejam tomadas medidas de prevenção da recorrência dos mesmos (HOSTUTLER; CHEW; DIBARTOLA, 2005).

Os tipos de urólito mais frequentes em felinos são os de estruvita (fosfato amoníaco-magnesiano) e oxalato de cálcio, ambos radiopacos (OSBORNE *et al.*, 2008). Para formação de um urólito de estruvita, a urina precisa estar saturada com íons de magnésio, amônio e fosfato. A precipitação de estruvita pode estar associada a infecção do trato urinário com bactérias produtores de urease que alcalinizam o pH da urina, porém, em felinos, é mais comum a presença de estruvita estéril. Neste caso, a formação destes urólitos pode estar relacionada com dietas ricas em magnésio (BARTGES; CALLENS, 2015), porém a presença de pH urinário alcalino é o principal fator associado (TARTTELIN, 1987).

Urólitos de oxalato de cálcio tendem a se formar em pH urinário ácido, porém outros fatores estão relacionados, como o excesso da excreção de oxalato e cálcio na urina, além de alterações metabólicas, como hipercalcemia idiopática, acidose metabólica e ausência de inibidores da precipitação destas substâncias (BARTGES; CALLENS, 2015).

3.3.2 Tampões uretrais

Os tampões uretrais são formados de material proteináceo proveniente da inflamação do trato urinário, e podem ou não ter componente mineral associado (BALAKRISHNAN, 2013). Cerca de 90% dos tampões uretrais em felinos contém cristais de estruvita, 11,5% contém apenas matriz sem presença de minerais, e o restante é formado a partir de outros componentes minerais associados. O diagnóstico é dado pela observação direta dos mesmos e também é indicada a análise quantitativa e qualitativa para avaliar a sua composição (OSBORNE *et al.*, 2008).

3.3.3 Infecção do trato urinário

Infecção do trato urinário não é comum em felinos, exceto em animais geriátricos, acima de dez anos (HOSTUTLER; CHEW; DIBARTOLA, 2005), e associado a doenças concomitantes, como hipertireoidismo, doença renal crônica e *Diabetes mellitus* (MAYER-ROENNE; ERB; GOLDSTEIN, 2007), em pacientes nos quais foi realizada cateterização uretral recente ou ainda naqueles que foram submetidos à uretrostomia perineal (HOSTUTLER; CHEW; DIBARTOLA, 2005). O diagnóstico definitivo é dado pela realização da urocultura e antibiograma de uma amostra de urina coletada por cistocentese, sendo que a presença de bactérias, mesmo que em pequena quantidade, é suficiente para o diagnóstico de infecção do trato urinário (BARTGES, 2004).

3.3.4 Cistite idiopática

A cistite idiopática afeta principalmente felinos jovens a meia-idade. A ocorrência de casos de obstrução uretral sem identificação de uma causa mecânica específica sugere a presença de obstrução funcional secundária a espasmo e edema uretral. Sua fisiopatogenia ainda não está bem estabelecida, entretanto, sugere-se a presença de um processo inflamatório estéril, mediado por uma resposta neuro-humoral imprópria, principalmente em felinos submetidos a situações de estresse crônico. A liberação de mediadores inflamatórios resulta em edema, espasmo da musculatura lisa e dor no trato urinário. A dor pode intensificar o espasmo uretral, gerando um ciclo vicioso (COOPER, 2015).

O diagnóstico de cistite idiopática é dado pela exclusão de outras causas, quando os exames não detectam uma etiologia específica da doença. Denomina-se cistite intersticial caso seja realizada cistoscopia com observação de petéquias na submucosa (glomerulações) (HOSTUTLER; CHEW; DIBARTOLA, 2005).

3.3.5 Outras causas

Outras causas menos comuns de obstrução uretral incluem neoplasias, defeitos congênitos e estenose de uretra. O carcinoma de células transicionais é o principal tipo de tumor encontrado na bexiga de gatos, seguido de adenocarcinoma e leiomiona (GUNN-MOORE, 2003). Divertículo vesico-uracal é uma anomalia congênita que predispõe a infecção bacteriana pois causa retenção de urina (ESSMAN, 2005). Estenose uretral pode decorrer de uretrite crônica ou trauma devido a repetidas cateterizações da uretra (CORGOZINHO *et al.*, 2007).

3.4 Alterações bioquímicas, hematológicas e da urinálise

Em muitos casos, principalmente quando a obstrução já vem ocorrendo por mais de 24 horas, os gatos encontram-se em estado crítico e a morte pode ocorrer em decorrência de alterações metabólicas, como estado urêmico avançado e hipercalemia (SCHAER, 1977). A obstrução uretral ocasiona aumento da pressão intravesical, que ascende para os rins resultando em diminuição da taxa de filtração glomerular, do fluxo sanguíneo renal e da função tubular. Como consequência, ureia, creatinina, fósforo e outros solutos se acumulam no sangue, resultando em azotemia e hiperfosfatemia acentuadas (BARTGES *et al.*, 1996; RIESER, 2005). Além do componente pós-renal, a azotemia geralmente tem um componente pré-renal causado pela desidratação. Além disso, em casos de obstrução prolongada, injúrias renais persistentes podem ocorrer (POLZIN; OSBORNE; BARTGES, 1996).

O lactato é um metabólito intermediário da glicólise, produzido principalmente em situações de metabolismo anaeróbico, e pode se acumular no organismo em estados de choque. A hiperlactatemia tende a ocorrer devido à baixa perfusão tecidual e/ou falta de suprimento de oxigênio nestes casos (PANG; BOYSEN, 2007). A presença de azotemia, hiperfosfatemia e hiperlactatemia em gatos obstruídos está amplamente descrita na literatura (EISENBERG *et al.*, 2013; LEE; DROBATZ, 2003; NERI *et al.*, 2016; SEGEV *et al.*, 2011).

Como a função renal tubular também é prejudicada, ocorre perda da capacidade de concentração urinária, devido a um prejuízo na reabsorção de água. Com o restabelecimento da patência urinária, a diurese pós-obstrutiva tende a ocorrer devido a este mecanismo (BARTGES *et al.*, 1996). Em um estudo, a média da densidade urinária de gatos obstruídos foi 1.025, e 67% dos gatos tinham densidade menor que 1.035 (SEGEV *et al.*, 2011). Alterações observadas na urinálise incluem hematúria, proteinúria, piúria, associada ou não à bacteriúria. No exame químico é descrita a presença de glicosúria e bilirrubinúria (NERI *et al.*, 2016; SEGEV *et al.*, 2011). Foi relatado um pH urinário médio de 7,0 nestes pacientes, sendo que em 26% deles foi considerada a presença de alcalúria (pH > 7,5) (SEGEV *et al.*, 2011). No exame do sedimento urinário podem ser observados ainda cristalúria de estruvita e presença de células epiteliais e cilindros granulosos. A hematúria decorre de sangramentos na parede da bexiga devido a inflamação e distensão vesical prolongada. A proteinúria observada é predominantemente de origem pós-renal. A glicosúria pode indicar um defeito tubular renal (SEGEV *et al.*, 2011). Um estudo mostrou que gatos obstruídos que apresentavam urina com aspecto vermelho escuro tiveram maior propensão a desenvolver distúrbios metabólicos, como azotemia e hipercalemia (BRABSON; BLOCH; JOHNSON, 2015).

Não há muitos dados na literatura com relação às alterações hematológicas em gatos obstruídos, mas é descrita a presença de leucocitose e aumento do hematócrito (SEGEV *et al.*, 2011). Entretanto, um estudo recente relatou a presença de anemia grave em 17 gatos com obstrução uretral, provavelmente em decorrência de hemorragia intravesical acentuada (BEER; DROBATZ, 2016).

3.5 Alterações hidroeletrolíticas e do equilíbrio ácido-básico

As principais alterações relatadas em gatos com obstrução uretral são hipercalemia, acidose metabólica, hiponatremia e hipocalcemia ionizada (EISENBERG *et al.*, 2013; FULTS; HEROLD, 2012; HALL, J.; HALL, K.; POWELL, 2015; LEE; DROBATZ, 2006). Dentre todos os distúrbios, a hipercalemia é de grande importância, pois pode causar alterações que colocam em risco a vida do paciente, principalmente quando o potássio sérico atinge concentrações maiores que 8 mEq/L (SCHAER, 1977). Este desequilíbrio eletrolítico pode gerar bradicardia devido a um aumento no tempo de despolarização e repolarização do sistema de condução do miocárdio. Também podem ocorrer alterações na condução cardíaca e arritmias. As principais alterações observadas no eletrocardiograma são: presença de ondas T em tenda, alargamento do complexo QRS, bloqueios atrioventriculares, bloqueio sinoatrial, fibrilação ventricular e assistolia (ODUNAYO, 2014). A hipercalemia resulta da incapacidade dos rins em excretar potássio, do deslocamento de potássio do meio intracelular para o extracelular em resposta a acidose e da reabsorção de potássio através da mucosa vesical lesionada. Hiponatremia, hipocalcemia e a acidemia podem exacerbar os efeitos cardiotóxicos da hipercalemia (SCHAER, 1977).

Acidose metabólica também é um distúrbio frequente e decorre da incapacidade dos rins em excretar íons hidrogênio, da acidose láctica, devido ao baixo débito cardíaco (RIESER, 2005) e da hiperfosfatemia, em decorrência do aumento na concentração de ácidos fracos não voláteis (MORAIS, 2008a). A acidose metabólica é caracterizada pela diminuição da concentração sérica de bicarbonato e a resposta compensatória é a alcalose respiratória por meio da hiperventilação, porém gatos tendem a não ter esta resposta compensatória como os cães, portanto sua pCO_2 geralmente permanece igual. Quando o pH atinge valores menores que 7,1, a acidose é considerada grave e pode prejudicar a contratilidade cardíaca (MORAIS, 2008a).

A hiponatremia pode ocorrer devido a perdas gastrointestinais, como vômito (MORAIS, 2008b) ou pela hipovolemia. Esta última estimula o sistema renina-angiotensina-aldosterona, a liberação de ADH e o sistema nervoso simpático. Como consequência, ocorre diminuição da excreção de água livre, culminando em hiponatremia (DIBARTOLA; MORAIS, 2012). A hipocalcemia ionizada ocorre devido a quelação do cálcio pelo fósforo em excesso, e pode contribuir com a disfunção cardíaca em casos mais graves (BURROWS; BOVEE, 1978; RIESER, 2005). Assim como ocorre com outros solutos, pode ocorrer retenção de magnésio devido a diminuição da taxa de filtração glomerular (BARTGES *et al.*, 1996).

3.6 Tratamento emergencial

Um dos aspectos mais importantes do tratamento da obstrução uretral é que as medidas terapêuticas iniciais devem ser direcionadas para estabilização do paciente, de forma emergencial. Correção da hipotermia, hipoglicemia, desidratação, bem como analgesia devem ser os procedimentos instituídos inicialmente (HOSTUTLER; CHEW; DIBARTOLA, 2005). A fluidoterapia intravenosa é indicada para o reestabelecimento do volume vascular, diluição do potássio sérico e correção da desidratação (COOPER, 2015). Tanto soluções cristaloides isotônicas balanceadas (ex: Ringer’s com lactato) como a solução de cloreto de sódio (NaCl 0,9%) foram efetivas e seguras quando utilizadas em gatos com obstrução uretral, porém a primeira mostrou resultados mais rápidos para correção dos desequilíbrios hidroeletrolíticos e ácido-básicos, se comparada com a segunda (DROBATZ; COLE, 2008).

A cistocentese descompressiva permite a rápida diminuição da pressão intravesical e, consequentemente, o reestabelecimento da filtração glomerular, interrompendo a progressão da injúria renal, além de fornecer uma amostra de urina não contaminada que pode ser encaminhada para urocultura. Além disso, o esvaziamento da bexiga pode facilitar a posterior cateterização uretral (COOPER, 2015). Apesar de ser desencorajada por alguns profissionais, este procedimento não foi associado com ruptura da bexiga em um estudo com 47 gatos (HALL; HALL; POWELL, 2015).

Relaxantes da musculatura lisa, como os α-1 agonistas (acepromazina, prazosina e fenoxibenzamina) e de musculatura estriada esquelética (diazepam e dantrolene), podem ser utilizados para diminuir o espasmo uretral, associados com analgésicos opioides (MARSHALL, 2011).

Os desequilíbrios eletrolíticos e ácido-básico devem ser corrigidos antes de qualquer procedimento anestésico. Um bolus intravenoso de gluconato de cálcio a 10%, na dose de 0,5-1,5 mL/kg, apesar de não diminuir as concentrações séricas de potássio, imediatamente neutraliza os efeitos cardiotóxicos da hipercalemia. Administração de bicarbonato de sódio na dose de 1-2 mEq/kg, pela via intravenosa, é uma opção para o tratamento da acidose metabólica, além de resultar em deslocamento do potássio para o meio intracelular devido à diminuição da acidose, auxiliando também na correção da hipercalemia. Outra terapia segura e efetiva para o tratamento da hipercalemia é a administração de insulina regular na dose de 0,5 U/kg e glicose a 50% na dose de 2,0 g para cada unidade de insulina, pois a insulina facilita a entrada do potássio na célula (WILLARD, 2008).

Após a estabilização do paciente, pode ser realizada a anestesia e desobstrução uretral. Não foi observada diferença na condição ácido-básica de gatos anestesiados com propofol ou com a associação de cetamina e diazepam, porém, os primeiros se recuperaram mais rapidamente (FREITAS *et al.*, 2012). A desobstrução uretral pode ser feita com um cateter n°24 ou 22 (sem mandril), lubrificado com gel de lidocaína e posterior substituição por uma sonda flexível. A desobstrução é realizada mediante massagem da uretra distal e lavagem com solução de cloreto de sódio estéril. A bexiga pode ser lavada com a mesma solução, com objetivo de remover debris celulares e pequenos urólitos. A sonda pode ser mantida em circuito fechado, em casos de hematúria intensa, fluxo urinário fino, nova obstrução ou atonia do músculo detrusor. Caso não seja possível realizar a cateterização uretral, a uretrostomia perineal é indicada (WILLIAMS, 2009).

4 MATERIAL E MÉTODOS

4.1 Animais

4.1.1 Critérios de inclusão

Foram incluídos no estudo gatos machos, com diagnóstico de obstrução uretral, que se apresentaram para atendimento no Hospital de Clínicas Veterinárias da Universidade Federal do Rio Grande do Sul (HCV-UFRGS), em Porto Alegre/RS, no Serviço de Medicina de Felinos (MedFel), no período de dezembro de 2015 a dezembro de 2016. Para o diagnóstico de obstrução uretral foi considerado o histórico de sinais clínicos de DTUIF obstrutiva associado a palpação vesical, com a presença de bexiga repleta não passível de compressão.

O estudo foi aprovado pela Comissão de Ética no Uso de Animais da Universidade Federal do Rio Grande do Sul, sob o número 29039 (Anexo A) e o uso dos animais foi autorizado pelos tutores através da leitura e assinatura do Termo de Consentimento Livre e Esclarecido (Anexo B), no qual constava os tipos de procedimentos a serem realizados e os riscos associados a estes.

4.1.2 Critérios de exclusão

Foram excluídos pacientes que apresentavam histórico de uretrostomia ou cateterização uretral recente.

4.2 Avaliação e estabilização inicial

Os pacientes eram submetidos a um exame físico inicial (Anexo C), que incluía aferição da temperatura retal, pressão arterial sistólica, frequência cardíaca, avaliação do tempo de preenchimento capilar, estado de hidratação, estado mental, pulso, coloração das mucosas e ausculta cardio-pulmonar. Para analgesia era utilizado tramadol na dose de 2,0 mg/kg pela via intramuscular. Era realizada a cateterização de uma veia periférica para fluidoterapia e reposição da desidratação com solução de Ringer’s com lactato. Pacientes que se apresentassem hipotensos ou com desidratação grave eram tratados com até duas provas de carga que consistiam em bolus do mesmo fluido na dose de 10-20 mL/kg durante 15 minutos. Os animais que se apresentavam hipotérmicos eram aquecidos, e se estivessem hipoglicêmicos, era realizado um bolus de glicose a 50%, pela via intravenosa. Os dados de anamnese foram obtidos após a estabilização clínica inicial (Anexo C).

4.3 Aferição da pressão arterial sistólica

A pressão arterial sistólica (PAS) era mensurada pelo método indireto *Doppler* vascular, conforme orientações do consenso do Colégio Americano de Medicina Veterinária Interna (BROWN *et al.*, 2007). O animal era posicionado em decúbito esternal ou lateral direito. Era utilizada a artéria palmar distal do membro torácico esquerdo para a detecção do pulso arterial, o qual era mantido no nível do átrio direito. A braçadeira utilizada tinha largura de 30% a 40% da circunferência do antebraço. Eram realizadas cinco aferições, sendo feita a média destas, e excluídos dois valores extremos, o maior e o menor.

4.4 Coleta de sangue

O sangue venoso era coletado por meio de punção a vácuo da veia jugular, após avaliação inicial, porém, antes de realizar outros procedimentos de estabilização no animal ou anestesia. Após tricotomia do local, era realizada antissepsia com álcool 70% e era coletado até 0,6 mL de sangue venoso da veia jugular em seringa heparinizada (heparina de lítio) (BD A-Line, BD, São Paulo/SP) para hemogasometria. Após, era realizada punção venosa com uma agulha 21G, sendo colocados 1,0 mL em tubo com anticoagulante (EDTA-K_2) para hemograma e 3,0 mL em tubo seco para as provas bioquímicas, nesta ordem.

4.5 Cistocentese descompressiva

A cistocentese descompressiva era realizada com uma seringa de 20 mL acoplada a uma torneira de três vias e um extensor de equipo. Após palpação e estabilização da bexiga, tricotomia e antissepsia com álcool 70%, a agulha era inserida em ângulo de 45° com a parede abdominal e todo o conteúdo da bexiga drenado, com objetivo de diminuir rapidamente a pressão intravesical e retomar o fluxo urinário, além de ser realizada colheita de material para urinálise e urocultura.

4.6 Correção das alterações do equilíbrio hidroeletrolítico e ácido-básico

A correção da hipocalcemia ionizada (quando a concentração sérica de cálcio ionizado era menor que 2,4 mEq/L) era feita com gluconato de cálcio a 10% na dose de 0,5-1,5 mL/kg, pela via intravenosa, durante 10 minutos. A correção da hipercalemia (quando a concentração sérica de potássio era maior que 6,0 mEq/L) era realizada com insulina regular, na dose de 0,25-0,5 unidade/kg, pela via intravenosa, associada com glicose a 50% na dose de 2,0 g/unidade de insulina, também pela via intravenosa. A correção da acidose metabólica (quando pH sanguíneo era menor que 7,15) era feita com bicarbonato de sódio pela via intravenosa, durante 30 minutos, utilizando a seguinte fórmula:

$HCO_{3\ (bicarbonato)}$ = Peso x 0,3 x BE (excesso de base) ÷ 2

4.7 Exames de imagem

Efetuou-se exame radiográfico abdominal em duas projeções (latero-lateral e ventro-dorsal) para pesquisa de urolitíase, antes da cateterizacão uretral. Era realizado estudo contrastado do trato urinário (uretrocistografia retrógrada ou urografia excretora), quando se suspeitava de rupturas, estenoses, neoplasias, cálculos radioluscentes ou má formações do trato urinário (aparelho Multix B 500/125, Siemens, São Paulo/SP).

Era realizado exame ultrassonográfico abdominal para avaliação do trato urinário um dia após a admissão do paciente, para avaliação do trato urinário (aparelho MyLab 40 Vet, Esaote Healthcare, São Paulo/SP; utilizando transdutores linear 7,5-12 MHz e microconvexo de 5,0-8,0 MHz).

4.8 Anestesia e desobstrução uretral

A anestesia e desobstrução uretral eram realizadas somente após a estabilização do paciente e correção dos desequilíbrios hidroeletrolíticos e ácido-básicos. Era utilizado propofol na dose de 2,0 mg/kg, pela via intravenosa, seguido de diazepam na dose de 0,25 mg/kg, pela mesma via. Após, de acordo com a necessidade de cada paciente, era administrado propofol ao efeito. Era realizada pré-oxigenação de todos os pacientes.

A desobstrução uretral era realizada de forma estéril, utilizando luvas e campo plástico estéreis. Inicialmente, era realizada ampla tricotomia da região perineal e antissepsia com clorexidine 2% e álcool 70%. Era realizada massagem da uretra distal objetivando a remoção de tampões nesta região. Após, era utilizado um cateter n°24 ou 22 sem mandril, lubrificado com gel de lidocaína e injeção de solução de cloreto de sódio para realização da lavagem uretral. Após a desobstrução, era utilizada uma sonda flexível para lavagem vesical. Esta sonda permanecia no local por até 48 horas, em circuito fechado, de acordo com o nível de hematúria, para realização de sucessivas lavagens vesicais. A sonda era fixada com esparadrapo e pontos de sutura simples, na pele da região adjacente lateral ao pênis e bolsa escrotal. Toda a urina retirada era filtrada em um filtro de papel, objetivando resgatar pequenos urólitos.

4.9 Demais procedimentos

Os pacientes eram mantidos internados durante pelo menos 72 horas, recebendo fluidoterapia de reposição da desidratação e manutenção, com solução de Ringer´s com lactato, analgesia com tramadol na dose de 2,0 mg/kg, a cada 12 horas, pela via subcutânea, dipirona na dose de 25 mg/kg a cada 12 horas, pela via subcutânea, diazepam na dose de 0,25 mg/kg a cada 8 horas, pela via intravenosa e prazosina na dose de 0,25 mg/gato, a cada 12 horas, por via oral. De acordo com a necessidade, era realizada a lavagem vesical a cada quatro horas, durante o período em que os pacientes estavam com a sonda de espera.

4.10 Processamento das amostras

O hemograma era realizado em um analisador hematológico automático (Idexx Procyte DX, Idexx Laboratories, Westbrook, USA) e o hematócrito era determinado pelo método de microhematócrito. Foi realizada a conferência da contagem diferencial e a análise do esfregaço sanguíneo por microscopia óptica. Para a análise bioquímica, as amostras de sangue sem anticoagulante eram centrifugadas por três minutos a 3500 rpm, para obtenção do soro. As análises eram realizadas em duplicata, e eram obtidos os valores médios de ureia, creatinina, fósforo e magnésio pelo ensaio cinético em equipamento automático (CM 200, Wiener Lab Group, Rosário, Argentina).

A hemogasometria era realizada imediatamente após a coleta, em analisador automático de pH, gases e eletrólitos sanguíneos (i-STAT, EG7+, Abbott Laboratories, Chicago, USA), sendo obtidos os valores de pH, pCO_2, pO_2, bicarbonato, excesso de base, sódio, potássio e cálcio ionizado. A hemogasometria também foi realizada em um grupo controle composto por dez gatos saudáveis, devido à falta de dados na literatura com relação a valores de referência de hemogasometria em felinos, bem como para controle interno de possíveis interferências causadas pela coleta.

A glicemia era aferida com um aparelho portátil (Accu-chek Performa Nano, Roche Diagnostics, Basel, Switzerland), assim como o lactato (Accutrend Plus, Roche Diagnostics, Basel, Switzerland).

O exame químico da urina era realizado por meio de tiras reagentes e a análise do sedimento urinário após a centrifugação de 10 mL de urina, por 5 minutos, a 1500 rpm e a observação da amostra por microscopia. A densidade urinária era realizada por refratometria. Para urocultura, as amostras eram incubadas a 37°C durante 48 horas em meio de cultura (ágar-sangue, ágar MacConkey e caldo BHI) e caso houvesse crescimento era realizado o antibiograma.

4.11 Análise estatística

Para a análise estatística, utilizou-se o software IBM SPSS versão 20.0 (SPSS Inc. IBM, Atlanta, USA). Para avaliar a normalidade dos dados, foi utilizado o teste de Shapiro-Wilk. Foram calculadas as frequências relativas para as variáveis categóricas, além da média e desvio-padrão para as variáveis quantitativas com distribuição simétrica e da mediana e intervalo interquartil para as assimétricas. Para comparação das variáveis categóricas, foi utilizado o teste exato de Fisher. Já para as variáveis quantitativas com distribuição simétrica foi utilizado o teste t de Student para variáveis independentes e, para aquelas com distribuição assimétrica, o teste de Mann-Whitney.

Os pacientes foram divididos em três grupos (sobreviventes, não-sobreviventes e grupo controle saudável). Para comparação destes grupos, foi utilizado o teste ANOVA (Análise de Variância) seguido de um teste *post-hoc* de Tukey. As correlações de Spearman e Pearson foram usadas para avaliar a relação entre as variáveis quantitativas assimétricas e simétricas, respectivamente. Uma correlação foi considerada forte quando r > 0,5 e considerada muito forte quando r > 0,9. Foi considerado um nível de significância de 5%.

5 RESULTADOS

Os resultados serão apresentados na forma de artigo científico, que serão submetidos aos periódicos *Journal of Veterinary Emergency and Critical Care* e *Journal of Feline Medicine and Surgery*, respectivamente.

5.1 Artigo 1

Association of clinical, laboratory, hydroelectrolyte and acid-base parameters in male cats with urethral obstruction

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Abstract

Objective: To evaluate the association of clinical, laboratory, hydroelectrolyte and acid-base parameters in male cats with urethral obstruction and to correlate these data.

Design: Prospective clinical study

Setting: University Teaching Hospital

Animals: Twenty-eight client-owned male cats diagnosed with urethral obstruction

Methods: Data regarding medical history, clinical signs and physical examination were gathered from 28 cats that went to Rio Grande do Sul Federal University Teaching Hospital with urethral obstruction. Blood was collected for complete blood count, serum chemistry (urea, creatinine, phosphorus, magnesium, glucose, lactate), venous pH, gas and electrolyte analysis prior to any intervention. Cats were treated accordingly to a previously established protocol, which included analgesic therapy, balanced electrolyte intravenous fluid therapy, decompressive cystocentesis and correction of acid-base and electrolyte disorders. After stabilization, the patients were anesthethized for urethral catheterization and remained hospitalized for supportive care. The patients were classified accordingly to their outcome as survivors and non-survivors. They were also classified in respect to the length of urethral obstruction prior to hospital admission in two groups (within 24 hours and more than 24 hours). Venous blood analysis was also performed in a control group composed of ten healthy cats, regarding to blood pH, gas and electrolyte analysis.

Results: Twenty-three (82%) cats presented acid-base and electrolyte disorders. Seventeen cats (60.7%) were discharged home (survivors) while eleven (39.3%) died due to complications related to urethral obstruction (non-survivors). No significant difference was observed between the survivors and non-survivors considering clinical and laboratorial parameters. There was significant difference between the healthy group and the other two groups (survivors and non-surivors) for the venous pH, gas and electrolyte values, except for pCO_2. The length of obstruction prior to admission was less than 24 hours in 50% of cats and longer than 24 hours in the other half. There was no statistically association among time of urethral obstruction and clinical parameters but there was significant difference between the means of these two groups for the variables urea, creatinine, phosphorus, potassium and ionized calcium. Dehydration and depressed mental status were statistically associated with hypothermia, azotemia, hyperphosphatemia, hyperkalemia, ionized hypocalcemia and acidemia. Bradycardia was also statistically related to hypothermia, azotemia, acidemia, hyperkalemia and ionized hypocalcemia. Rectal temperature was inversely correlated with potassium, urea, creatinine and pCO_2 values and directly correlated with pH; potassium was inversely correlated with pH, bicarbonate, base excess, sodium and ionized calcium and directly correlated to urea, creatinine and phosphorus; and pH was inversely correlated with urea, pCO_2 and potassium and directly correlated with bicarbonate and base excess. Lactate did not correlate with any clinical or laboratory parameter.

Conclusions: Most of obstructed cats were presented with multiple severe systemic clinical signs, as well as, metabolic, electrolyte and acid-base alterations. This fact may be justified by the delay of emergency care in half of the cases and explain the high mortality rate (39.3%). Hypothermia, depressed mental status, bradycardia and dehydration were the clinical parameters that had a greater amount of associations with the metabolic alterations and can be considered as good predictors of metabolic disorders. On the other hand, lactate was not considered a good predictor of clinical and laboratory abnormalities or mortality in cats with urethral obstruction in this study.

Key words: feline lower urinary tract disease; venous blood pH; hyperkalemia; metabolic acidosis

Introduction

Urethral obstruction is a common and potentially life-threatening manifestation of feline lower urinary tract disease, characterized by severe metabolic, electrolyte and acid-base disturbances.[1,2] Clinical signs include vomiting, stranguria, hematuria, pollakiuria, vocalization, excessive licking of the perineal area and lethargy. More severe systemic signs can occur depending on the duration of obstruction and some cats can present with severe cardiovascular compromise and collapse.[3] The main metabolic disorders developed are azotemia, hyperphosphatemia, hyperkalemia, metabolic acidosis, hyponatremia and ionized hypocalcemia.[4–7] Clinical signs associated with metabolic changes include dehydration, hypovolemia, bradycardia, hypothermia and weak pulse.[6,8,9] Cats that have been obstructed for more than 48 hours are most likely to be severely ill.[10] Previous studies reported that approximately one out of ten cats with urethral obstruction are critically ill.[6] Survival is related to the precocity of the treatment performed.[11] The prognosis for survival is described as good, providing they are stabilized within the first few hours of presentation.[3]

There are several studies characterizing these disorders in cats with this condition, however most are retrospective studies with limitations inherent of this design.[4–6,9] This is a prospective study in naturally occurring cases, which allows a standardized assessment of the clinical and laboratory parameters and protocol treatment. The aim of this study was to evaluate the association of clinical, laboratory, hydroelectrolyte and acid-base parameters in male cats with urethral obstruction. The main purpose is to obtain clinical predictors of the laboratory findings to help clinicians direct diagnosis and determine prognosis.

Materials and methods

Animals and including criteria

A prospective study was performed to evaluate the clinical, laboratorial, acid-base and electrolytic parameters in male cats with urethral obstruction. The inclusion criteria were male cats with a diagnosis of urethral obstruction, presenting with a history of lower urinary tract disease and a distended non-expressible urinary bladder. The patients were admitted to the Veterinary Teaching Hospital of Rio Grande do Sul Federal University, located in Porto Alegre - Brazil, between december 2015 and december 2016. Cats with history of previous urethrostomy or recent urethral catheterization were excluded. A control group was composed of ten healthy cats, evaluated through physical examination and blood work evaluation. In this group, venous blood analysis was performed in regarding to blood pH, gas and electrolyte analysis.

This study was approved by the Ethics Committee on the Use of Animals of this University (no. 29039). The owners had been informed about the procedures and allowed the inclusion of the animals on the study by signing a consent form.

Clinical examination

Data regarding previous medical history, clinical signs and physical examination were collected from all patients. All cats were examined and the blood was collected prior to anesthesia or any physical intervention. Physical examination included measurement of rectal temperature and heart rate, evaluation of mental status, mucous membranes color, capillary refill time, degree of hydration and pulse. Systolic blood pressure was measured using a Doppler ultrasonography device[a], according to the American College of Veterinary Internal Medicine Guidelines.[12]

Laboratorial sampling

Blood samples were collected for complete blood count (CBC), serum biochemistry (urea, creatinine, phosphorus and magnesium), blood pH, gas and electrolyte (Na, K, iCa) analysis, glucose[b] and lactate[c]. For blood pH, gas and electrolyte analysis, venous blood was collected on a lithium heparinized syringe[d], and immediately analyzed in a portable analyzer[e]. Venous blood was collected also from a control group composed of ten healthy cats, for blood pH, gas and electrolyte analysis. All serum biochemical tests were performed in an automatic biochemistry equipment[f]. To CBC, EDTA blood samples were analyzed in an automatic counter[g], hematocrit was determined by the microhematocrit method and total plasma protein by refractometry.

Clinical procedures

Cats were treated accordingly to a previously established protocol, which included analgesic therapy with tramadol (2 mg/kg intramuscular), balanced electrolyte intravenous fluid therapy with lactated Ringer's solution, proportionaly to the degree of dehydration and intravenous bolus to hypotensive patients (10-20 mL/kg in ten minutes), heating for body temperature control, oxygen therapy for patients with dyspnea, correction of hypoglycemia and decompressive cystocentesis. Correction of ionized hypocalcemia was performed using 10% calcium gluconate (0.5-1.5 mL/kg in ten minutes, intravenous). Hyperkalemia (potassium > 6.0 mEq/L) was corrected using intravenous regular insulin (0.25-0.5 units/kg) associated with intravenous dextrose (2 g/unit of insulin). Metabolic acidosis (pH < 7.15) was corrected with intravenous 8.4% sodium bicarbonate (bicarbonate (mL) = body weight x 0.3 x base excess ÷ 2).

An abdominal radiography was performed after patient stabilization to screen for urolithiasis. After that, patients were anesthetized with an association of diazepam (0.25 mg/kg intravenous) and propofol (2 mg/kg intravenous or more, if necessary). Catheterization and retrohydropulsion was performed aseptically, using a 22-24 gauge intravenous catheter (minus the stylet) lubricated with lidocaine gel, that was replaced by a flexible 3.5 french polyvinyl urethral catheter[h] to perform bladder flushing. The bladder was flushed gently with normal saline solution and the urethral catheter was maintained for 24-48 hours with a closed system, accordingly to the severity of persistent hematuria. The patients were hospitalized for minimum of 72 hours, and were classified correspondingly to their outcome as survivors (discharged home) and non-survivors (death despite treatment). They were also classified related to the length of urethral obstruction prior to hospital admission in two groups (within 24 hours and more than 24 hours).

Statistical analysis

The statistical analysis was performed applying a statistical software program[i]. The Shapiro-Wilk test was used to evaluate data for normal distribution. The relative frequencies were calculated for categorical variables. Mean and standard deviation (SD) were used for quantitative variables with symmetric distribution. Median an interquartile range (IR) were used for quantitative variables with asymmetric distribution. To compare categorical variables the Fisher's exact test was applied; for quantitative variables with symmetric distribution, the Student's t-test was performed; and for quantitative variables with asymmetric distribution, the Mann-Whitney test was used. For comparison of three groups (survivors, non-survivors and control group), ANOVA (analysis of variance) was performed followed by a Tukey *post hoc* test. Spearman correlation test and Pearson correlation test were used to access relationship between asymmetric and symmetric quantitative variables, respectively. A strong correlation was considered when $r > 0.5$. For all statistical analysis, a p-value < 0.05 was considered significant.

Results

Signalment and history

Twenty-eight client-owned male cats were included in the study. Fifteen (53.6%) were neutered males and all of them (100%) were mixed-breed. The median age was two years (0.8-4.7) and ranged from three months to 11 years old. The mean body weight was 3.9 kg (±1) and median body condition score 5 / 9 (range 4 - 7). Twenty-two cats (78.6%) had outdoors access.

All cats came up with multiple clinical signs. The majority presented nonspecific clinical signs, including vomiting (71.4%), anorexia (71.4%) and prostration (67.9%). Other signs related to lower urinary tract disease were excessive licking of the perineum (60.7%), dysuria (57.1%), stranguria (39.3%), hematuria (35.7%), pollakyuria (21.4%) and periuria (21.4%). Less frequently, signs as vocalization (3.6%), ataxia (3.6%), hematemesis (3.6%) and aggressiveness (3.6%) were reported.

Physical examination

The median rectal temperature (RT) was 37.1°C (35.5-37.8) (range 32-39.1). Fifteen (53.6%) cats were considered hypothermic (< 37.3°C). The mean systolic blood pressure was 120 mmHg (± 52) (range 60-250 mmHg). Ten cats (35.7%) were considered hypotensive (< 90 mmHg). The mean heart rate was 176 beats/min (± 42) (range 112-256). Only five cats (17.9%) were considered bradycardic (< 140 beats/min). Seventeen (60.7%) were dehydrated, 9 (32.1%) presented depressed mental status, eight (28.6%) had a prolonged capillary refill time, four (14.3%) had a pale mucous membrane and four (14.3%) presented with weak femoral pulse.

Clinical pathology

Twenty-six cats (92.8%) were considered azotemic based in serum creatinine, 24 (85.7%) had hyperlactatemia, 22 (78.6%) had hyperphosphatemia and acidemia, 19 (67.9%) had hyponatremia and low bicarbonate levels, 18 (64.3%) had hyperkalemia and ionized hypocalcemia, 13 (46.4%) were hyperglicemic, eight (28.6%) had increased pCO_2 levels and two (7.1%) were hypoglicemic. The clinicopathologic data are described in Table 1.

The venous pH, gas and electrolyte values were compared between three groups (survivors, non-survivors and control healthy group) and the results are summarized in Table 2. There was significant difference between the healthy group and the other two groups for all the variables, except for pCO_2. There was no significant difference between survivors and non-survivors. Twenty-three (82%) cats presented some acid-base disorder. Of these, 16 (70%) had metabolic acidosis, three (13%) had respiratory acidosis and four (17%) had both metabolic and respiratory acidosis. Twenty-three (82%) cats also developed some electrolyte disorder and 19 (67.8%) exhibited both acid-base and electrolyte disorders.

Inter-relationship of qualitative variables

There was association of depressed mental status and the following variables: presence of bradycardia (p= 0.026), prolonged capillary refill time (p= 0.005), dehydration (p= 0.049), pale mucous membrane (p= 0.003). There was also association of pale mucous membrane and the following variables: presence of hypotension (p= 0.011), prolonged capillary refill time (p= 0.011) and weak femoral pulse (p= 0.01). Other variables were not related to each other.

Considering the length of obstruction prior to admission at Veterinary Teaching Hospital, was less than 24 hours in 14 cats (50%) and longer than 24 hours in the other half. There was no significant difference between these two groups considering the presence of hypotermia, bradycardia, hypotension, depressed mental status, prolonged capillary refill time, pale mucous membrane and weak femoral pulse.

Inter-relationship of quantitative and qualitative variables

There was no significant difference between the means and medians for any variable related to the presence of hypotension or weak femoral pulse. Prolonged capillary refill time only showed different means and medians related with rectal temperature (p= 0.01) and potassium (p= 0.012). Pale mucous membrane showed different means and medians related with rectal temperature (p= 0.035), pH (p= 0.048) and pCO_2 (p= 0.018). The means and medians for the presence of bradycardia, depressed mental status and dehydration and their matching with the normal group are described in Tables 3, 4 and 5, respectively. Lactate was not related to any clinical parameter.

Regarding the length of obstruction, there was significant difference between the means of the two groups (within 24 hours and longer than 24 hours) for the variables urea, creatinine, phosphorus, potassium and ionized calcium (Table 6).

Inter-relationship of quantitative variables

Rectal temperature was inversely correlated with urea, creatinine, pCO_2 and potassium and directly correlated with pH. pH was inversely correlated with urea, pCO_2 and potassium and directly correlated with base excess and bicarbonate. Potassium was directly correlated with urea, creatinine, phosphorus and inversely correlated with pH, base excess, bicarbonate, sodium and ionized calcium. All the correlations for rectal temperature, pH and potassium are described in Table 7. Lactate did not correlate with any variable (rectal temperature, urea, creatinine, phosphorus, pH, pCO_2, base excess, bicarbonate, sodium, potassium and ionized calcium).

Outcome

Seventeen cats (60.7%) were discharged home (survivors) while eleven (39.3%) died due to complications related to urethral obstruction (non-survivors). There was no significant difference between the means and medians of the two groups for the following variables: body weight, heart rate, rectal temperature, systolic blood pressure, lactate, glucose, urea, creatinine, magnesium, phosphorus, pH, pCO_2, base excess, bicarbonate, sodium, potassium and ionized calcium (Table 2). There was also no difference between the categorical variables: hydration status, mental status, capillary refill time, mucous membrane color and femoral pulse.

Discussion

Feline urethral obstruction is a life-threatening condition, often present in veterinary clinics and hospitals, and requires emergency treatment to diagnose and correct hydroelectrolyte and acid-base disorders[1,5]. Short-term mortality rate reported is 4.9% [5] 5.8% [9], 8.5% [13], 9% [14] and 22%[15] in five different studies. At present study, a higher mortality rate was observed (39.3%). A lower mean blood pH value was observed in non-survivors cats, but the difference did not reach statistical significance. Despite no significant difference was found between the survivors and non-survivors in this study in respect to clinical and laboratorial analysis, a high frequency of severe alterations was observed in both groups, including hypothermia (53.6%), azotemia (92.8%), hyperlactatemia (85.7%), acidemia (78.6%) and hyperkalemia (64.3%). The difference found in mortality rate could be explained by a lower frequency of these alterations in the other studies. In one of them, only 40% presented acidemia, 41% were hyperkalemic, 45% had hyperlactatemia and 39% were hypothermic.[9] In the other, 51% were hypothermic, 15% presented a circulatory shock, 48% had hyperkalemia and 85% were azotemic.[13] Likewise, in a study comparing survivors and non-survivors, no significant difference was observed within the two groups, considering the serum values of sodium, potassium and creatinine, except for ionized calcium.[13] Furthermore, in the present study, a higher frequency of systemic signs, such as vomiting and prostration, was observed, compared to the other studies[9,13], wich indicates greater severity of the disease.

Other possible explanation for the high mortality includes the fact that the study was sited in a Veterinary Teaching Hospital in Brazil, and the clients who attend there usually have low income, since the costs are much lower to treat their pets. Therefore, these clients only seek veterinary assistance when their pet are very ill to be sure they need care. Besides, 78.6% of the cats in this study had outdoors access. This could make it difficult for the owner to observe their cat's urinary habits and probably there was a delay on the demand for medical care.

More than 50% of the cats presented dehydration and hypothermia. Less frequent clinical parameters were depressed mental status (32.1%) and hypotension (35.7%). Although bradycardia was found in only five patients (17.9%), the median potassium levels were significant higher in bradycardic cats, which corroborates with findings from other study.[6]

A low frequency (7.1%) of hypoglycemia was found in the present study. Other studies reported similar frequencies, ranging from 0.5 to 3.8%.[9,16] In contrast, a high frequency (46.4%) of hyperglycemia was observed. The prevalence of hyperglycemia reported in hospitalized cats was 64% in one research and hyperglycemic cats had increased lenght of hospitalization when compared with normoglycemic ones. This alteration may occur due to a stress response to sickness.[17] Other studies with urethral obstruction observed a similar frequency of hyperglycemia.[9,16]

Systemic signs reflect the metabolic disorders associated with urethral obstruction and tend to occur in more severe cases.[18] Obstruction of the urine flow results in increased pressure in the bladder, wich rises to the kidneys, decreasing the glomerular filtration rate, renal blood flow and tubular function. As a consequency, urea, creatinine, phosphorus, potassium, hydrogen ions and other solutes accumulate in blood.[19,2] The magnitude of azotemia typically reflects both pre renal and post renal components. Dehydration results from lack of oral intake, sequestration of fluid in the bladder and continued fluid losses, such as vomiting.[18] Fluid deficits can lead to hypovolemia and decreased tissue perfusion.[2] Also, in cases of prolonged obstruction, persistent renal injuries may occur.[18] In this study, potassium concentrations were directly correlated to urea, creatinine and phosphorus, what is compatible with decreased renal excretion of these metabolites and is similar to other study results[5,9].

Rectal temperature was inversely correlated with urea, creatinine, potassium and pCO_2 and directly correlated with pH, similiar to previous studies.[5,16] The presence of depressed mental status and dehydration were associated with higher levels of urea, creatinine, phosphorus, potassium and pCO_2 and lower levels of ionized calcium, and a low pH. Increased pCO_2 can produces disorientation, narcosis and coma[20]. In this study, the mean values of pCO_2 were significantly higher on the group presenting depressed mental status. Neurologic signs, such as mental status alteration, can also result from acidosis, uremia, poor tissue perfusion or the combination of them.[2] In a retrospective study hypothermia was an excellent predictor of hyperkalemic status in cats with urethral obstruction.[6] Hypothermia may occur due to poor peripheral perfusion, volume depletion and shock. Cardiovascular shock and volume depletion in cats tend to manifest with hypothermia, bradycardia and hypotension, because cats do not undergo the compensatory stage of shock.[21]

Regarding the length of urethral obstruction prior to hospital admission, the mean values of creatinine, phosphorus and potassium were significantly higher and the mean ionized calcium level was lower in the group obstructed for more than 24 hours. There was no difference for clinical parameters and acid-base status between these two groups. Azotemia may occurs after a 24-hour period of complete obstruction[22] and hyperkalemia within 48 hours.[11] One study observed no significant difference in blood pH, biochemical values and electrolyte concentrations between cats obstructed 24 hours and those obstructed 48 hours or longer.[23] Another study demonstrated increased creatinine, phosphorus, lactate, potassium and sodium, in addition to decreased blood pH, in cats that presented more than 36 hours of obstruction.[16] In this study, hyperkalemia and azotemia were more severe in cats obstructed for more than 24 hours, showing that, even in the absence of bradycardia, these conditions should be diagnosed and treated in all obstructed cats.

Hyperkalemia results from the inability of the kidneys to excret potassium, the shifting of potassium from the intracellular space in response to acidosis, and reabsorption of potassium from the damaged bladder mucosa. This electrolyte disturbance can lead to bradycardia and life-threatening cardiac arrhythmias. Hyponatremia, hypocalcemia and acidemia may exacerbate these clinical effects[18,2] and all of them were observed in this study. Potassium was also inversely correlated to pH, base excess and bicarbonate, what correlates hyperkalemia to metabolic acidosis and the shifting of potassium from the intracellular space. Bradycardia was related to higher levels of urea, creatinine, potassium and lower levels of pH and ionized calcium, in this study. We could not evaluate the presence of arrhythmias because electrocardiogram was not performed.

Metabolic acidosis occurs as a result of inability of the kidneys to excrete hydrogen ions, but lactic acidosis secondary to low cardiac output may contribute to a worsening acid-base status in these patients.[2] Hyperphosphatemia can also contribute to metabolic acidosis, as a result of increased nonvolatile weak acids.[24] In this study, pH was directly correlated to bicarbonate and base excess, what is consistent with metabolic acidosis, but also inversely correlated to pCO_2, which can be explained by the presence of respiratory acidosis in 30% of the patients. One possible explanation for respiratory acidosis could be the development of respiratory center depression associated with depressed mental status and electrolyte abnormalities[20], since pH was also directly correlated with potassium. Hyperkalemia also results in generalized muscle weakness[2], what can contribute to changes in respiratory pattern. Besides, cats do not seem to compensate a metabolic acidosis developing hyperventilation, as dogs does.[24]

Hyponatremia was observed in 67.7% of the cats in this study and has also been reported in other studies.[5,9,4] It is described in cats with a number of diseases[25] in association with hyperkalemia, and may occur due to gastrointestinal losses,[26] but also hypovolemia. Hypovolemia stimulates the renin-angiotensin-aldosterone system, ADH release and the sympathetic nervous system. As a consequence, sodium and water is retained, but also compensatory free water excretion is impaired.[27] This mechanism can explain hyponatremia in cases of urethral obstruction associated with hypovolemia. Hyponatremia results in decreased sodium delivery to the distal renal tubules and inappropriately low kaliuresis because of a decrease in both the concentration and electrochemical gradients for potassium excretion.[27] This second mechanism may exacerbate hyperkalemia.

Ionized hypocalcemia has been reported to occur in 75% of cats with urethral obstruction and was inversely correlated with potassium,[28] similar to this study. This may occur due to chelation of calcium by phosphorus and contribute to cardiac dysfunction in some severely affected cats.[2,23]

Lactate is an intermediary metabolite of glycolysis and can accumulate in the body during states of shock.[29] Hyperlactatemia was not related with any variable in this study. Lactate was expected to be increased because of poor tissue perfusion (in cases of hypovolemia and hypotension) and/or decreased oxygen supply (in cases of respiratory acidosis). The lack of relation of lactate with physical parameters could be explained because even in cases of compensatory shock, when physical parameters are normal, there is still ongoing tissue hypoperfusion, and consequent lactate increase.[29] One clinical trial that evaluated serial lactate in hyperlactatemic cats did not consider lactate as a good prognostic tool for survival or duration of hospitalization.[30] We consider that lactate was not a good predictor of clinical and laboratory abnormalities in cats with urethral obstruction in this study.

Hypothermia, depressed mental status, dehydration and bradycardia were considered good predictors of the main metabolic disorders associated with urethral obstruction, in this study. Considering the existence of metabolic disorders in cats with urethral obstruction without showing clinical signs, one cannot exclude the possibility of occurring these imbalances based only on clinical status alone. The establishment of clinical predictors does not make the laboratory assessment less important, but it helps the clinician directs a diagnosis and determine prognosis.

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Footnotes

[a] DV 610V, Med Mega, Franca, SP, Brazil

[b] Accu-chek Performa Nano, Roche Diagnostics, Basel, CH, Switzerland

[c] Accutrend Plus, Roche Diagnostics, Basel, CH, Switzerland

[d] BD A-Line, BD, São Paulo, SP, Brazil

[e] i-STAT, EG7+, Abbott Laboratories, Princeton, NJ, USA

[f] CM 200, Wiener Lab Group, Rosário, Argentina

[g] Procyte DX, Idexx Laboratories, Westbrook, USA

[h] Urethral catheter 3.5 french, Kendall Company, Mansfield, MA, USA

[i] SPSS v. 20.0, IBM Inc. Company, Atlanta, GA, USA

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Table 1: Laboratorial values from blood collected at the time of admission from 28 male cats diagnosed with urethral obstruction.

Parameters	Descriptive measures	Range	Reference range
Lactate (mmol/L)	3.6 (3-4.3)**	2.4-6.5	< 2.87
Glucose (mg/dL)	144.5 (±55.9)*	59-268	73-134
Urea (mg/dL)	396.5 (±227)*	52-812	32-54
Creatinine (mg/dL)	10.6 (±6.5)*	0.8-22	0.8-1.6
Phosphorus (mg/dL)	12.2 (±6.4)*	3.8-28.7	2.7-6.2
Magnesium (mg/dL)	3 (2.6-3.6)**	1-6.5	1.4-3.1
pH	7.192 (±0.116)*	6.922-7.397	7.277-7.409
pCO_2 (mmHg)	40.9 (±7.6)*	28.7-58	32.7-44.7
Base excess (mm/L)	-12.3 (±4.9)*	-21 to -4	-3 to 2
Bicarbonate (mm/L)	15.8 (±3.4)*	9.5-23	18-23
Sodium (mEq/L)	142.8 (±5.3)*	133-153	145-157
Potassium (mEq/L)	6.5 (±2)*	2.8-9.0***	3.6-5.5
Ionized calcium (mmol/L)	0.97 (±0.2)*	0.57-1.31	1.07-1.5
PCV (%)	40 (±6.6)*	31-57	24-45
WBC ($x10^3$)	22.253 (±8.170)*	7.000-38.500	5.000-19.500

*mean, ± SD; **median, IR

***Highest value measured by the analyser

Table 2: Venous pH, gas and electrolyte values from blood collected at the time of admission from 28 male (survivors and non-survivors) cats diagnosed with urethral obstruction and from a control healthy group.

Parameters	Survivors (n = 17)		Non-survivors (n = 11)		Control group (n = 10)		*p*-value
	Mean (± SD)	**Range**	**Mean (± SD)**	**Range**	**Mean (± SD)**	**Range**	
pH	7.195 (±0.11) [a]	7.023-7.367	7.186 (±0.13) [a]	6.922-7.397	7.322 (±0.43) [b]	7.242-7.390	0.007
pCO_2 (mmHg)	39.6 (±8.4)	28.7-58	43 (±5.9)	29.4-54.1	40.5 (±3.1)	36.3-46.9	0.416
Base excess (mm/L)	-12.76 (±5) [a]	-21 to -4	-11.7 (±5) [a]	-21 to -7	-4.9 (±2.5) [b]	-8 to 0	0.001
Bicarbonate (mm/L)	15.4 (±3.5) [a]	9.5-23	16.5 (±3.1) [a]	11.1-20.5	21.1 (±2.1) [b]	17.9-25.3	0.001
Sodium (mEq/L)	143.1 (±4.8) [a]	136-152	142.4 (±6.2) [a]	133-153	151.7 (±2.5) [b]	147-157	0.001
Potassium (mEq/L)	6.4 (±1.9) [a]	2.8-9.0*	6.5 (±2) [a]	3.7-9.0*	3.9 (±0.3) [b]	3.2-4.3	0.002
Ionized calcium (mmol/L)	0.95 (±0.19) [a]	0.57-1.29	1 (±0.23) [a]	0.63-1.31	1.28 (±0.81) [b]	1.17-1.4	0.001

a, b: different letters mean statistically different means (ANOVA followed by Tukey *post hoc* test)

*Highest value measured by the analyser

Table 3: Presence of bradycardia and its correlation with the other variables in cats with urethral obstruction.

Parameters	Normal or tachycardia	Bradycardia	*p*-value
Rectal temperature (°C)	37.3 (36.5-37.9)	33.5 (32-36.2)	0.003**
Lactate (mmol/L)	3.6 (3-4.3)	3.8 (3.2-5.5)	0.447**
Urea (mg/dL)	343.5 (±214.3)	640.4 (±67.4)	0.006*
Creatinine (mg/dL)	9.3 (±6.2)	16.9 (±3.8)	0.014*
Phosphorus (mg/dL)	11.1 (±5.6)	17.2 (±8.2)	0.057*
pH	7.218 (±0.1)	7.097 (±0.1)	0.042*
pCO_2 (mmHg)	40 (±7.8)	45.3 (±4.9)	0.169*
Base excess (mm/L)	- 11.6 (±4.8)	- 15.8 (±4.5)	0.086*
Bicarbonate (mm/L)	16.2 (±3.4)	14.1 (±2.7)	0.206*
Sodium (mEq/L)	143.7 (±5)	138.8 (±4.8)	0.057*
Potassium (mEq/L)	6. (±1.9)	8.2 (±1)	0.024*
Ionized calcium (mmol/L)	1.02 (±0.18)	0.72 (0.09)	0.002*

*mean, ± SD (Student's t-test for independent variables)

**median, IR (Mann-Whitney test)

Table 4: Presence of depressed mental status and its correlation with other variables in cats with urethral obstruction.

Parameters	**Normal**	**Depressed mental status**	***p*-value**
Rectal temperature (°C)	37.7 (36.9-38.1)	34.6 (32.7-36.2)	0.001**
Lactate (mmol/L)	3.6 (3.2-4.3)	3.8 (2.8-4.5)	0.809**
Urea (mg/dL)	319.8 (±213.9)	558.4 (±165.3)	0.007*
Creatinine (mg/dL)	8.7 (±6.5)	14.6 (±4.5)	0.023*
Phosphorus (mg/dL)	10.4 (±4.7)	16.6 (±8)	0.019*
pH	7.241 (±0.08)	7.087 (±0.1)	0.001*
pCO_2 (mmHg)	39 (±7.7)	45 (±5.7)	0.047*
Base excess (mm/L)	- 10.5 (±4.4)	- 16.2 (±3.7)	0.003*
Bicarbonate (mm/L)	16.8 (±3.4)	13.6 (±2.1)	0.017*
Sodium (mEq/L)	144 (±5.1)	140.3 (±5)	0.082*
Potassium (mEq/L)	5.7 (±1.6)	8 (±1.6)	0.002*
Ionized calcium (mmol/L)	1.05 (±0.18)	0.8 (±0.16)	0.002*

*mean, ± SD (Student's t-test for independent variables)

**median, IR (Mann-Whitney test)

Table 5: Presence of dehydration and its correlations with other variables in cats with urethral obstruction.

Parameters	**Hydrated**	**Dehydrated**	***p*-value**
Rectal temperature (°C)	37.8 (37.3-38.1)	36.3 (34.5-37.4)	0.002**
Lactate (mmol/L)	3.4 (3-4.3)	3.8 (3-4.5)	0.285**
Urea (mg/dL)	256 (±190)	485.4 (±207)	0.007*
Creatinine (mg/dL)	6.3 (±5.3)	13.3 (±5.7)	0.003*
Phosphorus (mg/dL)	8.9 (±4.7)	14.5 (±6.6)	0.024*
pH	7.266 (±0.91)	7.144 (±0.1)	0.004*
pCO_2 (mmHg)	37 (±5.7)	43.5 (±7.7)	0.026*
Base excess (mm/L)	- 9.9 (±4.6)	- 13.9 (±4.6)	0.033*
Bicarbonate (mm/L)	17.1 (±3.3)	15 (±3.2)	0.11*
Sodium (mEq/L)	143.6 (±5)	142.3 (±5.5)	0.541*
Potassium (mEq/L)	5.5 (±1.9)	7.1 (±1.7)	0.027*
Ionized calcium (mmol/L)	1.07 (±0.17)	0.9 (±0.2)	0.034*

*mean, ± SD (Student's t-test for independent variables)

**median, IR (Mann-Whitney test)

Table 6: Variables related to the length of obstruction prior to admission in cats with urethral obstruction.

Parameters	Within 24 horas (n = 14)	More than 24 horas (n = 14)	*p*-value
Urea (mg/dL)	273 ± 166	519.3 ± 216	0.002*
Creatinine (mg/dL)	6.6 ± 4.2	14.6 ± 5.9	0.001*
Phosphorus (mg/dL)	8.8 ± 3.5	15.9 ± 7	0.003*
pH	7.202 ± 0.99	7.181 ± 0.13	0.651*
pCO_2 (mmHg)	42.2 ± 7.7	39.7 ± 7.5	0.385*
Base excess (mm/L)	- 11.5 ± 4.4	- 13.2 ± 5.5	0.37*
Bicarbonate (mm/L)	16.6 ± 3.1	15 ± 3.5	0.214*
Sodium (mEq/L)	143.9 ± 4.9	141.8 ± 5.6	0.292*
Potassium (mEq/L)	5.7 ± 1.7	7.2 ± 1.9	0.048*
Ionized calcium (mmol/L)	1.05 ± 0.2	0.89 ± 0.19	0.037*
Rectal temperature (°C)	37.3 (36.2-37.8)	36.8 (35.1-38)	0.55**
Lactate (mmol/L)	4.05 (3.3-4.3)	3.3 (3-3.9)	0.123**

*mean, ± SD (Student's t-test for independent variables)

**median, IR (Mann-Whitney test)

Table 7: Correlation between rectal temperature, pH, potassium with other quantitative variables in cats with urethral obstruction.

Parameters	Rectal temperature (°C)		pH		Potassium	
	r (Spearman correlation coefficient)	*p*-value	r (Pearson correlation coefficient)	*p*-value	r (Pearson correlation coefficient)	*p*-value
Lactate (mmol/L)	-0.09	0.65*				
Urea (mg/dL)	-0.53	0.003*	-0.607	0.001**	0.839	0.001**
Creatinine (mg/dL)	-0.5	0.007*	-0.493	0.008**	0.823	0.001**
Phosphorus (mg/dL)	-0.4	0.037*	-0.445	0.020**	0.732	0.001**
pH	0.61	0.001*			-0.53	0.004**
pCO_2 (mmHg)	-0.57	0.001*	-0.58	0.001**	0.168	0.392*
Base excess (mm/L)	0.47	0.011*	0.873	0.001**	-0.55	0.002**
Bicarbonate (mm/L)	0.35	0.065*	0.712	0.001**	-0.516	0.005**
Sodium (mEq/L)	0.28	0.142*	0.344	0.073**	-0.7	0.001**
Potassium (mEq/L)	-0.524	0.004*	-0.53	0.004**		
Ionized calcium (mmol/L)	0.419	0.026*	0.47	0.01**	-0.698	0.001**

*Spearman correlation test
**Pearson correlation test

5.2 Artigo 2

Evaluation of the etiology of urethral obstruction in male cats in southern Brazil

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Abstract

Urethral obstruction is a common clinical condition in male cats and can occur due to idiopathic cystitis, urolithiasis, urethral plugs and urinary tract infection, among other less frequent causes. Characteristics related to management, diet and owner's profile can influence the manifestation of the disease in different populations. The aims of this study were to investigate the previous medical history and determine the causes of urethral obstruction in male cats in southern Brazil. This was a prospective study that included client-owned male cats with urethral obstruction and data about previous medical history, physical examination, imaging tests, urinalysis and urine culture were collected. The causes of urethral obstruction in 28 cats included 18 (64.3%) with idiopathic cystitis, 8 (28.6%) with urethral plugs, and two (7.1%) with urinary tract infection. Surprisingly, there were no diagnosis of urolithiasis. Factors like age, environment and life style of cats may be responsible for this finding in Southern of Brazil.

Introduction

Feline lower urinary tract disease (FLUTD) can be described as a collection of conditions that affect the urinary bladder and/or urethra, but do not identify the underlying etiology.[1,2] Urethral obstruction is a clinical complication of FLUTD, often present in veterinary clinics and hospitals. Cats with FLUTD commonly present dysuria, pollakiuria, stranguria, hematuria, periuria and signs of pain.[1,2] In cases of urethral obstruction, systemic signs may be present, such as vomiting, anorexia and prostration. In severe cases, and depending on the duration of obstruction, some cats can present with cardiovascular compromise and colapse.[3]

The diagnosis of the cause of urethral obstruction is mainly based on urinalysis with sediment evaluation, urine culture and sensitivity testing, and urinary tract imaging[1]. Imaging modality may include a combination of plain abdominal radiography and abdominal ultrasonography. Contrast radiography can be performed to detect radiolucent uroliths. Crystalluria can suggest crystalline oversaturation, a high urine specific gravity (USG) suggests an increase in concentration of urolithic precursors and urine pH can be associated to specific types of uroliths.[1,4]

Idiopathic cystitis is the most common cause of FLUTD and urethral obstruction plus a frequency up to 60% is reported in several studies.[5–7] Other causes are urolithiasis (10-29%), urethral plugs (10-18%) and urinary tract infection (12%). Neoplasia and congenital disorders are rare.[5–7] Since the diagnostic of the cause is essential for treatment and prevention, efforts should be directed to determine the causes of urethral obstruction in different populations. Characteristics related to management, diet and owner's profile can influence the manifestation of the disease. The lack of standardization on diagnostic workup is a problem of many researches. The aims of this study were to investigate the previous medical history and determine the causes of urethral obstruction in male cats in southern Brazil.

Materials and methods

Animals

This was a prospective descriptive study to evaluate the previous medical history and determine the causes of urethral obstruction of 28 client-owned male cats admitted to the Veterinary Teaching Hospital of Federal University of Rio Grande do Sul, Porto Alegre, Brazil between december 2015 and december 2016. Cats were included in the study when they were diagnosed with urethral obstruction, meaning presenting with clinical signs of lower urinary tract disease and a distended non-expressible urinary bladder. Cats who had previous urethrostomy or recent urethral catheterization at the previous year were excluded, as well as those receiving antibiotics. This study was approved by the Ethics Committee on the Use of Animals (no. 29039).

Procedures

A protocol of clinical evaluation and complementary tests was established. All the cats underwent the same procedures and all the exams were performed in a standardized way. Data regarding previous medical history included signalment, length of urethral obstruction, housing conditions (eg, indoors/outdoors), nutrition (eg, dry/wet/combination of food), the presence of other animals in the house, amount of litter boxes per cat, amount of water bowls per cat, history of stress situation and history of previous urethral obstruction.

All cats underwent physical examination and urine collection prior to any intervention. Urine was obtained by cystocentesis. An abdominal radiography (lateral and ventrodorsal views) was performed to screen for urolithiasis prior to urethral catheterization (Multix B 500/125, Siemens, São Paulo, Brazil). Abdominal ultrasonography was performed to evaluate the urinary tract (MyLab 40 Vet, Esaote Healthcare, São Paulo, Brazil) one day after admission. All the urine rescued in urethral catheterization was filtered with a paper coffee filter to search for small uroliths. Urethral plugs obtained were submitted to quantitative analysis on the Minnesota Urolith Center (St. Paul, Minnesota, USA).

Urine chemical evaluation was performed using an urine dipstick (Combur Test, Roche Diagnostics, Basel, Switzerland) and the USG was measured by refractometry. Urinary sediment analysis was evaluated by microscopy after urine centrifugation. Urine cultures were performed by plating the urine on blood, MacConkey and nutrient agar, during 24-48 hours at 37°C. Sensitivity analysis was performed using the disc diffusion technique.

The diagnosis of urolithiasis was made when uroliths were detected by imaging tests or if stones were found during the filtering of urine. Urethral plug was diagnosed when it was obtained during urethral catheterization and submitted to quantitative analysis. Urinary tract infection was diagnosed when a positive urine culture was obtained of a sample collected by cystocentesis prior to catheterization. Idiopathic cystitis was defined when no identifiable cause was detected.

Statistical analysis

The statistical analysis was performed applying a statistical software program (SPSS v. 20.0, IBM Inc. Company, Atlanta, USA). The Shapiro-Wilk test was used to evaluate data for normal distribution. The relative frequencies were calculated for categorical variables. Mean and standard deviation (SD) were used for quantitative variables with symmetric distribution. Median and interquartile range (IR) were used for quantitative variables with asymmetric distribution.

Results

Signalment and history

Twenty-eight client-owned male cats were included in the study. Fifteen (53.6%) were castrated males and all of them (100%) were mixed-breed. The median age was two years (0.8-4.7) and ranged from three months to 11 years old. The mean body weight was 3.9 kg (±1) and median body condition score 5 / 9 (range 4 - 7).

Most of the cats (89.3%) did not have access to an adequate number of litter boxes, 22 (78.6%) had outdoors access, 19 (67.9%) were fed exclusively a dry food, 19 (67.9%) had less than one water bowl per cat, 19 (67.9%) underwent a recent stress situation, 18 (64.3%) had a body condition score less or equal to 5 / 9, 12 (42.6%) had other cats living in the same environment and six (21.4%) had a history of previous urethral obstruction

All patients came up with multiple clinical signs. The majority of the cats presented with nonspecific clinical signs, including vomiting (71.4%), anorexia (71.4%) and prostration (67.9%). Other signs related to lower urinary tract disease were excessive licking of the perineum (60.7%), dysuria (57.1%), stranguria (39.3%), hematuria (35.7%), pollakyuria (21.4%) and periuria (21.4%). Less frequently, owners reported vocalization (3.6%), ataxia (3.6%), hematemesis (3.6%) and aggressiveness (3.6%).

Urinalysis

Nineteen cats (67.8%) had a red or dark red urine, and 26 (92.8%) had a turbid urine. The median USG was 1.026 (range 1.016-1.060) and was below 1.035 in 20 cats (71.4%). The median urine pH was 7.3 (range 6.5-8.0) and 16 (57.1%) presented alkaluria (pH > 7.5). All cats (100%) presented with some degree of proteinuria and hematuria. In sediment analysis, all samples (100%) showed epithelial cells (above the acceptable value), pyuria and hematuria. Other findings observed were bacteriuria (75%), struvite crystalluria (35.7%) and granular casts (3.6%).

Imaging tests

Abdominal radiographic studies did not reveal the presence of uroliths in the urinary tract of none of the patients, except for one patient that had small bilateral renal uroliths. Excretory urography and retrograde urethrocistography were performed in two and three cats, respectively, that showed abdominal effusion hours after catheterization. A rupture was not found in the urinary tract of these cats.

The abdominal ultrasonography findings were: presence of echogenic urinary bladder sediment (50%), thickening and irregularity of urinary bladder wall (28.6%), abdominal effusion (25%), amorphous structures compatible with blood clots (21.4%), hyperechogenicity of renal cortices (17.8%), pyelectasia (17.8%), reduced renal corticomedullary differentiation (3.6%) and ureteral dilatation (3.6%).

Cause of urethral obstruction

Of the 28 cats with urethral obstruction, 18 (64.3%) were diagnosed with idiopathic cystitis, 8 (28.6%) with urethral plugs, and two (7.1%) with urinary tract infection. All urethral plugs were analyzed by a quantitative method to access the mineral component and six of them (75%) were composed of struvite, one (12.5%) of calcium phosphate apatite and one (12.5%) of an osseous-like material. Regarding the two urinary tract infection cases, *Escherichia coli* and coagulase-negative *Staphylococcus* spp. were isolated. Both bacteria were susceptible to four or more antibiotics.

Discussion

In this study, idiopathic cystitis was the most frequent diagnosis and was made in 64.3% of cases. This is similar to previous studies that reported frequencies ranging from 53 to 63%.[5–7] At the time, the pathogenesis of this condition has not yet been fully elucidated, but it appears to be a sterile inflammatory process, mediated by a neurohumoral response to chronic stress. This may lead to the release of inflammatory mediators, which causes edema, smooth muscle spasm and pain, resulting in functional obstruction of the urethra.[8] The most of studied cats (67.9%) of the cats underwent a recent stress situation. Moreover, 42.6% had other cats living in the same environment, that could be a potential source of social conflicts, and 21.4% were exclusively indoors, considered a stressful situation for some cats. The existence of a sterile inflammatory process is in agree with the presence of hematuria, pyuria, proteinuria and high numbers of epithelial cells per microscopic field in all the patients diagnosed in this study. Despite 75% of the cats had bacteriuria in the urinary sediment analysis, only two urine cultures were positive, which demonstrates that urinary tract infection is not a common etiology of this process in cats, as described in other studies[5,6]. Asymptomatic bacteriuria may also occur in healthy cats without previous signs of FLUTD, but the prevalence is low.[9]

Urethral plugs as a cause of obstruction was diagnosed in 28.6% of the cats. A lower frequency (10-21%) was observed in other studies.[5–7] Urethral plugs are formed by proteinaceous material leaking from an inflammed urinary tract.[3] It usually contains varying quantities of minerals in proportion to large quantities of matrix. More than 90% of feline urethral plugs contains struvite crystals.[10] In the present study, 75% of the plugs contained struvite crystals. The frequency of urethral plugs may have been underestimated, since some plugs may be lost or dissolved during the urethral catheterization. Although urethral plug was considered a separate diagnosis as in other studies.[5–7], we think that this condition may be associated with idiopathic cystitis, as the plugs were mainly composed by protein from the inflammatory process. In that case, the frequency of idiopathic cystitis in this study could be higher.

Two cats (7.1%) were diagnosed with urinary tract infection. Other studies reported a frequency about 12%[5,6]. One of the cats was three and the other eleven years old. Urinary tract infection is not a common condition in cats, except in geriatric patients[1], or in the presence of a concomitant disease, such as chronic kidney disease, diabetes mellitus or hyperthyroidism[11]. These animals were not fully evaluated for these diseases, but one of them was considered a senior cat. Although their USG was considered low, this may be associated to urethral obstruction, since the tubular renal function is impaired in this condition.[12]

Urolithiasis was not considered the cause of urethral obstruction in the 28 cats. Other studies reported a frequency ranging from 5.7 to 29%[5–7,13]. We expected to find a higher frequency of urolithiasis in this study, based on our routine clinical observations at the Hospital and because 67.9% of the cats were fed with standards dry food. Struvite precipitation can be related to high levels of magnesium on the diet[4]. Although no struvite urolith was diagnosed, alkaluria was observed in 57.1% of the cats and struvite crystalluria in 35.6%. However, a high frequency of urethral plugs composed by struvite was diagnosed, what can explain these findings in urinalysis.

Crystalluria can suggest crystalline oversaturation.[4] Of the six cats that were diagnosed with struvite plugs, three (50%) also presented struvite crystalluria.

Despite the dietary habits found, most cats (78.6%) had outdoors access and 64.3% had a body condition score less or equal to 5 / 9. This shows that these cats were mostly active, and possibly had good environmental enrichment. Outdoor access is considered a protector factor and obesity a risk factor for stone formation in the urinary tract.[14] Indoor cats are less active and probably urinate less frequently, developing a high concentrated urine.

The formation of uroliths depends on supersaturation of the urine with lithogenic minerals, which is related to water intake and urine volume. Consumption of increased quantities of water may result in lowering concentrations of lithogenic substances in urine, thus decreasing the risk of urolith formation.[15] The majority of the cats in this study (89.3%) did not have access to an adequate number of litter boxes and 19 (67.9%) had less than one water bowl per cat, what can contribute to less frequency of urination and less water intake. However, this does not appear to have contributed to the formation of uroliths because these cats had outdoors access and may have urinated and drunk water outdoors.

One study showed that cats from four to seven and ten to 15 years old presented a higher risk of developing FLUTD due to urolithiasis[6]. In the present study, the median age of the cats was two years old. The sample bias may also have contributed to the low frequency of urolithiasis, since most the cats in this study were considered young.

Except for urolithiasis, the frequency of the causes of urethral obstruction in male cats presented to the Veterinary Teaching Hospital of Federal University of Rio Grande do Sul are similar to those reported in previous studies. This difference may be mainly due to factors related not only to diet, but to the life style of these cats in our region. This confirms the multifactorial nature of the disease and reinforces the need for studies in different cat populations.

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6 CONCLUSÕES

A causa mais comum de obstrução uretral neste estudo foi a cistite idiopática, que ocorreu em mais de 60% dos casos, seguida de tampões uretrais e infecção do trato urinário. Nenhum caso de urolitíase foi diagnosticado, o que pode ser explicado por fatores como idade e estilo de vida dos animais da população estudada.

A maioria dos gatos com obstrução uretral deste estudo apresentou múltiplos sinais clínicos, assim como alterações metabólicas e do equilíbrio hidroeletrolítico e ácido-base e alta taxa de mortalidade.

Os principais parâmetros clínicos associados com alterações laboratoriais graves foram hipotermia, depressão do estado mental, bradicardia e desidratação. Entretanto, considerando a existência de alterações laboratoriais e metabólicas na ausência de sinais clínicos, a possibilidade da ocorrência destas alterações não pode ser excluída baseado apenas no estado clínico do paciente.

A azotemia, hiperlactatemia, acidose metabólica, hipercalemia e hipocalcemia ionizada foram muito frequentes nos gatos com obstrução uretral e, quanto maior o tempo de obstrução, mais graves se tornam os parâmetros laboratoriais. A lactimetria não se correlacionou com os sinais clínicos, resultados laboratoriais e com a taxa de mortalidade em gatos com obstrução uretral.

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ANEXO A

U F R G S
UNIVERSIDADE FEDERAL
DO RIO GRANDE DO SUL

PRO-REITORIA DE PESQUISA

Comissão De Ética No Uso De Animais

CEUA UFRGS

CARTA DE APROVAÇÃO

Comissão De Ética No Uso De Animais analisou o projeto:

Número: 29039

Título: AVALIACAO CLINICO-LABORATORIAL DA OBSTRUCAO URETRAL EM FELINOS DOMESTICOS

Vigência: 01/05/2015 à 30/12/2016

Pesquisadores:

Equipe UFRGS:

FELIX HILARIO DIAZ GONZALEZ - coordenador desde 01/05/2015
FERNANDA VIEIRA AMORIM DA COSTA - coordenador desde 01/05/2015
CAMILA DE OLIVEIRA PEREIRA - Médico Veterinário desde 01/05/2015
Gabriela da Cruz Schaefer - Aluno de Mestrado desde 01/05/2015

Comissão De Ética No Uso De Animais aprovou o mesmo , em reunião realizada em 26/10/2015 - Sala 323 do Anexo I do Prédio da Reitoria - Campus Centro da UFRGS- Bairro Farroupilha - Porto Alegre - RS, em seus aspectos éticos e metodológicos, para a utilização de 60 felinos machos, castrados ou não, com quadro de obstrução uretral provenientes do atendimento do HCV/UFRGS, de acordo com os preceitos das Diretrizes e Normas Nacionais e Internacionais, especialmente a Lei 11.794 de 08 de novembro de 2008, o Decreto 6899 de 15 de julho de 2009, e as normas editadas pelo Conselho Nacional de Controle da Experimentação Animal (CONCEA), que disciplinam a produção, manutenção e/ou utilização de animais do filo Chordata, subfilo Vertebrata (exceto o homem) em atividade de ensino ou pesquisa.

Porto Alegre, Quinta-Feira, 5 de Novembro de 2015

Cristiane Matte

CRISTIANE MATTE
Coordenador da comissão de ética

ANEXO B

Termo de Consentimento Livre e Esclarecido

Eu ____, tutor do paciente _____________________, ficha clínica do Hospital de Clínicas Veterinárias da UFRGS número ____________, estou ciente de que o animal de minha propriedade estará participando do projeto de pesquisa: **"AVALIAÇÃO CLÍNICO-LABORATORIAL DA OBSTRUÇÃO URETRAL EM FELINOS DOMÉSTICOS"**.

A doença do trato urinário inferior dos felinos ocorre frequentemente em gatos e quando se caracteriza por um quadro obstrutivo é potencialmente fatal, se não tratado de forma urgente. As causas desta doença incluem tampões uretrais, cálculos, infecção bacteriana, tumores e lesões neurológicas. É importante diagnosticar corretamente a causa da obstrução para que medidas terapêuticas e preventivas sejam adotadas. O projeto de pesquisa irá buscar a causa da obstrução uretral e avaliar alterações nos exames de sangue e urina de gatos com obstrução uretral antes e após o tratamento. As avaliações clínicas e exames de sangue não terão custos.

Autorizo a realização das coletas de sangue e urina (por cistocentese), assim como a aferição da pressão arterial, realização de exames de imagem e manobras de desobstrução uretral sob sedação, quando necessário, no animal do qual sou tutor. Da mesma forma, autorizo a publicação dos dados obtidos neste projeto. Me comprometo a trazer o animal para as reavaliações sempre que solicitado pelo médico veterinário. Estou ciente de que posso desistir da participação do projeto a qualquer momento, sem que haja qualquer prejuízo ao meu animal.

Porto Alegre,_____de ____________de 20__.

____
Tutor
RG:

____

Pesquisador responsável: Félix González
Responsável: Gabriela da Cruz Schaefer
E-mail: gabrielacschaefer@gmail.com
End: Av. Bento Gonçalves 9090, PA, RS Fone:33086107

ANEXO C

Ficha de avaliação

Data_____________ Nome___________________________ Ficha HCV_________________

Proprietário________________ Telefone_______________ e-mail______________________

( ) macho castrado ( ) macho inteiro Idade_____ Raça _____________ Peso________

Escore de Condição Corporal ( )1 ( )2 ( )3 ( )4 ( )5 ( )6 ( )7 ( )8 ( )9

<u>Histórico & Anamnese:</u>

Obstrução prévia ( ) não ( ) sim: quantas vezes _________ quando (dias)___________

Sondado anteriormente ( ) não ( ) sim ( ) não sabe

Cirurgia anterior no trato urinário ( ) não ( ) não sabe ( ) sim: qual__________________

Uso prévio de antibióticos ( ) não ( ) não sabe ( ) sim: quais ______________________

Número de gatos na casa ( ) 1 ( ) 2 ( ) 3 ( ) 4 ( ) 5 ou mais

Acesso à rua ( ) não ( ) sim

Número de vasilhas sanitárias ( ) nenhuma ( ) 1 ( ) 2 ( ) 3 ( ) 4 ( ) 5 ou mais

Número de vasilhas de água ( ) nenhuma ( ) 1 ( ) 2 ( ) 3 ( ) 4 ( ) 5 ou mais

Dieta ( ) caseira ( ) ração seca: qual_____________ ( ) ração úmida: qual___________

Situação de estresse recente ( ) não ( ) sim: qual ________________________________

Que sinais clínicos apresentou: ( ) normúria ( ) disúria ( ) hematúria ( ) polaquiúria ( ) estrangúria ( ) periúria ( ) anúria ( ) vômito ( ) anorexia ( ) prostração ( ) lambedura do pênis ( ) outro:________________________ - há quanto tempo (dias) _________

<u>Avaliação clínica:</u>

TR°C_____ FC_____ PAS doppler_______ PAS Petmap______ FR_____

TPC ( ) < 2seg ( ) > 2 seg

Estado mental ( ) alerta ( ) apático ( ) inconsciente

Hidratação ( ) normal ( ) desid. leve ( ) desid. moderada ( ) desid. grave

Mucosas ( ) normais ( ) hipocoradas ( ) congestas ( ) ictéricas ( ) cianóticas

Sons Respiratórios ( ) normais ( ) taquipnéia ( ) dispneia inspiratória ( ) dispneia expiratória ou mista ( ) abdominal

Sons cardíacos ( ) normais ( ) sopro ( ) ritmo de galope ( ) arritmia

Pulso ( ) forte ( ) fraco ( ) filiforme

Trato urinário ( ) bexiga repleta ( ) bexiga não palpável

Lactato_______ Glicemia_______