UNIVERSIDADE ESTADUAL PAULISTA
FACULDADE DE MEDICINA VETERINÁRIA E ZOOTECNIA

AVALIAÇÃO ULTRASSONOGRÁFICA DA ARTÉRIA CARÓTIDA COMUM EM EQUINOS DA RAÇA QUARTO DE MILHA

ADRIANA CRISTINA SALDANHA DE AGUIAR

BOTUCATU – SP
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Dissertação apresentada junto ao programa de Pós-graduação em Biotecnologia Animal para obtenção do título de Mestre.

Orientadora: Prof[a]. Dr[a]. Vânia Maria de Vasconcelos Machado
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bpm – Batimentos por minutes / Beats per minute

CI – Confidence interval

CCA – Common carotid artery

EIM – Espessura íntima-média

FSAT – Fluxo sanguíneo arterial total

IMT – Intima-media thickness

IC – Intervalo de confiança

IP – Índice de pulsatilidade

IR – Índice de resistividade

L – Left

PI – Pulsatility index

R – Right

RI – Resistivity index

SD – Standard deviation

SE – Standard error

VDF – Velocidade diastólica final

VPS – Velocidade do pico sistólico

SUMÁRIO

AGUIAR, ACS. **Avaliação ultrassonográfica da artéria carótida comum em equinos da raça Quarto de Milha.** Botucatu, 2015. 67p. Dissertação (Mestrado) – Faculdade de Medicina Veterinária e Zootecnia, Campus de Botucatu, Universidade Estadual Paulista "Júlio de Mesquita Filho" – UNESP.

RESUMO

A artéria carótida comum em equinos se trifurca com algumas variações anatômicas e é o principal vaso que fornece sangue arterial para o cérebro, sendo que é conhecido que sua oclusão causa lesões encefálicas em ratos e humanos. Há muito pouca literatura a respeito de estudos anatômicos e ultrassonográficos desse vaso nessa espécie. Esse estudo avaliou a artéria carótida comum de 50 equinos da raça Quarto de Milha em diferentes idades, divididos em três grupos (grupo I: >2anos, n=14; grupo II: 3-10 anos, n=21; grupo III 15-30 anos, n=15), e obteve valores de referencia para espessura intima-media (EIM), índice de resistividade (IR), índice de pulsatilidade (IP) e diâmetro para ambas artérias carótidas comuns. Os exames foram feitos utilizando um transdutor de 18 MHz no sulco jugular, na altura de C5-C6. O diâmetro esquerdo médio foi de 8,71 ± 1,09 mm para o grupo I; 10,11 ± 0,72 mm para o grupo II e 10,72 ± 0,96 mm para o grupo III. O diâmetro direito médio foi de 8,92 ± 1,24 mm para o grupo I; 10,96 ± 1,06 mm para o grupo II e 11,76 ± 1,07 mm para o grupo III. A EIM foi de 0,90 ± 0,15 mm; 1,02 ± 0,09 mm e 0,97 ± 0,10 mm para os grupos I, II e III, respectivamente. Os valores médios de IR e IP obtidos foram 0,75 ± 0,07 e 1,63 ± 0,33 para o grupo I; 0,81 ± 0,06 e 2,08 ± 0,46 para o grupo II; 0,90 ± 0,10 e 3,20 ± 0,74 para o III, respectivamente. As variáveis IR, IP e EIM não são influenciadas por sexo ou lado, mas sim por idade. Já o diâmetro está correlacionado com o lado e idade, sendo sempre maior do lado direito.

Palavras-chave: equino, artéria carótida comum, ultrassonografia.

AGUIAR, ACS. **Ultrasonografic evaluation of the common carotid artery in American Quarter Horses.** Botucatu, 2015. 67p. Dissertação (Mestrado) – Faculdade de Medicina Veterinária e Zootecnia, Campus de Botucatu, Universidade Estadual Paulista “Júlio de Mesquita Filho” – UNESP.

ABSTRACT

Common carotid artery in horses trifurcates with some anatomical variations and it is the main supply of arterial blood to the brain. It is known that carotid occlusion can cause encephalic lesions in rats and humans. There are few studies on this vessel, including ultrasonografic evaluation of his vessel in this species. This study evaluated the common carotid artery in 50 American Quarter horses with different ages, separated into three groups (group I: >2years, n=14; group II: 3-10 years, n=21; group III 15-30 years, n=15), and reference values for intima-media thickness (IMT), resistivity index (RI), pulsatility index (PI) and diameter were obtained for both arteries. Exam was performed using an 18 MHz transducer on jugular groove, on level of C5-C6. Mean left diameter was 8.71 ± 1.09 mm for group I; 10.11 ± 0.72 mm for group II and 10.72 ± 0.96 mm for group III. Right diameter was 8.92 ± 1.24 mm for group I; 10.96 ± 1.06 mm for group II and 11.76 ± 1.07 mm for group III. IMT was 0.90 ± 0.15 mm; 1.02 ± 0.09 mm and 0.97 ± 0.10 mm for groups I, II and III, respectively. Mean RI and PI obtained were 0.75 ± 0.07 and 1.63 ± 0.33 for group I; 0.81 ± 0.06 and 2.08 ± 0.46 for group II; 0.90 ± 0.10 and 3.20 ± 0.74 for group III, respectively. The variables RI, PI and IMT are not influenced by gender or side, but were by age. Diameter was influenced by both, age and side, and right diameter was always greater than the left.

Key words: equine, common carotid artery, ultrasound.

Capítulo 1

1. INTRODUÇÃO

A ultrassonografia é um método de diagnostico por imagem não invasivo e seguro, que não utiliza radiação ionizante e fornece informações em tempo real das estruturas analisadas (CARVALHO et al., 2008; MANNION, 2006).

A artéria carótida comum é um importante vaso que dá origem a três artérias: artéria carótida interna e externa e artéria occipital (ORR et al., 1983; GETTY, 1981; FURUHATA, 1964). Apesar de o melhor vaso para se avaliar o fluxo sanguíneo cerebral ser a artéria carótida interna (SCHÖNING et al., 1994), a ramificação da artéria carótida comum apresenta ao menos cinco variações anatômicas na espécie equina (HAYAH, 2012). Além disso a artéria carótida interna está intimamente associada com a bolsa gutural (HAYAH, 2012), que é repleta de ar e, portanto, um péssimo condutor das ondas sonoras necessárias para a formação da imagem ultrassonográfica. Tendo em vista essas limitações, a avaliação da artéria carótida comum pode servir como alternativa para a avaliação de fluxo sanguíneo cerebral, pois é um dos três vasos que supre sangue para esse órgão (SCHUMUCKER et al., 2000).

Há poucos estudos sobre a avaliação ultrassonográfica da artéria carótida comum em equinos (CIPONE et al., 1997) apesar de sua pesquisa em humanos ser extensa (CAVIEZEL et al., 2013; JURASIC et al., 2007; FRICK et al., 2002; DENARIE et al., 2000).

A espessura intima-media (EIM) é, provavelmente, o parâmetro mais estudado dessa artéria em humanos já que sabe-se que seu espessamento está associado ao risco de doenças cardiovasculares (COLL et al., 2013; FRICK et al., 2002). Em humanos, sabe-se também que o diâmetro desse vaso varia com a pressão sanguínea e o peso (KREJZA et al., 2006). E que estenose ou placas instáveis nesse vaso levam a lesões encefálicas em humanos e ratos (KANDIAH et al., 2013; ALTAF et al., 2006; UEHARA et al., 1999).

Em relação ao fluxo, três medidas têm sido mais comumente utilizadas na ultrassonografia Doppler, são eles: índice de resistividade (IR), índice de pulsatilidade (IP) e fluxo sanguíneo arterial total (FSAT) (BAILEY et al., 2012). Sendo que IR e IP além de fornecerem informações sobre o fluxo, fornecem também informações sobre a impedância do vaso (BAILEY et al., 2012; POZOR et al., 2004; HEDRICK 1995).

Diâmetro, velocidades e IR em equinos já foram relatados, porém não foram correlacionados com idade (CIPONE et al., 1997; SCHUMUCKER et al., 2000).

O presente trabalho teve como objetivo obter valores de referência para o diâmetro, espessura intima-média, IR e IP da artéria carótida comum em equinos, bem como avaliar como esses parâmetros são influenciados por idade, sexo e lado.

2. REVISÃO DE LITERATURA

2.1. ANATOMIA DA ARTÉRIA CARÓTIDA COMUM

A artéria carótida comum esquerda é um ramo direto da aorta e a direita surge do tronco braquicefálico em humanos (JURASIC et al., 2007; DENARIE et al., 2000). Em equinos, elas são descritas como ambas originárias do tronco bicarotídeo e como apresentando diversos ramos colaterais, entre eles os ramos musculares, esofágicos, traqueais, artérias tireoideas cranial e caudal, artéria parotídea e a artéria faríngea ascendente (GETTY, 1981).

A artéria carótida comum direita passa obliquamente da superfície dorsal da traqueia para seu lado direito e inclina-se no sentido da superfície dorsal da traqueia próximo a sua terminação. E está superficialmente em contato com a veia jugular externa na parte caudal do pescoço, porém são separadas pelo músculo omo-hioideo mais cranialmente. Próximo a sua terminação, a artéria se apresenta mais profunda e está relacionada lateralmente às glândulas mandibulares e parótida e medialmente ao esôfago. Na região do músculo cricofaríngeo divide-se em três importantes artérias: artéria occipital, artérias carótidas externa e interna (GETTY, 1981).

A artéria carótida comum esquerda se difere da direita, pois apresenta-se mais profundamente em relação ao esôfago e em contato com a traqueia por uma curta distância, aproximadamente 8 a 10 cm na base do pescoço. Esse contato pode ser ainda menor caso o esôfago seja mais ventral e o tronco bicarotídeo longo (GETTY, 1981).

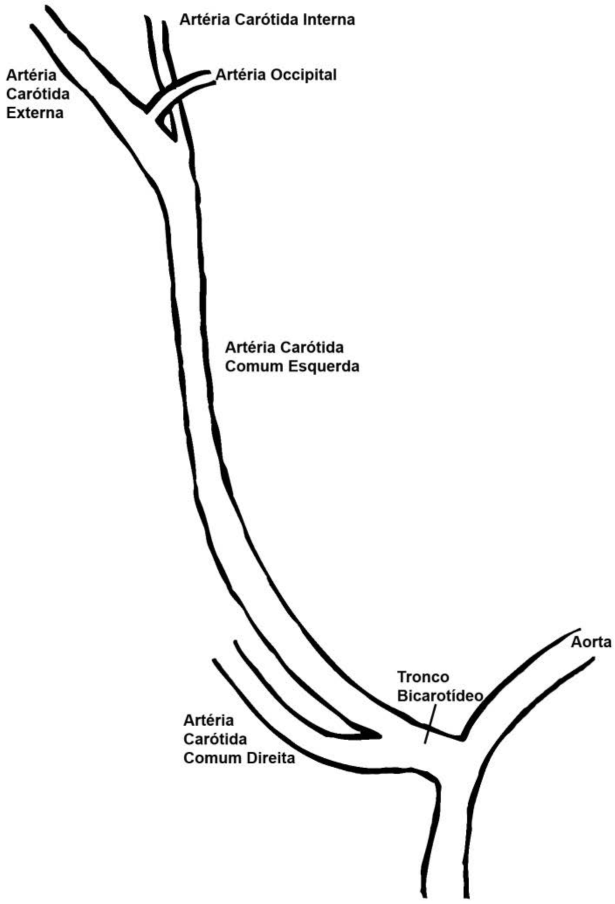

Figura 1: Esquema anatômico da origem e trifurcação da artéria carótida comum. (Fonte: arquivo pessoal)

Em humanos, a artéria carótida comum se bifurca em artéria carótida interna e externa, porém nos equinos, ela termina no que é conhecida como trifurcação carotídea, ou seja, divide-se em três ramos: artéria carótida externa, artéria carótida interna e artéria occipital. Essa terminação é conhecida como trifurcação carotídea (FURUHATA, 1964)

A artéria carótida externa é o ramo mais calibroso da trifurcação da artéria carótida comum e, portanto, considerada sua continuação (FURUHATA, 1964) A artéria occipital normalmente é o segundo maior ramo e geralmente se origina cranialmente à artéria carótida interna, mas algumas vezes a artéria carótida interna e a artéria occipital se originam de um ramo comum para depois se dividirem (ORR et al., 1983; FURUHATA, 1964).

Já a artéria carótida interna provém sangue arterial diretamente para o cérebro dos equinos, com muito pouco de seu fluxo associado a tecidos extracerebrais (ORR et al., 1983)

O estudo de Hayah (2012), que utilizou 50 cabeças de equinos, mostrou que há variações na árvore carotídea e descreveu 5 variações anatômicas referentes da artéria carótida interna:

1. A artéria carótida interna e a artéria occipital emergem de um ramo comum da artéria carótida comum
2. Um ramo aberrante da artéria carótida interna se une a artéria basilar
3. Um ramo aberrante da artéria carótida interna não se une a artéria basilar
4. Um ramo aberrante da artéria carótida interna dá origem a diversos ramos satélites
5. Um ramo aberrante da artéria carótida interna apresenta um ramo satélite que se conecta ao ramo caudal da artéria occipital ipsilateral

2.2. ULTRASSONOGRAFIA E DOPPLER

A ultrassonografia diagnóstica utiliza ondas sonoras de alta frequência que não são audíveis ao ser humano (MANNION, 2006). As ondas sonoras são produzidas por cristais piezoelétricos presentes nos transdutores e interagem com os tecidos, onde podem ser refletidas, refratadas ou absorvidas (CARVALHO et al., 2008; MANNION, 2006). As ondas que retornam ao transdutor são as responsáveis pela formação da imagem (MANNION, 2006). O modo B fornece imagem em tempo real onde cada ponto na tela é um eco que retornou e é o modo mais comumente usado (MANNION, 2006).

Apesar de ser um método não invasivo e que não utiliza radiação ionizante como outros métodos de diagnóstico por imagem, ainda não é claro se é um método sem complicações. É o método mais seguro de todos, porém, pode ter consequências como aquecimento, cavitação e formação de hematoma se utilizado inadequadamente (MANNION, 2006). A cavitação e formação de hematomas são raramente relatados e o aquecimento pode ser de 2 a 3ºC na superfície óssea ou corpórea (MANNION, 2006).

A ultrassonografia é aplicada à medicina equina para o diagnóstico de alterações musculoequeléticas, cardiovasculares, abdominais e reprodutivas

(CIPONE et al, 1997). O ultrassom no modo B associado com os recursos Doppler, também conhecido como Doppler Duplex e fornece informações anatômicas e hemodinâmicas em tempo real (CARVALHO et al., 2008; HEDRICK, 1995) Essa ferramenta tem sido utilizada também para medir o fluxo sanguíneo na artéria carótida comum em humanos (SCHÖNING et al., 1994).

A ultrassonografia com Doppler permite a avaliação qualitativa e quantitativa de vasos e tecidos, fornecendo informações estruturais e hemodinâmicas (FERREIRA, et al., 2011).

A ultrassonografia bidimensional, também conhecida como modo B, permite distinguir nas imagens a arquitetura dos tecidos estudados (CARVALHO, 2009) Já o recurso Doppler caracteriza o fluxo sanguíneo, por meio do traçado dos vasos, velocidades e direção do fluxo (CARVALHO, 2009).

O efeito Doppler foi descrito pelo físico austríaco Johann Christian Andreas Doppler em 1842, no qual ele descreve a variação da altura do som do apito de trem, em movimento, em relação à posição do observador (CARVALHO, 2009). Neste fenômeno, a frequência do som parece variar se há um movimento relativo entre a fonte emissora e o observador (HEDRICK, 1995).

O princípio físico do efeito Doppler é aplicado à ultrassonografia Doppler, onde as hemácias em movimento nos vasos correspondem à fonte emissora de som e o transdutor ao observador. Dessa forma, o efeito Doppler se refere à diferença entre a frequência da onda sonora emitida pelo transdutor e a frequência dos ecos que retornam do fluxo sanguíneo em movimento. Sendo assim, a frequência aumenta quando o fluxo sanguíneo está em direção ao transdutor e diminui quando está no sentido contrário (NYLAND & MATTOON, 2005).

A variação entre a frequência emitida e recebida se chama variação de frequência Doppler que é definida pela fórmula: $\Delta f = f_{recebida} - f_{emitida}$. A variação de frequência Doppler é positiva quando o fluxo se aproxima do transdutor, pois a frequência recebida será maior que a emitida, e negativa quando o fluxo vai em direção contrária.

Porém, para o ângulo formado entre o feixe sonoro emitido pelo transdutor e o fluxo sanguíneo, denominado ângulo Doppler, pode variar. Para isso foi proposta uma fórmula com fator de correção para que essa variável possa ser considerada (NYLAND & MATTOON, 2005). A fórmula Doppler é:

$$\Delta f = \frac{2.f.V.cos\,\hat{a}ngulo\;Doppler}{c}$$

Considera-se que *Δf* representa a mudança de frequência, *f* representa a frequência do transdutor, *V* significa a velocidade do fluxo sanguíneo, *c* é uma constante que representa a velocidade média do som nos tecidos (1540m/s) e o ângulo Doppler é aquele formado entre o eixo do vaso e da onda sonora (HEDRICK, 1995).

A velocidade do fluxo pode ser calculada a partir da frequência e do ângulo Doppler (HEDRICK, 1994). Como ângulos grandes podem gerar erros de cálculo para a velocidade, é indicado que sinais de vasos superficiais sejam obtidos com ângulos entre 30 e 60º (HEDRICK, 1995). Quanto mais paralelo o eixo do vaso com a onda sonora (ângulo 0º), mais preciso será o valor calculado da velocidade, visto que o cosseno de 0º é um. Quando o feixe sonoro se encontra perpendicular ao vaso analisado, não há detecção de fluxo, pois o cosseno de 90º é zero.

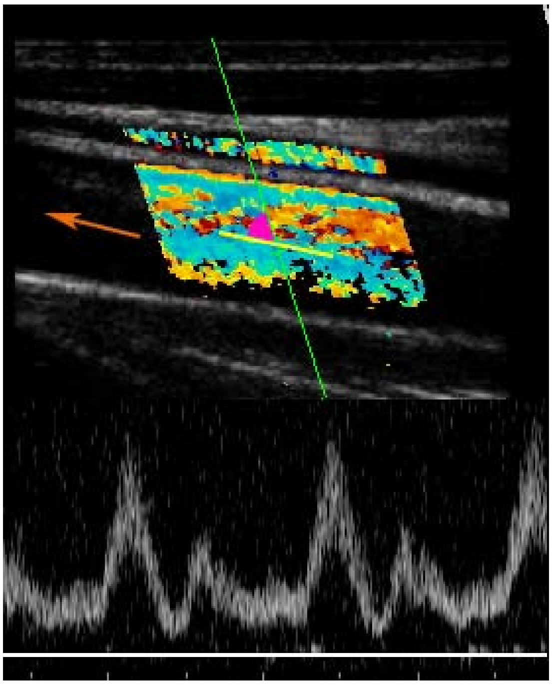

Figura 2: Imagem do Doppler Triplex, indicando o ângulo Doppler (área rosa) formado pela intersecção da direção do feixe sonoro (linha verde) e direção do fluxo (linha amarela). A seta laranja indica o sentido do fluxo. (Fonte: arquivo pessoal)

2.2.1. DOPPLER ESPECTRAL

O Doppler espectral demonstra as variações de frequência captadas pelo transdutor através de um gráfico bidimensional, onde marca a variação da velocidade calculada (eixo y) em relação ao tempo (eixo x ou linha de base), essa linha representa o fluxo zero (CARVALHO et al., 2008; NYLAND & MATTOON, 2005). As variações de frequência positivas, ou seja, quando o fluxo está indo em direção ao transdutor, aparecem acima dessa linha e as variações negativas, abaixo (CARVALHO et al., 2008).

O modo Duplex combina a imagem em tempo real do modo B com o traçado do Doppler pulsado e a localização da amostra. Nesse modo, a variação da frequência Doppler é expressa através do gráfico e também sonoramente, sendo o volume do som diretamente proporcional à quantidade de células sanguíneas em movimento (CARVALHO et al., 2008).

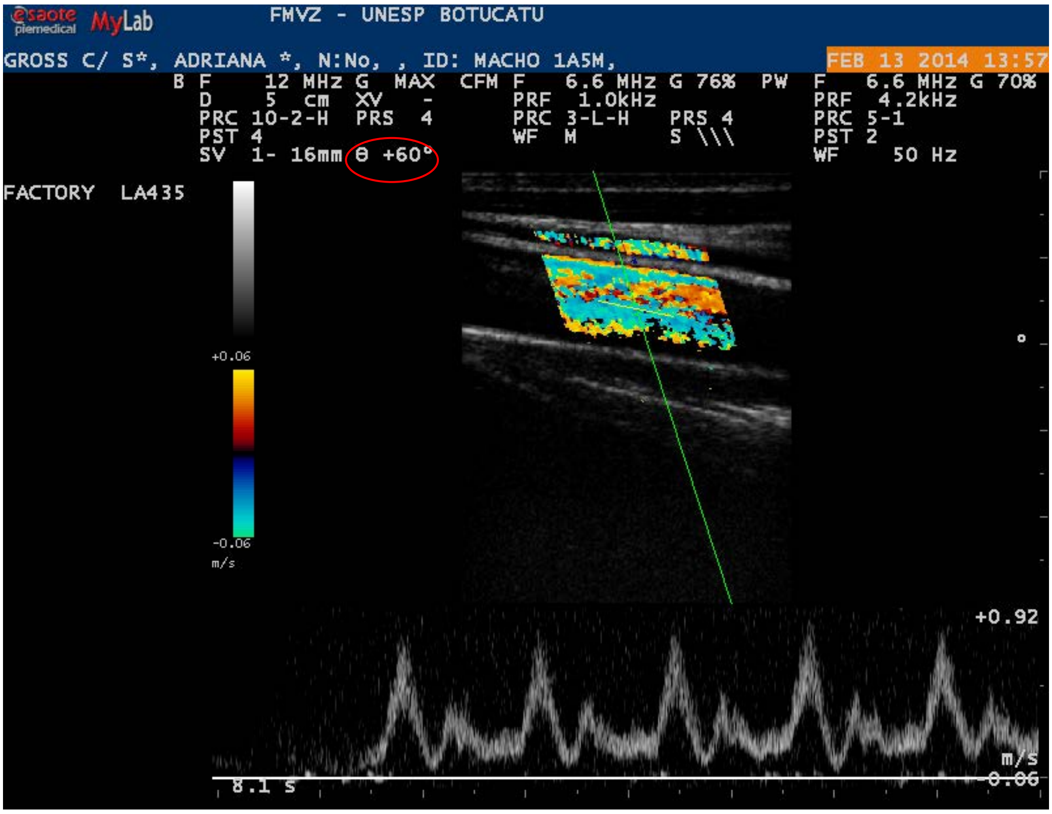

Figura 3: Imagem do Doppler Triplex do fluxo da artéria carótida comum de um equino. A linha verde indica a direção do feixe sonoro, a linha amarela a direção do fluxo, a seta amarela indica o traçado espectral do vaso. O valor ângulo Doppler calculado pelo aparelho está assinalado pelo círculo vermelho. (Fonte: arquivo pessoal)

Os espectros fornecem inúmeras informações e cada artéria ou veia pode ser identificada pelo seu traçado característico (CARVALHO et al., 2008).

O sangue apresenta um fluxo laminar no interior da maioria dos vasos, o que fornece diferentes variações de frequência Doppler dependendo da região (CARVALHO et al., 2008; HEDRICK, 1995). A velocidade do fluxo é mais lenta na periferia e mais rápida no centro do vaso, devido às forças de atritos que causam a perda de energia das células mais próximas as paredes dos vasos (CARVALHO et al., 2008; HEDRICK, 1995). Nesses casos, a mensuração das velocidades pode ser feita de duas maneiras: insonação uniforme (quando o volume de amostra envolve todo o caso) ou velocidade máxima (quando o volume amostrado é apenas no centro do vaso) (CARVALHO et al., 2008).

A artéria carótida comum em humanos apresenta um traçado composto por características da artéria carótida interna e externa e a velocidade do pico sistólico é entre 60 e 100 cm/s (HEDRICK, 1995). Em equinos, tem características de um vaso de baixa resistência, com uma alta velocidade sistólica seguida de uma onda diastólica visível (CIPONE et al, 1997).

Animais com baixa frequência cardíaca (abaixo de 45bpm) podem apresentar uma onda sistólica bífida, que foi sugerido por alguns autores como sendo consequência do turbilhonamento na aorta ascendente, mas que se acredita ter origem cardíaca (CIPONE et al, 1997).

2.3. PARÂMETROS VASCULARES

Parâmetros de artérias periféricas e centrais são muito estudados em humanos como um método não invasivo para acessar o risco de doença cardiovascular em humanos (STEIN et al., 2008; FRICK et al., 2002). Inúmeros estudos mostraram que o diâmetro do lúmen e a espessura da parede da artéria carótida comum são indicadores confiáveis do risco de arteriosclerose (CAVIEZEL et al., 2013; STEIN et al., 2008; FRICK et al., 2002). A espessura íntima-média (EIM) e o diâmetro do lúmen da carótida fornecem informações estruturais e anatômicas do vaso enquanto o modo como esses variam ao longo de um ciclo cardíaco fornecem informações funcionais (CAVIEZEL et al, 2013). A aplicabilidade e repetibilidade dos parâmetros funcionais, tais como distensibilidade, complacência, tensão, índice de rigidez, módulo de elasticidade de Young e de Peterson, ainda estão em discussão (CAVIEZEL et al., 2013).

Há correlação comprovada entre diâmetro, volume de fluxo, velocidades sistólica, diastólica e média em equinos (CIPONE et al, 1997). Foi encontrada, também, diferença entre o diâmetro da ateria carótida comum de homens e mulheres, sendo que o diâmetro em mulheres era menor que dos homens, mesmo quando ajustado para peso (KERJZA et al., 2007; DENARIE et al., 2000). O mesmo foi relatado para equinos em um estudo de Cipone et al. (1997). Já em um estudo para cães da raça Labrador, não foi encontrada corelação entre sexo e diâmetro (SVICERO et al., 2013).

Furuhata (1964) realizou um dos poucos estudos anatômicos sobra a artéria carótida comum em equinos. Em seu estudo *post mortem*, ele relata que o diâmetro varia ao longo do vaso e próximo ao local de divisão, a artéria se dilata, podendo chegar ao dobro do diâmetro anterior. Os valores obtidos foram: 4,3±0,9 mm e 4,0±0,7 mm para a base, variando de 3 a 7 mm no eixo maior e 2,8 a 5,6 mm no eixo menor. Já próximo à trifurcação, os diâmetros maiores e menores foram, respectivamente: 9,9±1,2 mm e 7,5±0,9 mm, variando de 7,5 a 13 mm e 6,0 a 9,2mm. Porém o autor não diferenciou lados esquerdos de direitos, idade ou raça dos animais.

Denarie et al. (2000) realizaram um estudo, em humanos sadios, onde avaliaram como o sexo, lado e idade influenciavam os seguintes parâmetros: espessura intima-média (EIM) e diâmetro. Jurasic et al.(2007) também avaliaram a influência da idade sobre variáveis estruturais e hemodinâmicas (IR e IP) desse vaso, para que pudessem ser usados como valores de referência para futuros estudos.

O exame padrão no modo Duplex é utilizado para, primeiramente, se identificar placas oclusivas na carótida. O risco de doença cardiovascular pode ser acessado pela aferição da espessura da íntima-media da carótida, pois os aparelhos atuais ainda não permitem que seja medida apenas a espessura da camada intima (STEIN et al., 2008).

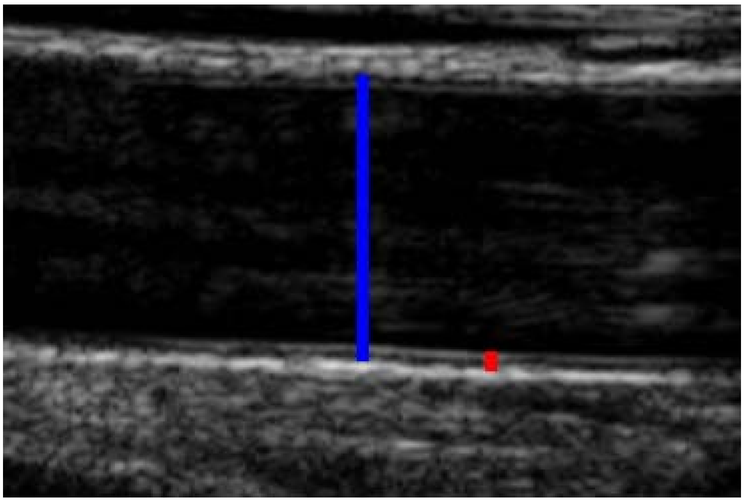

Figura 4: Sonograma em modo B da artéria carótida comum de um equino. O diâmetro do vaso é considerada a distância entre a transição da camada intima-advinetícia proximal até distal (linha azul). A espessura intima-média é a distância entre a luz do vaso até a transição da camada intíma para adventícia (linha vermelha). (Fonte: arquivo pessoal)

Frick et al (2002) realizaram o exame ultrassonográfico em modo M e Doppler espectral da artéria braquial de 117 pacientes para avaliar a correlação dos parâmetros morfológicos, mecânicos e funcionais dessa artéria com o risco de arteriosclerose coronária. Observaram que apenas houve correlação entre os parâmetros estruturais e a presença de doença da artéria coronária, os parâmetros funcionais e mecânicos não foram significativos nesse estudo (FRICK et al., 2002). Os parâmetros funcionais ainda tem sua significância discutida (CAVIEZEL et al., 2013).

Os parâmetros funcionais, como tensão, coeficiente de distensão, pressão de pulso, coeficiente de complacência, índice de rigidez e módulos elásticos refletem a capacidade elástica da artéria carótida comum (CAVIEZEL et al., 2013). Eles são obtidos através de cálculos complexos de medidas feitas em imagens no modo M (CAVIEZEL et al., 2013; FRICK et al., 2002). Porém sua reprodutibilidade não é tão alta quanto os parâmetros estruturais e parece não ser tão confiáveis para vasos periféricos (CAVIEZEL et al., 2013; FRICK et al., 2002).

Três medidas têm sido mais comumente utilizadas para quantificar o fluxo sanguíneo através da ultrassonografia Doppler, são eles: índice de resistividade (IR), índice de pulsatilidade (IP) e fluxo sanguíneo arterial total (FSAT) (BAILEY et al., 2012). Enquanto o IR e IP informam sobre a resistência do fluxo pelo vaso, o FSAT mede o fluxo de sangue que passa por determinado local dentro de um ciclo cardíaco por meio da seguinte fórmula:

$$FSAT = \left(\frac{VPS + (IR.VPS - VPS)}{IP}\right)\left(\frac{D}{2}\right)^2 .\pi$$

Onde VPS é a velocidade do pico sistólico e D o diâmetro. (BAILEY et al., 2012).

O Doppler espectral permite mensurar a resistência e a velocidade do fluxo através do cálculo do índice de resistividade (IR) e o índice de pulsatilidade (IP) (CARVALHO et al., 2008; YING & AHUJA, 2005). Essas grandezas adimensionais são utilizadas para quantificar a impedância ou resistência do fluxo (HENDRICK, 1995). A impedância vascular está relacionada com a rigidez do vaso (PIZZI et al., 2006). POZOR & DONNELL (2004) sugerem que IR e IP são indicadores mais sensíveis do fluxo arterial que as velocidades sistólica e diastólica, justamente por fornecerem informação também sobre a impedância vascular.

Outras vantagens do uso desses índices se dão também pelo fato de não serem dependentes do ângulo de insonação e conseguir avaliar vasos tortuosos ou pequenos (HENDRICK, 1995).

Esses dois parâmetros podem ser calculados por meio das seguintes equações:

$$\mathrm{IR} = \frac{\text{velocidade no pico sistólico – velocidade no fim da diástole}}{\text{velocidade no pico sistólico}}$$

$$\mathrm{IP} = \frac{\text{velocidade no pico sistólico – velocidade no fim da diástole}}{\text{velocidade média}}$$

(NYMAN & O'BRIEN, 2007, POZOR & DONNELL, 2004; HENDRICK, 1995).

Baixos valores pra IR indicam alto metabolismo enquanto altos valores de IR indicam baixo metabolismo (CARVALHO et al., 2008). Ou seja, IR altos indicam ondas pulsáteis (HENDRICK, 1995), com grande diferença entre a VPS e VDF. Já o IP é mais indicado para traçados que possuem uma fase negativa (CARVALHO et al., 2008).

Schmucker et al. (2000) avaliaram o terço proximal da artéria carótida comum de 17 equinos durante o descanso, sedação e anestesia para obter valores de IR, fluxo total máximo e área transversal do vaso. Os valores obtidos para animais em descanso foram: índice de resistividade de 0,9 ±0,07; fluxo total máximo de 34,6 ±7,8 ml/seg; área transversal de 70±22 mm^2.

O índice de resistividade diminuiu após a sedação e anestesia, indicando, provavelmente, uma vaso dilatação das artérias carótidas interna e externa (SCHUMUCKER et al., 2000). O autor afirma ainda não haver diferença estatística significativa entre os vasos direito e esquerdo (SCHUMUCKER et al., 2000).

Os parâmetros fisiológicos da artéria carótida comum, se bem conhecidos, podem ser indicadores potenciais de desempenho atlético ou grau de adaptação ao exercício, uma vez que podem refletir o fluxo aórtico (CIPONE et al, 1997).

2.4. IMPORTÂNCIA CLÍNICA

Há poucos estudos sobre a avaliação fisiológica e os parâmetros normais da artéria carótida comum em equinos. E o estudo dessa estrutura é de extrema importância, uma vez que o conhecimento da hemodinâmica desse vaso pode fornecer informações valiosas sobre o sistema cardiovascular dos equinos (CIPONE et al, 1997).

O conhecimento sobre os parâmetros e o equipamento de ultrassom podem fazer com que o exame ultrassonográfico seja quase tão sensível quanto exames de ressonância ou tomografia computadorizada. Em um estudo realizado por Dematte et al., 2012 mostrou que exames ultrassonográficos com Doppler conseguiram detectar quase todos os casos de paragangliomas de carótida, diagnosticados posteriormente por ressonância magnética ou tomografia computadorizada. O ultrassom possibilitou detectar 92% dos casos apesar de não ser preciso quanto ao tamanho da lesão (DEMATTE et al., 2012).

Em humanos, a EIM da carótida é utilizada para prever o risco de doença cardiovascular, como aterosclerose sistêmica. Essa medida está significativa e positivamente relacionada com idade, pressão arterial, índice de massa corpórea e circunferência abdominal, por um p menor que 0,001 (COLL et al., 2013).

Uehara et al (1999) realizaram a seção bilateral da artéria carótida comum de 22 ratos com 5 dias de idade e comprovaram, através de exames imunohistoquímicos, que após dois dias de hipoperfusão cerebral, já haviam lesões significativas nos encéfalos desses animais. As lesões constituíam de necrose de coagulação e cistos, sendo que 91% afetavam a cápsula interna ou a subcortical de matéria branca, confirmando que a substância branca é mais susceptível a isquemias moderadas que a matéria cinzenta.

Kandiah et al (2013) também demonstraram como a estenose da artéria carótida influencia lesões da substância branca no encéfalo de humanos, sendo que tanto maior a estenose, maior eram as lesões de substância branca, especialmente periventricular. E Altaf et al. (2006) afirma que placas instáveis na carótida estão associadas com microembolismo e podem causar lesões com aparência de hipersinal da ressonância magnética, em áreas de substância branca.

Em humanos, o volume sanguíneo cerebral era estimado pelo fluxo da artéria carótida comum devido à facilidade de acesso da mesma (SCHÖNING et al., 1994). Até que se notou que o aumento do fluxo na artéria carótida comum a idade é consequência do aumento de fluxo na artéria carótida externa e não necessariamente há um aumento no fluxo sanguíneo cerebral, sendo mais indicada a análise da artéria carótida interna nesses casos (SCHÖNING et al., 1994). Porém a anatomia da ramificação da artéria carótida comum em equinos é variável (HAYAH, 2012) e mesmo não sendo o vaso mais indicado, a artéria carótida comum pode ser utilizada para estimar o fluxo cerebral ou diagnosticar mudanças no fluxo (SCHUMUCKER et al., 2000).

Devido a grande proximidade entre a bolsa gutural e os ramos da artéria carótida comum, são frequentes casos de placas micóticas que danificam a artéria carótida interna. Há ainda casos que a micose de bolsa gutural afeta a artéria carótida externa. A clínica apresentada nesses casos é epistaxe, a qual quando não tratada, resulta na morte de 50% dos animais afetados (HAYAH, 2012).

O conhecimento das medidas desses vasos, bem como características anatômicas, contribui também para o planejamento cirúrgico dessa região (HAYAH, 2012) e para a melhor escolha do acesso aos vasos da região de cervical.

Capítulo 2

Title: Ultrasonographic Evaluation of the Common Carotid Artery in Horses

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ABSTRACT

Studies focusing the evaluation of the normal equine common carotid artery (CCA) are scanty. Reference values could be used to access the blood supply to the brain and its correlation with neurological findings. The aims of this study were to obtain reference values for the common carotid artery intima-media thickness (IMT), resistivity index (RI), pulsatility index (PI), diameter, and assess how these parameters were influenced by gender, age and side in American Quarter Horses. 50 American Quarter horses were submitted to bilateral ultrasonographic evaluation of the CCA with an 18MHz linear transducer, on the jugular grove of the lower neck. Subjects were divided into 3 groups according to age (I: <2 years, n=14; II: 3-10 years, n=21; III: 15-30 years, n=15). 3 to 5 measurements of IMT and lumen diameter were performed using at least two different images of each artery. Mean RI and PI were obtained by an average of 3 to 5 cardiac cycles. The RI, PI, and IMT were influenced only by age, not by gender or side. However, diameter was influenced by age and side, but not by gender. Diameter was greater on the right (10.63 ± 1.57 mm) than on the left side (9.90 ± 1.19 mm) in every age groups and this asymmetry increased with age. This study provides an insight on how morphological and blood flow CCA parameters are influenced by age, gender and side. It also provides values that can be used to assist the assessment of blood flow to the brain.

INTRODUCTION

Many ultrasonographic studies have been conducted to estimate cerebral blood flow by of the common carotid artery (CCA) in humans. They demonstrated that measurements of the internal carotid and cervical arteries were more reliable to estimate.[1] However, in horses there are five anatomical variation of the CCA trifurcation and the internal carotid artery is intimately related to the guttural pouch.[2] Due to the easy access and execution of duplex sonography of the CCA, data from this vessel could be an alternative to determinate stroke volume.[3] Changes in CCA flow could suggest changes in blood flow to the brain because the CCA is one of the three arteries supplying it.[4]

Intima-media thickness (IMT) and lumen diameter are structural parameters that have an excellent reproducibility and low variability.[5] IMT has been associated with age and blood pressure, and it is commonly used to evaluate cardiac risk in patients.[6,7] Diameter has also been correlated to blood pressure, weight and size.[8] Studies have demonstrated that CCA stenosis or unstable plaques can contribute to white matter lesion in the brain of humans and rats.[9, 10,11] Resistivity index (RI) and pulsatilily index (PI) are indirect measurements of blood flow that are independent of insonation angle and provide information on vessel impedance.[12,13,14] High RI values indicate pulsed waveforms[14] while PI is more indicated to measure waveforms that contain negative velocities.[15]

Although CCA diameter, velocities and RI in horses have been previously reported[3,4], their correlation with age has not been described. The aims of this study were to obtain reference values for the CCA´s IMT, RI, PI, and diameter in American

Quarter Horses, and assess how these parameters are influenced by gender, age and side.

MATERIAL AND METHODS

The sample size for this study was calculated based on a pilot experiment with 10 animals. To estimate the mean CCA diameter in the target population with an acceptable error of ± 1 mm and a confidence interval of 95%, 5 subjects were necessary. To estimate IMT with an acceptable error of ± 0.1 mm, 7 animals were required. This study was approved by and performed according to the Sao Paulo State University Ethics Committee (process number 100/2014 – CEUA).

Fifty American Quarter Horses with no history of cardiovascular disease were included in the study. Subjects were divided into groups according to gender and age (group I: <2 years; group II: 3-10 years; group III: 15-30 years-old).

Bilateral evaluation of the CCA was performed at the level of C5-C6, on the jugular groove of the horse at rest and without any sedation, in order to avoid hemodynamic alterations. Examination was conducted using a portable ultrasound (MyLab 30 Vet, Esaote, Genova, Italy) and a 18MHz linear transducer (model LA435, Esaote, Genova, Italy). All exams were performed by the same observer to minimize interobserver error. Image acquisition was performed, on average, in three minutes and measurements were obtained later.

The CCA was identified on a transversal view along with the ipsilateral jugular vein (Figure 1A). Diameter and IMT were measured on a longitudinal view, where IMT was defined as the distance between the lumen-intima and the media-adventitia layers, as previously described.[5,7] Diameter was defined as the distance between the media-adventitia of the far and near wall, as already described.[5] Three to five measurements of IMT and diameter were performed using at least two different images of each artery (Figures 1B and 1C).

Pulsed wave Doppler was performed with an incident angle of 45 to 75^0, using angle correction. Sample volume was located in the middle of the vessel and kept at minimum in order to obtain the fastest flow. Mean RI and PI were obtained by use of the equipment´s software from at least three measurements of the same image.

Statistical analyses were performed using the mean value of the measurements from each vessel. The variables were examined for normality and no departures from a normal distribution were observed. Mixed linear models[16] were used to compare the mean diameter (mm), IMT (mm), RI, and PI among gender, age and side categories. Interaction terms between side and age or gender were included in all models to determine if the difference between sides was similar among age and gender categories. A compound symmetry covariance structure was used to model the correlation among repeated measures within the same animal. The Tukey's test was used to adjust the P-values resulting from multiple comparisons.

Linear regression[16] was used to assess the association between age (explanatory continuous variable) and CCA diameter, IR, IP or IMT (response variables). Quadratic terms were tested in all models and remained if significant. A compound symmetry covariance structure was used to model the correlation among repeated measures within the same animal. All analyses were performed at a significance level of 0.05.

RESULTS

The CCA and the ipsilateral jugular vein were easily differentiated because the jugular vein presented a triangular shape when pressure was applied and the carotid artery presented pulse (Figure 1A).

Descriptive statistics for the left and right CCA diameter, IMT, RI and PI for each group are presented on Table 1. Mean and standard deviation for age, diameter, and IMT of the right and left CCA are presented in Table 2 for both females and males in each group. Table 3 presents means and standard deviation of RI and PI on each side, for each gender in each group.

Left CCA diameter increased with age, ranging from 8.71 ± 1.09 mm in group I to 10.72 ± 0.96 mm in group III. Right CCA diameter was always greater than the left and the difference between sides increased with age (Table 1 and Figure 2). Right CCA diameter ranged from 8.92 ± 1.24 mm in group I to 11.76 ± 1.07 mm in group III. The difference between left and right diameter was significant ($P<0.001$) for both groups II and III. The difference in the CCA diameter found between the left and right sides of animals in group I was not statistically significant ($P=0.95$). Results also showed that diameter was highly associated with age ($P<0.001$), but there was no difference between genders ($P=0.3$). Mean CCA diameter was different between groups I and II ($P<0.001$), and groups I and III ($P<0.001$). No difference was observed between groups II and III ($P=0.08$, Table 1).

The CCA IMT was not associated with gender ($P=0.5$) or side ($P=0.1$). Mean IMT for groups I, II and III were 0.90 ± 0.15 mm, 1.02 ± 0.09 mm, and 0.97 ± 0.10 mm, respectively. Similarly to diameter, IMT increased significantly from group I to II (P<0.01) and did not vary between groups II and III (P=0.3) or between groups I and III (P=0.2).

Mean RI was not different between genders (P=0.3) or sides (P=0.1), but was different between age categories (P<0.001). Mean RI was 0.75 ± 0.07, 0.81 ± 0.06, and 0.90 ± 0.10 for groups I, II and II, respectively. There was no difference between groups I and II (P=0.1), but both the increases observed from group II to III and I to III were significant (P<0.01, Table 1).

PI differences were similar to those found for RI regarding gender (P=0.6), side (P=0.3) and age (P<0.001). Mean PI was 1.63 ± 0.33, 2.08 ± 0.46, and 3.20 ± 0.74 for groups I, II and III, respectively. Mean PI increased with age and there were expressive differences between groups II and III (P<0.001), and groups I and III (P<0.001, Table 3).

When age was analyzed as a continuous variable, it was significantly associated with RI (linear, P<0.001), PI (linear, P<0.001), and diameter (quadratic, P<0.001) (Figure 3).

DISCUSSION

The number of subjects used for morphological and flow evaluation was not similar because clipping was not possible in most animals due to aesthetic reasons. Some subjects were also restless during examination, which did not allow Doppler examination.

Total, average time, maximum, and minimum blood flow were not calculated because they depend on velocities [3,4] and the Doppler angle used in this study was in most cases greater than 60º. Since RI and PI are independent of angle[14], only these flow measures were analyzed.

The difference in the CCA diameter between genders has been inconsistent among previous studies. Although weight-adjusted CCA diameter has been reported to be 0.6 mm greater for males when compared to female horses[3]. And it has been reported that diameter is smaller in women as compared to men, even after adjustments for body size.[8,18]. Gender was not associated with diameter in the present study, similarly to results obtained for Labrador dogs.[19] This could indicate a difference among breeds or the influence of sexual hormones, since none of the studies present the number of animal that were intact, spayed or neutered.

No difference between left and right CCA areas was reported in horses[4] or diameter in Labrador dogs.[19] However, difference between right and left diameter was found to increase with age in this study (Figure 2). Right diameter has also been reported to be slightly greater (6.15 ± 0.91 mm) than the left (6.05 ± 0.87 mm) in women, but authors did not find the same difference in men.[8] The right diameter was greater for both genders but this difference was not statically significant for young and old individuals.[18] Older horses (group III) might present greater differences between the left and right diameter because unlike in humans, aging does not result in increased IMT and decreased diameter due to artherosclerotic risk.[18] In addition, mechanical arterial properties were affected by age while hemodynamics were still preserved.[20] In humans, it is known that the left CCA is a main branch from the aorta while the right derives from a braquiocephalic trunk[18,20] and there might be anatomical variations in horses, which would lead them to respond differently to aging and mechanical forces. It is important to emphasize that the carotid diameter is influenced by blood pressure[8] and this variable was not directly assessed in this study.

IMT increased from group I to II, but not from group II to III, which suggests that it increases as the animal grows, even though, linear regression with age, considered a continuous variable, was not significant (P=0.29). Unlike humans, IMT did not increase constantly with age[18] because older horses are probably not exposed to the same atherogenic risk factors. We did not expect to find wall thickening because subjects were considered healthy and several studies have shown that an increase in the vessel's wall thickness in humans was associated with cardiovascular risk.[6, 7, 21] However, authors did not find any study on equine IMT to compare results. And unlike a previous report[18] in which the left IMT was greater than the right for both men and women, left and right IMT were not different in the present study.

In our study, both RI and PI were only influenced by age, increasing linearly with age (Figure 3). In contrast, it has been reported in humans that the only age related hemodynamic parameter was the right CCA RI.[20]

Further studies are needed in different breeds in order to elucidate if there are anatomical differences. Right CCA diameter reported from a population of Saddlebred horses was 11.9 ± 1.5 mm[3], which was similar to the values obtained from horses over 15 years old (group III) in the present study. Nonetheless, 73% of the animals in that study were between 2 and 10 years old and would be considered adults (group II) in our study. Mean RI for group III (0.9 ± 0.10) was similar to that previously reported for a group of resting warm-blood horses (0.9 ± 0.07), with an average of 7±5 years old.[4] Another post mortem anatomical study reported that the arterial lumen near the trifurcation was 9.9 ± 1.2 mm.[17] Even though authors did not differentiate between left and right vessels or among breeds, values were within the 95% confidence interval for the left CCA (9.79 - 10.44 mm) for group II (adults). There are very few studies on normal values of equine CCA to allow conclusions if these parameters are only influenced by age, size or breed.

Morphologic parameters such as diameter and IMT increased from foals to adults, but did not vary significantly from adults to older horses, suggesting that once horses reach adulthood (around 3 years old), wall thickness and diameter become stable (Figure 3). On the other hand, blood flow indexes (RI and PI) increased more significantly from adults (group II) to elderly horses (group III), which indicates that blood flow in the CCA becomes more resistant as animals become older.

All parameters evaluated in this study varied with age and none was influenced by gender. The CCA IMT, RI and PI did not differ between sides, but CCA diameter presented an asymmetry between sides that increased with age. As far as the authors are concern, this is the first study to evaluate CCA IMT and PI in horses. Compilation of reference values regarding this vessel and a better understanding of normal variation can assist the assessment of the cardiovascular system and blood flow to the brain.

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TABLES

Table 1: Left (L) and right (R) values of diameter (mm), intima-media thickness (IMT) (mm), resistivity index (RI) and pulsatility index (PI) of the common carotid artery in American Quarter horses for each age group (I: <2 years; II: 3-10 years; III: 15-30 years). All measurements are indicated with the respective mean, 95% confidence interval (CI 95%), standard deviation (SD) and standard error (SE).

		Diameter (mm)			IMT (mm)			RI			PI		
	Group	Mean (CI 95%)	SD	SE	Mean (CI 95%)	SD	SE	Mean (CI 95%)	SD	SE	Mean (CI 95%)	SD	SE
	I	8.71 (8.08-9.34)^{b}	1.09	0.29	0.88 (0.79 – 0.97)^{a}	0.16	0.04	0.73 (0.68 – 0.78)^{a}	0.08	0.02	1.58 (1.35 – 1.80)^{a}	0.38	0.10
L	II	10.11 (9.79 - 10.44)^{a}	0.72	0.16	1.01 (0.97 – 1.06)^{b}	0.09	0.02	0.81 (0.77 – 0.85)^{a}	0.07	0.02	2.06 (1.77 – 2.35)^{a}	0.49	0.13
	III	10.72 (10.19 – 11.25)^{ac}	0.96	0.25	0.95 (0.89 – 1.01)^{ab}	0.11	0.03	0.89 (0.83 – 0.95)^{b}	0.09	0.03	3.14 (2.61 – 3.67)^{b}	0.84	0.24
	I	8.92 (8.20-9.63)^{b}	1.24	0.33	0.92 (0.83 – 1.00)^{a}	0.15	0.04	0.76 (0.72 – 0.80)^{a}	0.07	0.02	1.68 (1.52 – 1.85)^{a}	0.28	0.08
R	II	10.96 (10.48 – 11.45)^{cd}	1.06	0.23	1.03 (0.98 – 1.07)^{b}	0.09	0.02	0.80 (0.77 – 0.83)^{a}	0.05	0.01	2.10 (1.83 – 2.36)^{a}	0.44	0.12
	III	11.76 (11.17 – 12.36)^{d}	1.07	0.28	0.98 (0.93 – 1.04)^{ab}	0.10	0.03	0.91 (0.85 – 0.97)^{b}	0.10	0.03	3.26 (2.84 – 3.68)^{b}	0.66	0.19

***** Means and standard deviations followed by the same letter in lower case are not different between them.

Table 2: Mean and standard deviation of morphometric parameters (diameter and IMT – intima-media thickness) of the common carotid arteries in American Quarter horses. Values are displayed according to gender, side and ages groups (I: <2 years; II: 3-10 years; III: 15-30 years).

		Females			Males		
		I (n= 7)	**II (n=12)**	**III (n=8)**	**I (n=7)**	**II (n=9)**	**III (n=7)**
	Age (years)	1.36±0.29	5.67±2.23	17.38±3.25	1.18±0.33	5.15±2.37	21.86±4.81
Left	Diameter (mm)	8.78±0.92^{Aa}	10.11±0.72^{Ab}	10.04±0.57^{Ab}	8.64±1.31^{Aa}	10.12±0.75^{Ab}	11.49±0.68^{Ab}
	IMT (mm)	0.94±0.15^{a}	1.02±0.11^{b}	0.94±0.11^{ab}	0.82±0.17^{a}	1.00±0.07^{b}	0.96±0.12^{ab}
Right	Diameter (mm)	8.91±1.08^{Aa}	11.29±0.93^{Bb}	11.06±0.76^{Bb}	8.92±1.47^{Aa}	10.54±1.12^{Bb}	12.58±0.75^{Bb}
	IMT (mm)	0.93±0.10^{a}	1.04±0.10^{b}	0.96±0.07^{ab}	0.90±0.20^{a}	1.01±0.07^{b}	1.01±0.12ab

***** Means and standard deviations followed by the same letter in lower case are not different between groups. Values followed by the same letter in upper case are not different between sides.

Table 3: Mean and standard deviation for resistivity index (RI) and pulsatility index (PI) of the left and right common carotid arteries in American Quarter horses. Values are displayed according to gender and age groups (I: <2 years; II: 3-10 years; III: 15-30 years).

		Females			Males		
		I (n= 7)	**II (n=8)**	**III (n=7)**	**I (n=6)**	**II (n=5)**	**III (n=5)**
	Age (years)	1.36±0.29	6.13±2.17	17.71±3.35	1.18±0.33	5.00±2.92	23.40±4.72
Left	RI	0.75±0.09^{a}	0.84±0.06^{a}	0.89±0.12^{b}	0.71±0.07^{a}	0.76±0.06^{a}	0.89±0.06^{b}
	PI	1.61±0.40^{a}	2.25±0.50^{a}	2.14±0.51^{b}	1.55±0.38^{a}	1.76±0.29^{a}	3.70±0.94^{b}
Right	RI	0.78±0.07^{a}	0.81±0.05^{a}	0.90±0.13^{b}	0.75±0.07^{a}	0.78±0.06^{a}	0.93±0.04^{b}
	PI	1.76±0.33^{a}	2.12±0.35^{a}	3.08±0.75^{b}	1.62±0.23^{a}	2.06±0.60^{a}	3.52±0.48^{b}

***** Means and standard deviations followed by the same letter in lower case are not different between groups.

FIGURES LEGENDS

Figure 1: A - Sonogram of the left common carotid artery (C) and the ipsilateral jugular vein (J) on B mode. **B –** Two diameter measurements on longitudinal view indicated by crosses. **C –** Three Intima-media thickness measurements on longitudinal view indicated by crosses.

Figure 2: Left and right common carotid artery diameter (mm), in American Quarter horses for each age group. Group I (n=14) was composed of horses under 2 years old, group II (n=21) of horses between 3 and 10 years old, and group III (n=15) of horses between 15 and 30 years old. Asterisk indicates p<0.05 for the difference between left and right side on the group.

Figure 3: Linear regression of common carotid arteries measurements by age (years), with two measurements (left and right side) per horse, in American Quarter horses. Top left: diameter (mm); Top right: intima-media thickness (IMT) (mm); Bottom left: pulsatility index (PI); Bottom right: resistivity index (RI).

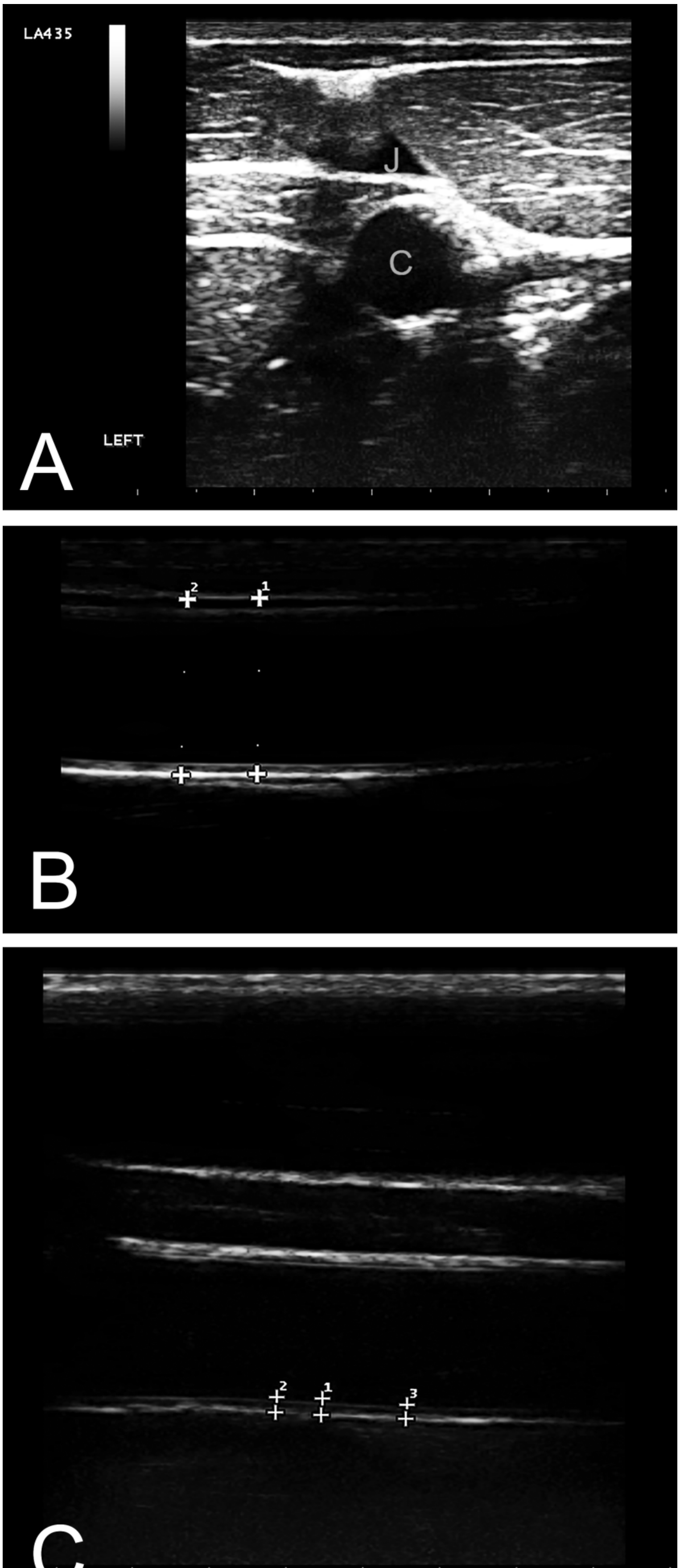
LA435
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Figure 1

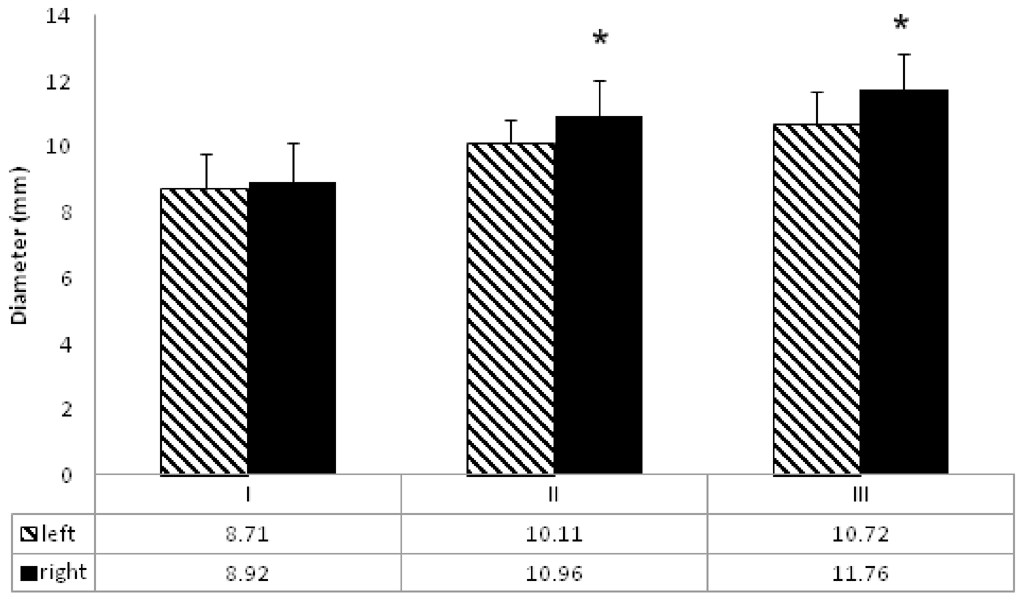

Figure 2

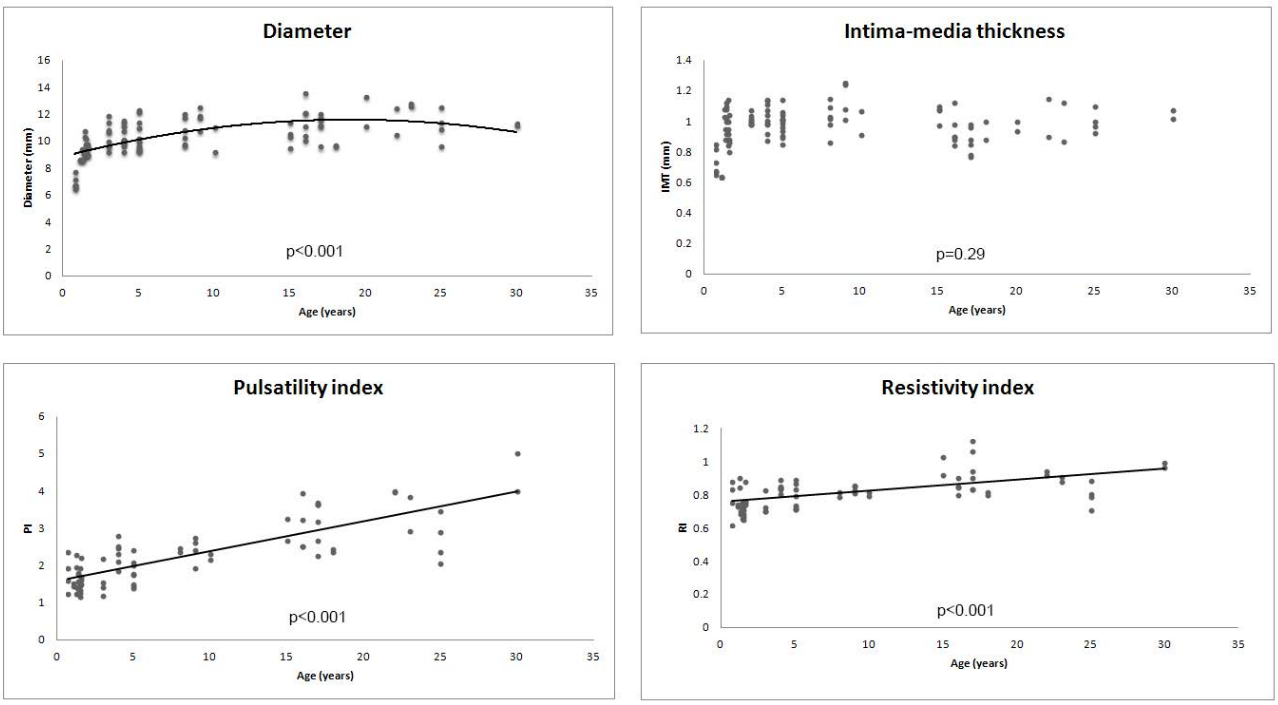

Figure 3

Capítulo 3

1. CONCLUSÕES GERAIS

O diâmetro, a EIM, IR e IP, da artéria carótida comum dos equinos, variaram com a idade. Nenhum dos parâmetros está correlacionado com sexo e apenas o diâmetro está associado ao lado.

A média do diâmetro direito maior que o esquerdo em todos os grupos de idade, sendo que essa assimetria aumenta com a idade e não foi significativa entre potros.

O IR e IP apresentaram aumento linear com a idade, indicando que o fluxo nesse vaso se torna mais resistente à medida que o animal envelhece.

A EIM variou apenas entre potros e adultos, não entre adultos e animais acima de 15 anos ou entre potros e animais mais velhos.

O estudo contribuiu com a escassa literatura a respeito deste vaso e forneceu valores que podem ser utilizados como referência para futuros estudos ou para comparação com animais sob diferentes circunstâncias, tais como micose de bolsa gutural, afecções cardiovasculares ou mesmo em animais sedados e anestesiados.

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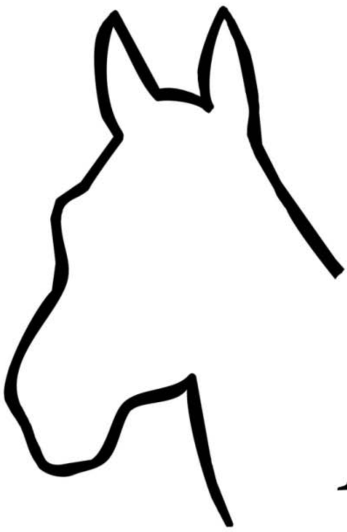

Anexos

Veterinary Radiology & Ultrasound

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Manuscript ID:	VRU-12-14-230
Title:	Ultrasonographic Evaluation of the Common Carotid Artery in Horses
Authors:	Aguiar, Adriana Pantoja, José Carlos Sousa, Nicole Machado, Vânia Maria
Date Submitted:	02-Dec-2014

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and analytical methods), most important findings (giving specific effect sizes and their statistical significance, if possible), and most important conclusions.
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Introduction: The introduction section should be concise (3 paragraphs) and orient the reader to the problem being addressed by the study
• Describe the nature of the problem and its importance.
• State the specific purpose(s) or research objective(s) of, or hypothesis(es) tested by, the study.
• Avoid lengthy literature reviews. Provide only findings from the most directly pertinent references.
• Do not include data or conclusions from the work being reported.

Methods: The Methods section should include only information that was available at the time the plan or protocol for the study was being written; all information obtained during the study belongs in the Results section.

• **Selection and Description of Subjects:** State whether the study was approved by and conducted in accordance with an Institutional Animal Care and Use Committee. Describe your selection of the study participants clearly, including eligibility and exclusion criteria. Describe the source population and define how decisions were made. Other descriptions should be put into the results section.
• **Technical Information:** Include descriptions of imaging techniques in the Methods section if they were among the criteria for inclusion in the study. If not, put this information into the results section. Identify the methods, apparatus (give the manufacturer's name and address in parentheses), and procedures in sufficient detail to allow others to reproduce the results (specific guidelines developed by the Diagnostic Imaging Service, Faculty of Veterinary Medicine,

University of Montreal are listed for each modality below). Use citations to reference established methods, including statistical methods (see below); provide references and brief descriptions for methods that have been published but are not well-known; describe new or substantially modified methods, give the reasons for using them, and evaluate their limitations. Identify precisely all drugs and chemicals used, including generic name(s), dose(s), and route(s) of administration.

Radiography

- Image receptor type: film-screen, computed radiography, digital radiography.
- Film:
• System speed and single vs double emulsion
- For digital/computed radiography:
• Brand of imaging plate (IP) and reader (if applicable)
- Technique (where applicable):
• kVp, mA, time
- Projections: correctly name each radiographic projection, using the terminology in *Smallwood et al.*, *Vet Rad and Ultrasound, 1985:26(1):2-9*.

- For contrast studies:
• Correctly name study type
• Medium used (generic and brand names [city and country of fabrication]), concentration and dose, specify dilution (if applicable)
• Route of administration
• Time delay between administration and image acquisition

Ultrasound

- System brand (name, city and country of fabrication)
- Probe: • Array (linear, convex, etc) • Type (mechanical vs electronic) • Frequency or frequency range (if broad bandwidth)
- Mode (B, M, A, Doppler [subtype: color, spectral, power, continuous, or other])
- Probe positioning/image plane (transverse, longitudinal, specific oblique, etc…), using the terminology in Nyland and Mattoon, Small Animal Diagnostic Ultrasound, Chapter 1: Physical Principles, Instrumentation, and Safety of

Diagnostic Ultrasound.
- For contrast and harmonic studies:
• Mechanical index
• Contrast medium, dose, rate of injection, time delay between administration and image acquisition

Scintigraphy
- System brand (name, city and country of fabrication)
- Image field of view and matrix dimensions
- Camera position(s) relative to the patient (views)
- Collimator type
- Radiopharmaceutical:
• Generic name
• Dose (in MBq)
• Route of injection
- Time delay between injection and image acquisition
- For static studies:
• Duration of acquisition or number of acquired counts (range)
• Specify whether or not motion correction was used
- For dynamic studies:
• Number of frames per second
• Frame duration
• Total study duration or number of acquired images

Computed Tomography
- System brand (name, city and country of fabrication)
- Detector type: single-slice vs multislice (and number of detector arrays)
- Type of acquisition: helical vs axial
- Section collimation thickness
- Image reconstruction interval or index
- Pitch (if helical)
- Technique:
• Tube rotation time, mA, kVp
- Image field of view and matrix dimensions

- Reconstruction algorithm(s): Bone, soft tissue, standard, etc.

- Window width and level if these were standardized for evaluation, or mention if evaluators could adjust these at will.

- Use of multi-planar and three-dimensional reformatting (if applicable)

- For contrast-enhanced studies:

• Medium used (generic and brand names [city and country of fabrication])

• Dose and concentration of iodine per ml

• Route of administration

• Rate of delivery and specify whether or not a pressure injector was used (including brand name [city and country of fabrication])

• Time delay (s) between administration and image acquisition (s)

Magnetic Resonance Imaging

- System brand (name, city and country of fabrication)

- Strength of magnetic field

- Type of coil For each sequence used:

• Generic sequence name (i.e. SE, FSE, GRE, SPGR, FLAIR, STIR, etc…) and manufacturer specific name if necessary

• Image weighting

• Plane of acquisition

• 2D vs 3D acquisition

• Echo time (TE)

• Repetition time (TR)

• Inversion time (TI)

• Flip angle for gradient sequences

• Number of acquisitions (NEX)

• Slice thickness and interslice gap

• Field of view and matrix dimensions

• Imaging options, if applicable: saturation (fat or water), magnetization transfer, parallel imaging, etc…

- For contrast-enhanced studies:

• Medium used (generic and brand names [city and country of fabrication])

• Dose and route of administration

• Rate of delivery and specify whether or not a pressure injector was used

(including brand name [city and country of fabrication])
• Time delay (s) between administration and image acquisition (s)
- Describe particular parameters for special studies (MRA, Diffusion, EPI, spectroscopy, etc.)

• **Data recorded:** Specify methods used for locating, selecting, extracting, and synthesizing data. These methods should also be summarized in the abstract. Specify how many observers were involved in data recording and how they were selected. Specify whether decisions were based on independent or consensus opinions. Specify what information observers were or were not aware of at the time of data recording. Define criteria used for making decisions.

• **Statistics:** Specify who selected and completed statistical tests. Specify the software used for analyses. Describe statistical methods with enough detail to enable a knowledgeable reader with access to the original data to verify the reported results. When possible, quantify findings and present them with appropriate indicators of measurement error or uncertainty (such as confidence intervals). Specify P value used for determining statistical significance. References for the design of the study and statistical methods should be to standard works when possible (with pages stated). Define statistical terms, abbreviations, and most symbols.

• **Results:** Present results in a logical sequence in the text, tables, and illustrations, giving the main or most important findings first. Do not repeat all the data in the tables or illustrations in the text; emphasize or summarize only the most important observations. Extra or supplementary materials and technical detail can be placed in an appendix where they will be accessible but will not interrupt the flow of the text, or they can be published solely in the electronic version of the journal. When data are summarized in the Results section, give numeric results not only as derivatives (for example, percentages) but also as the absolute numbers from which the derivatives were calculated, and specify the statistical methods used to derive findings. Restrict tables and figures to those needed to explain the argument of the paper and to assess supporting data. Use graphs as an alternative to tables with many entries; do not duplicate data in graphs and tables. Avoid nontechnical uses of technical terms in statistics, such as “random” (which implies a randomizing device), “normal,” “significant,” “correlations,” and “sample.” Where scientifically appropriate, analyses of the data by such variables as age and sex should be included.

• **Discussion:** Emphasize the new and important aspects of the study and the conclusions that follow from them. Do not repeat in detail data or other information given in the Introduction or the Results section. Do not include new results in this section that were not reported in the results section. For experimental studies, begin the discussion by briefly summarizing the main findings, then exploring possible mechanisms or explanations for these findings. Compare and contrast the results with other relevant studies, state the limitations of the study, and recommend future research. Link the conclusions with the goals of the study but avoid unqualified statements and conclusions not adequately supported by the data. Avoid alluding to work that has not been completed or published. Avoid lengthy literature reviews.

3b. Text, Imaging Diagnosis studies

• Signalment, history, and clinical findings: Specify age, breed, gender and species of patient. Specify the reason the patient was presented for imaging and key findings from clinical examinations.
• Imaging, diagnosis and outcome: Describe the imaging procedure, including technical parameters and equipment used. Describe the imaging findings. Describe the final diagnosis based on pathologic correlation. Describe follow-up outcome information.
• Discussion: Emphasize the new and important aspects of the case and the conclusions that are supported by findings. Explain how imaging findings contributed to case management. Compare findings with previous publications. Do not repeat in detail data or other information given in previous sections.

4. Acknowledgments

• List contributors to the paper who did not meet the criteria for authorship. Examples of those who might be acknowledged include clinicians/pathologists doing their usual duties; observers in multi-observer studies; a person who provided purely technical help, writing assistance, statistical analyses; or a department chairperson who provided only general support.

• Financial and material support should also be acknowledged.

• Acknowledge only persons who have made substantive contributions to the study.

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5. References

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• “Unpublished observations”, “unpublished data”, “article in preparation or submitted”, “personal communications” should not be used as references. • References listed as “in press” must have been accepted for publication.

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• Number all tables consecutively with Arabic numbers in order of appearance and insert a citation for each table at the most relevant location in the text section of the main document. Ex. (Table 1).
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• Define any abbreviations used in figures or figure legends.
• Explain the internal scale and identify the method of staining in photomicrographs.
• Provide key technical and image acquisition parameters in the legend. (see details in the method guidelines above)
• Radiographic images should be named according to the direction in which the central ray penetrates the part of interest, from point-of-entrance to point-of-exit.

• For CT and MR images, the following guidelines should be used for image orientation:

o Head and Spine

• sagittal plane: cranial (rostral) to left, dorsal at top

• transverse plane: dorsal at top, left to reader's right

• dorsal plane: cranial (rostral) at top, left to reader's right

o Thorax and Abdomen: Display images as they were acquired.

8. Appendix

• When essential for the understanding of the study, detailed information such as mathematical derivations, statistical analyses, and procedural descriptions may be presented in one or more appendices.

• Include in the appropriate section of the text (e.g., Materials and Methods, Results) a brief summary of the information contained in the Appendix and make reference to the corresponding Appendix in numerical order. Ex. Appendix 1

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