BRENDA VENTURA LOPES CARVALHO

HIDRATAÇÃO ENTERAL INTRACECAL EM EQUINOS UTILIZANDO DIFERENTES TAXAS DE INFUSÃO

Dissertação apresentada à Universidade Federal de Viçosa, como parte das exigências do Programa de Pós-Graduação em Medicina Veterinária, para obtenção do título de *Magister Scientiae*.

Orientador: José Dantas Ribeiro Filho

Coorientadores: Marcel Ferreira Bastos Avanza
Rinaldo Batista Viana

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Autora

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José Dantas Ribeiro Filho
Orientador

Ao meu sobrinho Benjamim, *por ter sido minha luz para o caminho à frente desde o segundo em que passou a existir.*

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mas forte mesmo é o carinho que sentimos. Mesmo pela tela do celular a presença constante de vocês, até quando estavam apenas compartilhando infinitos memes, me confortou o coração apertado com saudades de casa em incontáveis ocasiões.

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RESUMO

CARVALHO, Brenda Ventura Lopes, M.Sc., Universidade Federal de Viçosa, fevereiro de 2023. **Hidratação enteral intracecal em equinos utilizando diferentes taxas de infusão.** Orientador: José Dantas Ribeiro Filho. Coorientadores: Marcel Ferreira Bastos Avanza e Rinaldo Batista Viana.

O papel do cavalo e sua inter-relação com o homem tem mudado ao longo do tempo. Com altas exigências impostas pelas diversas atividades desempenhadas, os cavalos estão mais predispostos aos fatores causadores de doenças. Diversas doenças dos equídeos podem cursar com desidratação, especialmente aquelas que acometam em qualquer nível o sistema digestório, como a síndrome cólica, enterites e diarreias. Apesar da ampla utilização das vias tradicionais de hidratação, existem situações nas quais elas não são indicadas. Nestes casos, a hidratação pela via intracecal surge como uma solução que permitiria a utilização das soluções eletrolíticas enterais até mesmo em cavalos onde as porções iniciais do trato gastrointestinal estejam comprometidas. Dessa forma, este estudo objetivou avaliar os efeitos de duas diferentes taxas de infusão de uma solução eletrolítica enteral neutra hipotônica, pela via intracecal, sobre os parâmetros físicos e laboratoriais de equinos hígidos, submetidos à desidratação leve. Sete cavalos foram submetidos à cirurgia e, destes, seis receberam hidratação intracecal em um delineamento Cross Over 6x2. A videolaparotomia foi realizada adaptando a técnica de Hasson. Dois portais foram confeccionados no flanco direito para acesso à cavidade abdominal. No primeiro portal foi inserido um trocarte de 10mm para passagem do endoscópio rígido. No segundo portal foi inserida uma pinça Foerster. Após localizado, o ceco foi tracionado através do portal cranial e seguro nas posições 6 e 12 horas por duas pinças Allis. Suturas de ancoragem foram confeccionas. Procedeu-se a punço incisão do ceco para colocação da sonda de Foley. Uma sutura em bolsa de fumo foi confeccionada ao redor da sonda. Os portais de acesso à cavidade abdominal foram fechados. Os tratamentos consistiram de uma solução eletrolítica enteral neutra hipotônica. A solução foi administrada pela via intracecal em duas diferentes taxas de infusão, 10 mL kg-1 h-1 e 15 mL kg-1 h-1, em fluxo contínuo durante 12 horas. Todos os animais foram submetidos ao jejum hídrico e alimentar de 24 horas antes do início da hidratação. A avaliação clínica, exame físico e exames laboratoriais, foi realizada nos tempos: T-24h, T0h, T4h, T8h, T12h e T24h, com base no início da hidratação. A técnica cirúrgica descrita foi adequada e segura para manipulação e canulação do ceco. Esta técnica pode ser realizada mais rapidamente do que uma laparotomia tradicional e é relativamente mais segura.

Além disso, permite utilização imediata da cânula para hidratação intracecal, além da manutenção da sonda por longos períodos. A administração da solução eletrolítica enteral não provocou alterações prejudiciais à saúde dos cavalos. Ambas taxas de infusão foram seguras e bem toleradas. A modalidade de hidratação foi eficiente em restabelecer o grau de hidratação e volemia, sem causar desequilíbrios hidroeletrolíticos.

Palavras-chave: Fluidoterapia. Fluxo Contínuo. Canulação Cecal. Videocirurgia

ABSTRACT

CARVALHO, Brenda Ventura Lopes, M.Sc., Universidade Federal de Viçosa, February 2023. **Intracecal fluid therapy administered in two different rates in horses**. Adviser: José Dantas Ribeiro Filho. Co-advisers: Marcel Ferreira Bastos Avanza and Rinaldo Batista Viana.

Horse's role and its interrelationship with man has changed over time. With high demands imposed by the various activities performed, horses are more predisposed to disease-causing factors. Several equine diseases can be accompanied by dehydration, especially those that affect the digestive system at any level, such as colic syndrome, enteritis and diarrhea. Despite the widespread use of traditional fluid therapy routes, there are situations in which they are not indicated. In these cases, intracecal fluid therapy appears as a solution that would allow the use of enteral electrolyte solutions even in horses where the initial portions of the gastrointestinal tract are compromised. Thus, this study aimed to evaluate the effects of two different rates of infusion of an hypotonic neutral enteral electrolyte solution, via intracecal route, over physical and laboratory parameters of healthy horses submitted to mild dehydration. Seven horses underwent surgery and, of these, six received intracecal fluid therapy in a Cross Over 6x2 design. Videolaparotomy was performed adapting the Hasson technique. Two portals were made on the right flank for access to the abdominal cavity. One 10mm trocar was inserted for passage of the rigid endoscope on the first portal, and a Foerster forceps was inserted on the second portal. Once located, the cecum was pulled through the cranial portal and secured at the 6- and 12- o'clock positions by two Allis forceps. Anchoring sutures were made. An incision was made in the cecum to place the Foley catheter. A purse-string suture was placed around the catheter. The access portals to the abdominal cavity were closed. Treatments consisted of a hypotonic neutral enteral electrolyte solution. The solution was administered intracecally at two different infusion rates, 10 mL kg-1 h-1 and 15 mL kg-1 h-1, in continuous flow for 12 hours. All animals were submitted to water and food fasting for 24 hours before starting fluid therapy. Clinical evaluation, physical examination and laboratory tests were performed at times: T-24h, T0h, T4h, T8h, T12h and T24h, based on the start of fluid therapy. The described surgical technique was adequate and safe for manipulation and cannulation of the cecum. This technique can be performed more quickly than a traditional laparotomy and is relatively safer. In addition, it allows immediate use of the cannula for intracecal fluid therapy, as well as the maintenance of the catheter for long periods. Administration of the enteral electrolyte solution did not cause harmful changes to horses' health. Both infusion rates were safe and well tolerated. The

intracecal fluid therapy was efficient in restoring the hydration status and blood volume, without causing hydro electrolytic imbalances.

Keywords: Fluid Therapy. Continuous Flow. Cecum Cannulation. Endosurgery

SUMÁRIO

1 INTRODUÇÃO

O papel do cavalo e sua inter-relação com o homem tem mudado ao longo do tempo. Dos primórdios da humanidade, quando era utilizado na construção das cidades, nas guerras, na locomoção de tropas, até os tempos contemporâneos quando o animal passa a ser usado com mais frequência no serviço da pecuária extensiva, no lazer das pessoas, na prática de esportes (hipismo, adestramento, polo, salto, vaquejada e rodeio) e, mais recentemente, na terapia para pessoas com deficiência. Isso tem propiciado uma mudança de paradigmas nos cuidados e manutenção da saúde desses animais. Com altas exigências impostas pelas diversas atividades desempenhadas, os cavalos estão mais predispostos aos fatores causadores de doenças.

Além dos cuidados com a nutrição, alojamento, manutenção das condições de higidez e de bem-estar dos animais, há a necessidade da identificação precoce dos distúrbios que possam culminar com quadros patológicos que podem levar o animal ao óbito. Dentre as várias enfermidades que acometem o cavalo, tanto infecciosas, como aquelas relacionadas ao manejo dos animais, há alguns quadros clínicos que promovem inflamação e/ou dor, e limitam a ingestão de água e alimentos ad libitum, levando à desidratação em diferentes graus de intensidade (RIBEIRO FILHO et al., 2009). Assim, diversas doenças dos equídeos podem cursar com desidratação, especialmente aquelas que acometam em qualquer nível o sistema digestório, como a síndrome cólica, enterites e diarreias.

A desidratação é um sinal clínico de déficit hídrico, o qual comumente estará acompanhado de desequilíbrios nos eletrólitos e na relação ácido base do organismo (RIBEIRO FILHO et al., 2021). Considerando a porcentagem do peso corporal correspondente à água, cerca de 60%, pode-se confirmar a importância e a gravidade das diferentes formas de desidratação. Além do porquê de a hidratação se mostrar indispensável para a resolução dos desequilíbrios provocados em tais situações (CARLSON; BRUSS, 2008; RIBEIRO FILHO et al., 2009).

Na rotina da clínica de equídeos, duas vias de administração de soluções eletrolíticas são amplamente utilizadas: intravenosa (IV) e nasogástrica (NG). A primeira proporciona a reposição volêmica e eletrolítica de forma rápida e é utilizada em casos de desidratação intensa e choque hipovolêmico. Já a segunda via, é recomendada para quadros leves e moderados, nos quais teve sua eficácia comprovada. Além de possuir custo reduzido quando comparado à via

IV, tornando-a uma opção excelente (RIBEIRO FILHO et al, 2009; RIBEIRO FILHO et al, 2020).

Apesar da ampla utilização das vias tradicionais de hidratação, existem situações nas quais elas não são indicadas. Por exemplo, em casos de animais com refluxo enterogástrico de qualquer natureza, fica impossibilitada a administração da hidratação pela via nasogástrica, sendo necessária a utilização da via IV (RIBEIRO FILHO, 2020). Entretanto, há situações onde o custo do tratamento intravenoso não é viável para o proprietário. Nestes casos, a hidratação pela via intracecal surge como uma solução que permitiria a utilização das soluções eletrolíticas enterais até mesmo em cavalos onde as porções iniciais do trato gastrointestinal estejam comprometidas.

Dessa forma, este estudo objetivou avaliar os efeitos de duas diferentes taxas de infusão de uma solução eletrolítica enteral neutra isotônica, pela via intracecal, sobre os parâmetros físicos e laboratoriais de equinos hígidos, submetidos à desidratação leve.

2 REVISÃO DA LITERATURA

O ceco é o primeiro segmento do intestino grosso dos equinos, uma estrutura em formato cuneiforme ou “formato de vírgula” capaz de comportar cerca de 30 litros de ingesta. Está localizado na porção direita de flanco e abdômen, projetando-se cranioventralmente, e é dividido em três regiões: base, corpo e ápice (DABAREINER; WHITE, 1997; KRUNKOSKY; JARRET; MOORE, 2017).

O peristaltismo desloca o conteúdo do intestino delgado para o intestino grosso pela válvula ileocecal, cuja função é impedir que ocorra o retorno deste conteúdo para as porções anteriores. Dentro do ceco, a quantidade e composição do conteúdo pode variar conforme a dieta do animal; comumente, tem-se a fração gasosa na porção dorsal, seguida por uma mistura de sólidos e líquidos. O conteúdo ingerido leva de 1h30min até 3 horas para chegar ao ceco, onde pode permanecer por 6 a 10 horas antes de passar para o próximo segmento intestinal, o cólon ventral direito, através da válvula ceco cólica (HOWELL; CUPPS, 1950; SANTOS et al., 2011; LOPES; JOHNSON, 2017).

Assim como a maioria dos herbívoros, o intestino grosso dos equinos funciona como câmara de desenvolvimento para diversos microrganismos – especialmente bactérias, mas também fungos, vírus e protozoários – os quais realizam a digestão fermentativa do alimento,

culminando na liberação de ácidos graxos voláteis (AGVs). Estes AGVs funcionam como fonte de energia para o animal e são amplamente absorvidos através da mucosa intestinal, chegando a suprir cerca de 50% de suas necessidades energéticas (SANTOS et al., 2011; GOFF, 2015; LOPES; JOHNSON, 2017; WEESE, 2017).

Alguns autores comparam a atividade microbiana no ceco e cólons dos equinos àquela encontrada no rúmen, porém existem diferenças anatômicas importantes entre os ruminantes e os equídeos. A câmara fermentativa dos equinos (ceco) está localizada após os segmentos responsáveis pela maior parte da digestão endógena (estômago e intestino delgado). Assim, o intestino grosso se torna responsável por uma parcela importante da absorção e reabsorção de nutrientes - como água e eletrólitos - presentes na digesta, necessários à manutenção da homeostase (DABAREINER; WHITE, 1997; SANTOS et al., 2011; GOFF, 2015; LOPES; JOHNSON, 2017).

O volume de água no organismo de um equino adulto pode ser correspondente a 60% de seu peso corporal. Essa água é dividida em compartimentos dinâmicos que estão em constante interação para manter o equilíbrio, são eles: líquido intracelular (LIC) e líquido extracelular (LEC). Elementos como íons hidrogênio (H^+), sódio (Na^+), potássio (K^+), cloreto (Cl^-) e magnésio (Mg^{2+}) encontram-se nesses líquidos, e os mais diversos eventos biológicos, químicos e físicos acontecendo no corpo estão relacionados à sua concentração e distribuição (CARLSON; BRUSS, 2008; MAGDESIAN, 2014; FIELDING, 2015a).

O LEC equivale a aproximadamente um terço do volume total de água no organismo, os outros dois terços estão contidos dentro das células (LIC). Qualquer líquido corporal que não esteja dentro de células faz parte do LEC, como volume sanguíneo e líquido presente no lúmen de estômago e intestinos. O LEC é o primeiro compartimento a sofrer perda de água e eletrólitos quando o animal adoece, já que a prioridade do organismo é manter as células saudáveis para desempenhar suas funções (CARLSON; BRUSS, 2008; MAGDESIAN, 2014; FIELDING, 2015a).

Devido à grande capacidade volumétrica e habilidade de regular excreção e absorção, o intestino grosso nos equinos responde por uma grande parcela do LEC. Ele funciona como reservatório de água e eletrólitos, e pode ser mobilizado para suprir demandas do corpo. Quando o animal adoece, a reposição hidroeletrolítica realizada de forma terapêutica também é feita no LEC, através de diversas vias de administração (CARLSON; BRUSS, 2008; MAGDESIAN, 2014; FIELDING, 2015a).

2.1 Hidratação em equinos

A reposição hídrica e eletrolítica é uma parcela indispensável no tratamento de diversas doenças dos equinos, especialmente as que acometem em qualquer grau o trato gastrointestinal. A escolha da via de administração a ser utilizada depende de diversos fatores, que não envolvem apenas a situação clínica do animal. Além da gravidade do caso, deve-se avaliar o comportamento e temperamento do animal, os riscos envolvidos nas diferentes modalidades, a logística e até a disponibilidade financeira do proprietário (HIGGINS, 2015; FIELDING, 2018; CRABTREE; EPSTEIN, 2021).

A via intravenosa (IV) é a mais comumente usada na medicina equina para administração de soluções. Esta via permite administração de grandes volumes em curto tempo e sem necessidade de absorção, o que a torna essencial em casos de choque hipovolêmico ou desidratação intensa. O principal local para acesso intravenoso em equinos é a veia jugular, que pode ser facilmente localizada e cateterizada. Entretanto, diversos fatores de risco estão envolvidos no seu uso (FIELDING, 2018; RIBEIRO FILHO et al., 2020; CRABTREE; EPSTEIN, 2021).

Animais agressivos ou com dor intensa podem sofrer traumas mecânicos na região, podendo contaminar e até mesmo remover o cateter, além de lesionar o vaso. Quando apáticos, alguns equinos mantém a cabeça abaixada, o que pode comprometer o fluxo sanguíneo. Além disso, a permanência de cateteres por períodos prolongados, especialmente em animais imunocomprometidos ou com processos inflamatórios graves, também está associada ao desenvolvimento de tromboflebites (HIGGINS, 2015; SCHOSTER, 2017).

Para adequada utilização da via intravenosa são necessários procedimentos de antissepsia, materiais e soluções estéreis. No Brasil, a lista de soluções estéreis disponíveis comercialmente para uso intravenoso em equinos é limitada. Associando esses fatores, os custos para tratamentos prolongados em animais de grande porte são elevados. Há casos onde os proprietários não tem como arcar com os custos da terapia intravenosa e o animal pode não receber o tratamento que precisa (MEALEY et al., 1995; RIBEIRO FILHO et al., 2020).

As soluções eletrolíticas para hidratação devem sem tratadas como fármacos, com potencial terapêutico, mas também capazes de prejudicar a saúde quando usadas inadequadamente. A limitada quantidade de formulações de uso intravenoso no mercado torna difícil a elaboração de um tratamento adequado às necessidades individuais de cada paciente.

Porém, isso é factível através da hidratação pelas vias oral ou nasogástrica, que permitem a utilização de soluções não estéreis manipuladas *in loco*. As soluções enterais possibilitam não apenas um tratamento exclusivo para cada caso, mas também a alteração da solução em qualquer momento durante a hidratação (MEALEY et al. 1995; MOREIRA et al., 2019; RIBEIRO FILHO et al., 2020; CRABTREE; EPSTEIN, 2021; DIAS et al., 2022).

A hidratação enteral em equinos costumava ser realizada em *bolus* através da sondagem nasogástrica recorrente. Mas, a infusão de grandes volumes em um mesmo momento pode ser desconfortável, pois o estômago equino comporta pequenos volumes, entre 8 e 15 litros. Quando realizada dessa forma, a sonda nasogástrica é introduzida e removida em cada *bolus* da hidratação. Assim, o animal passa pelo estresse de contenção e sondagem diversas vezes, além de ter maiores chances de lesão das mucosas nasal e esofágica (THOMASSIAN, 2005; RIBEIRO FILHO et al., 2020).

O surgimento da Hidratação Enteral em Fluxo Contínuo (HETfc) proporcionou melhor controle sobre volume e tempo de infusão das soluções pela via nasogástrica. Para HETfc, se utiliza uma sonda nasogástrica de fino calibre, que pode permanecer no esôfago por longos períodos. Esta sonda permite ao animal a ingestão de água e alimentos *ad libitum* concomitantemente à hidratação. Além disso, a utilização de um equipo longo em espiral acoplado a um recipiente com capacidade para até 20 litros, permite livre movimentação na baia. Dessa forma, todo o processo de hidratação se torna menos estressante ao animal. Sendo até mesmo recomendado em casos pós-operatórios (GOMES et al., 2014a; MOREIRA et al., 2019; RIBEIRO FILHO et al., 2020; DIAS et al., 2021).

A administração de soluções enterais é eficiente no restabelecimento da volemia, redução da concentração urinária e estímulo da motilidade intestinal. Seus efeitos podem ser comparados à administração pela via intravenosa em alguns quadros. Outra grande qualidade é o baixo custo envolvido na produção das soluções, que podem ser manipuladas na clínica e sem necessidade de esterilização (MOREIRA et al., 2019; RIBEIRO FILHO et al., 2020).

Porém, para o uso da via nasogástrica é necessário que a motilidade e a capacidade absortiva do trato gastrointestinal estejam preservadas. Essa via é contraindicada em animais com refluxo enterogástrico, obstruções intestinais ou doenças inflamatórias que causam lesão de mucosa intestinal. Além disso, deve-se suspender o tratamento caso o animal apresente distensão abdominal enquanto recebe a solução enteral (MEALEY et al., 1995; DIAS et al., 2019; RIBEIRO FILHO et al., 2020).

Assim, a via intracecal surge como uma terceira opção para o tratamento de animais que precisam de reposição hidroeletrolítica, mas não podem ser submetidos à hidratação pelas vias intravenosa ou nasogástrica. Por exemplo, animais que apresentem refluxo enterogástrico e/ou cujo proprietário não possa custear o tratamento intravenoso. Ao administrar diretamente no ceco, evita-se a necessidade de passagem por estômago e intestino delgado, ao mesmo tempo em que se mantém a possibilidade de uso das soluções eletrolíticas enterais (MEALEY et al., 1995; FERREIRA et al., 2011).

Mealey e colaboradores (1995) realizaram um ensaio experimental com hidratação pela via intracecal em seis pôneis. Duas soluções eletrolíticas foram utilizadas. Durante as primeiras 24 horas, os animais recebiam as soluções em *bolus* a cada seis horas, na dose de 25 mL kg-^{1}. Nas 48 horas seguintes, a dose foi reduzida para 12,5 mL kg^{-1} a cada seis horas. O intervalo entre as repetições foi de 72 horas. Já Ferreira e colaboradores (2011) realizaram a hidratação intracecal em seis cavalos. Neste estudo os animais receberam a solução eletrolítica na dose de 50 mL kg^{-1} de peso corporal. O volume total foi fracionado em seis *bolus* ao longo de 24 horas, para um total de 96 horas de tratamento.

Ambos os estudos foram concluídos com recomendações positivas sobre a via, afirmando ser eficiente seu uso para reposição hidroeletrolítica. Entretanto, os autores sugerem novos estudos, sobretudo acerca da técnica cirúrgica empregada para a colocação da cânula cecal (MEALEY et a., 1995; FERREIRA et al., 2011).

2.2 Fistulização do ceco

Técnicas cirúrgicas para avaliação do trato gastrointestinal (TGI), através da exploração abdominal, e para colocação de cânulas nos segmentos intestinais são descritas desde o século XX. Inicialmente, esses procedimentos tinham como objetivo o estudo dos processos digestivos. Hoje em dia, a canulação do ceco serve desde a administração de substâncias até como portal de acesso cirúrgico para outras porções do TGI (BEARD; SLOUGH; GUNKEL, 2011; FIROUZABADI et al., 2017; MONTEIRO et al., 2022a).

A técnica para colocação de cânulas no ceco é descrita em um ou dois momentos cirúrgicos. Sugere-se que esta técnica em dois momentos cirúrgicos pode prevenir o extravasamento de conteúdo cecal para a cavidade peritoneal. Isso se dá pelo fato de que, ao aguardar alguns dias entre a tiflopexia e a tiflotomia, espera-se que a aderência formada entre

o ceco e a parede abdominal seja firme (BEARD; SLOUGH; GUNKEL, 2011; FIROUZABADI et al., 2017).

Entretanto, a colocação da cânula em um único momento é interessante, especialmente quando se considera a possibilidade de utilização da via intracecal para hidratação (MEALEY et al., 1995; FERREIRA, 2011). Independente de um ou dois momentos cirúrgicos, o sucesso do procedimento está diretamente relacionado ao estado geral do animal e a qualidade do manejo e dos cuidados clínicos pós cirúrgicos (BEARD; SLOUGH; GUNKEL, 2011; FIROUZABADI et al., 2017).

Uma das primeiras cirurgias para fistulização de ceco documentadas é da década de 1940, e tinha como objetivo a avaliação dos processos digestivos. Os pesquisadores realizaram a cirurgia em dois momentos cirúrgicos, espaçados em cinco dias. Não foi realizada a colocação de uma cânula, mas um dispositivo inflável foi utilizado como "tampa" para a fístula formada. Após sete dias, a mucosa cecal e a pele estavam firmemente unidas, aos 21 dias a cicatrização foi considerada satisfatória. A fístula foi mantida por vários meses (ALEXANDER; DONALD, 1949).

Já na década de 1960, a inserção de uma cânula de largo calibre foi realizada, também para estudos acerca de digestão e nutrição. Neste caso, os autores aguardaram seis dias entre os dois procedimentos. Os autores não descrevem quantos animais foram submetidos à técnica. Mas, afirmam que dois animais permaneceram fistulados por mais de um ano, sem apresentar quaisquer complicações (TEETER; NELSON; STILLIONS, 1968).

Um outro estudo avaliou a viabilidade da instalação de cânulas ruminais no ceco de cavalos. Oito dias foram aguardados após a realização da tiflopexia, para proceder com a tiflotomia e colocação da cânula. Em um dos dez animais deste estudo, complicações relacionadas a um quadro de cólica foram observadas. O animal veio a óbito. A cicatrização total das bordas das fístulas nos animais restantes foi observada por volta da terceira semana. As cânulas foram mantidas por mais de um ano sem complicações (BEARD; SLOUGH; GUNKEL, 2011).

A colocação de cânulas abomasais de látex no ceco também foi relatada com êxito por Diaz et al. (2010) e Monteiro et al. (2022a). Em ambos estudos, o tempo decorrido entre a tiflopexia e a tiflotomia foi de cinco dias. Técnicas cirúrgicas semelhantes foram utilizadas pelos autores para a realização da laparotomia, desde identificação, manipulação, fixação e abertura do ceco.

No estudo de Diaz et al. (2010), a avaliação clínica dos animais procedeu por até 160 dias sem manifestações de desconforto. Monteiro et al. (2022a) utilizaram a cânula cecal como acesso para avaliação endoscópica e manipulação ileal, através da válvula ileocecal. Neste caso, os animais foram mantidos com a cânula e avaliados ao longo de doze meses. Não foram relatadas manifestações relacionadas à dor nos animais do estudo.

Uma técnica pouco invasiva, em um único momento cirúrgico, foi descrita na década de 1990, em pôneis. Os autores realizaram a identificação do ceco por meio de ultrassonografia. Após identificação, o ceco foi inflado com infusão de 8 litros de ar, através de uma agulha espinhal 18G. A fixação do ceco se deu com a confecção de quatro pontos de ancoragem, delimitando uma área de aproximadamente 8cm². Além disso, prendedores em formato T foram inseridos para auxiliar na fixação do ceco (MEALEY et al., 1995).

Uma punço incisão foi realizada no centro da área delimitada e uma sonda *foley* n. 18 foi inserida. O balão da sonda foi preenchido com 20 mL de água estéril. A sonda foi fixada à pele com sutura simples. O tempo total do procedimento de aproximadamente 30 minutos. Dois animais apresentaram complicações relacionadas à cólica e foram eutanasiados. Nos demais animais, a sonda foi retirada após duas semanas e as fistulas cicatrizaram por segunda intenção sem complicações (MEALEY et al., 1995).

Em um outro estudo, a canulação cecal em único tempo cirúrgico foi realizada por meio de uma laparotomia tradicional. Neste ensaio, foi testada a viabilidade de uma sonda endotraqueal, desenvolvida para cães, como cânula cecal. Esta sonda foi utilizada para administração de uma solução eletrolítica e mantida por 96 horas. Não houve manifestação de dor ou sinais sistêmicos de infecção relacionados ao procedimento cirúrgico. Após a remoção da sonda, a fistula cecal cicatrizou por segunda intenção em quinze dias (FERREIRA et al., 2011).

Também utilizando sonda endotraqueal desenvolvida para cães, Ferreira (2011) avaliou a viabilidade de realização da tiflopexia de forma videoassistida. O autor realizou inspeção da cavidade abdominal e identificação do ceco por meio da videolaparotomia. Em seguida, procedeu a tiflopexia e colocação da cânula. A cânula foi utilizada para administração de solução enteral por 96 horas. Após a hidratação, as cânulas foram removidas e a cicatrização ocorreu por volta de 35 dias após o procedimento.

A viabilidade de uma cânula rígida, constituída de um parafuso oco e porcas de plástico, foi testada em quatro cavalos. Os autores relataram complicações relacionadas a cicatrização, como desenvolvimento de tecido granulomatoso em excesso. Foi necessária remoção do

excesso desse tecido para melhor desenvolvimento da ferida cirúrgica. As cânulas foram removidas cirurgicamente após dois meses e as fístulas remanescentes cicatrizaram em três semanas, sem novas complicações (FIROUZABADI et al., 2017).

2.3 Videolaparoscopia em ruminantes e equídeos

Diversos são os benefícios atribuídos a realização de uma intervenção por vídeo, em detrimento de uma cirurgia tradicional, especialmente quando se trata da cavidade abdominal. Uma das vantagens da videocirurgia está relacionada à possibilidade de manter o animal em estação, realizando o procedimento sob sedação e anestesia local. Dessa forma, evitando submeter o animal aos riscos de uma anestesia geral para decúbito (ZEBELI et al., 2015; STRATICÒ et al., 2022).

A videolaparoscopia permite ainda uma maior e mais detalhada exploração da cavidade abdominal, ao fornecer imagens das estruturas. Em uma laparotomia tradicional, a identificação dos órgãos depende da palpação realizada pelo cirurgião. A realização de procedimentos cirúrgicos videoassistidos também contribui para a melhoria do bem-estar animal no trans e pós cirúrgico (DEVICK et al., 2018; SANTOS et al., 2018).

Por ser um procedimento menos invasivo, as complicações pós-operatórias também são reduzidas. Especialmente as associadas ao manejo de dor e da ferida cirúrgica. Além do reduzido tempo de cirurgia e o menor tamanho das incisões, a manipulação peritoneal é minimizada e, portanto, o risco de formação de aderências também. Não obstante, a videolaparoscopia evita o contato da cavidade abdominal com materiais como compressas, luvas, aventais e até mesmo partículas suspensas no ar (TEIXEIRA et al., 2013; ZEBELI et al., 2015; STRATICÒ et al., 2022).

Entretanto, a técnica tem limitações. Sua execução está vinculada não apenas à disponibilidade do equipamento, frequência e custos de manutenção, mas também à equipe. Cirurgião e auxiliares precisam de treinamento prévio para adequado uso do aparelho, bem como identificação e manipulação das estruturas abdominais por meio dos instrumentos (STRATICÒ et al., 2022).

3 MATERIAL AND METHODS

3.1 Ethical approval, local of execution and animals

This study was conducted under approval of the Animal Ethics and Welfare Committee of Federal University of Viçosa (protocol no. 17/2015). The experimental part was conducted in the months of April, May and June of 2022 at the Large Animal Hospital – Veterinary Department – Federal University of Viçosa. Geographical coordinates: -20.768105100767638, -42.8542050026557.

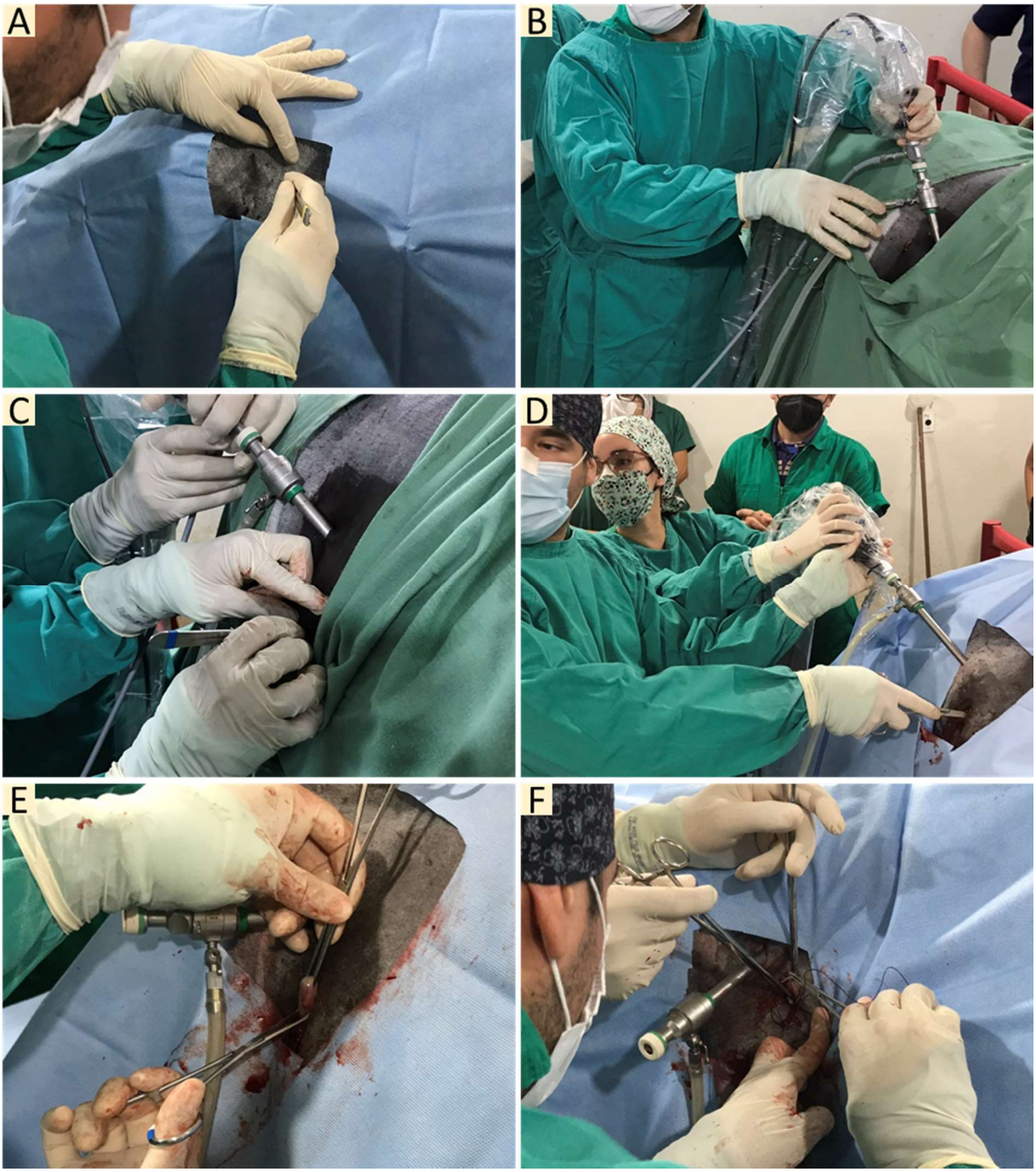
The horses were selected after general clinical examination and laboratorial analysis stated they were healthy and able to undergo surgical procedure. All animals were kept in individual stalls, fed fresh *Pennisetum purpureum* grass and *Cynodon* sp. hay, commercial concentrate, mineral salt and *ad libitum* water. Seven horses between 5 and 15 years and weighing between 295 and 445 kg were submitted to surgery. Fluid therapy data from six horses were used to assess the effects of the solution and infusion rates.

3.2 Anesthetic protocol and surgical procedure

The animals received 0.02 mg kg^{-1} of detomidine intravenously and 0.1 mg kg^{-1} of butorphanol intramuscular. The right flank was routinely prepared for surgery and lidocaine 2% was used for paravertebral locoregional blockage. The animals were in standing position and laparoscopy was performed adapting from the Hasson technique. Skin incisions were made with a scalpel (figure 1A), opening two laparoscopic portals of 10 mm. Dividing the paralumbar fossa into thirds, the first portal was at the part closer to the tuber coxae. The second portal was at the central third (figure 1C).

The abdomen was insufflated with carbon dioxide with stable velocity of 5 L min^{-1} and keeping the pressure of 10 mm Hg. Through the caudal portal one trocar was inserted for the rigid endoscope (0º, 10mm diameter, 40 cm length, Karl Storz-Esdoskope®) for abdominal cavity inspection and identification of cecum (figure 1B). After properly visualizing the base of the cecum, a Foerster forceps (figure 1D) was inserted through the cranial portal. This forceps was used for cecum manipulation and traction.

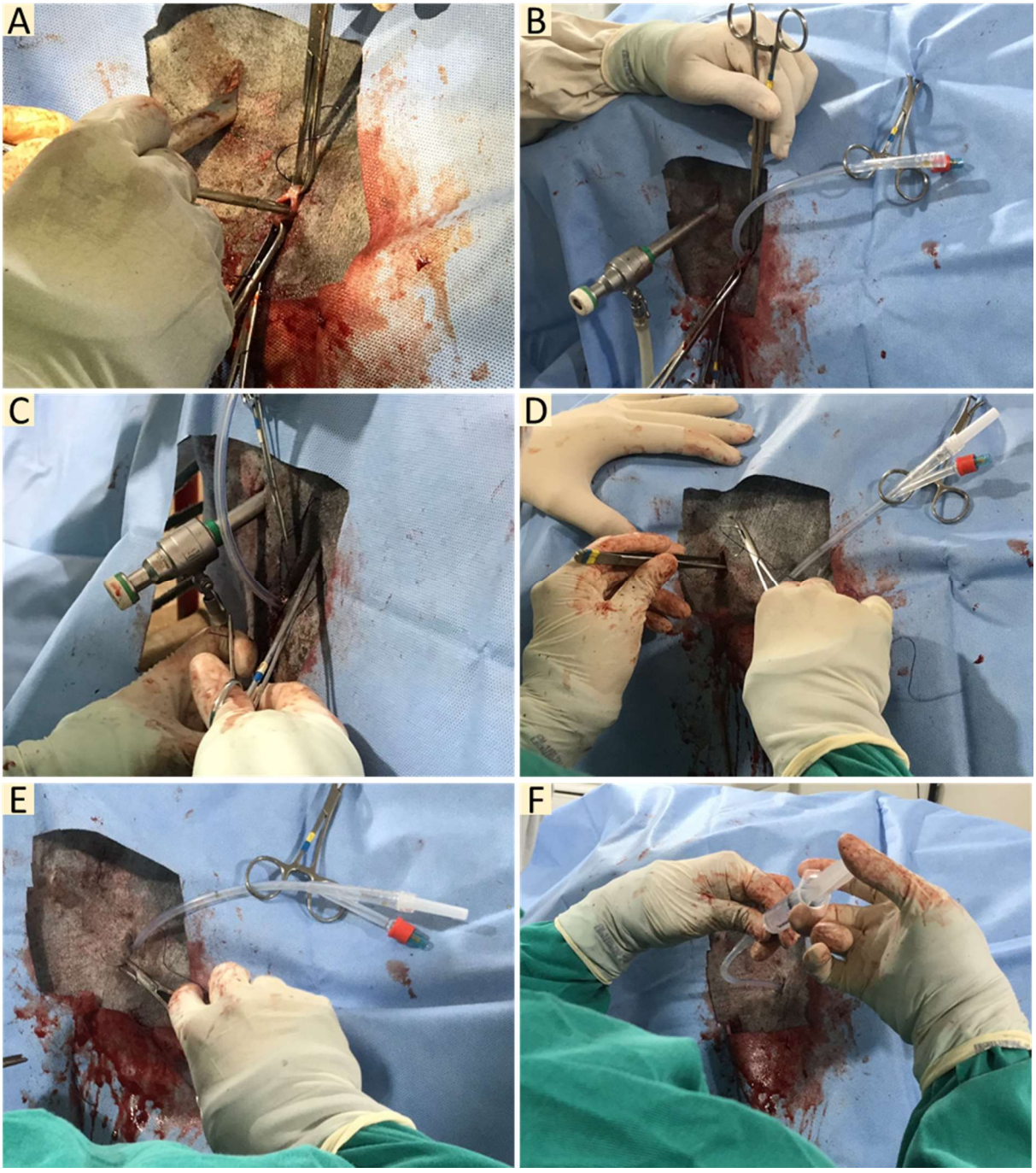
Figure 1. A) Incision for the first portal. B) Insertion of the trocar and rigid endoscope through first portal. C) Incision for the second portal. D) Insertion of the Foerster forceps to locate the cecum. E) Cecum exposed and held in place by two Allis forceps. F) Confection of anchor suture points.



Two Allis forceps were used at 6- and 12-hour position to hold the cecum in place (figure 1E). Portion chosen for suture was lateral, closer to the base and the greater curvature and avoiding the taeniae. Four anchor suture points were made at 3-, 6-, 9- and 12-hour positions with nº 0 poliglecaprone absorbable suture thread (figure 1F). After suturing the seromuscular

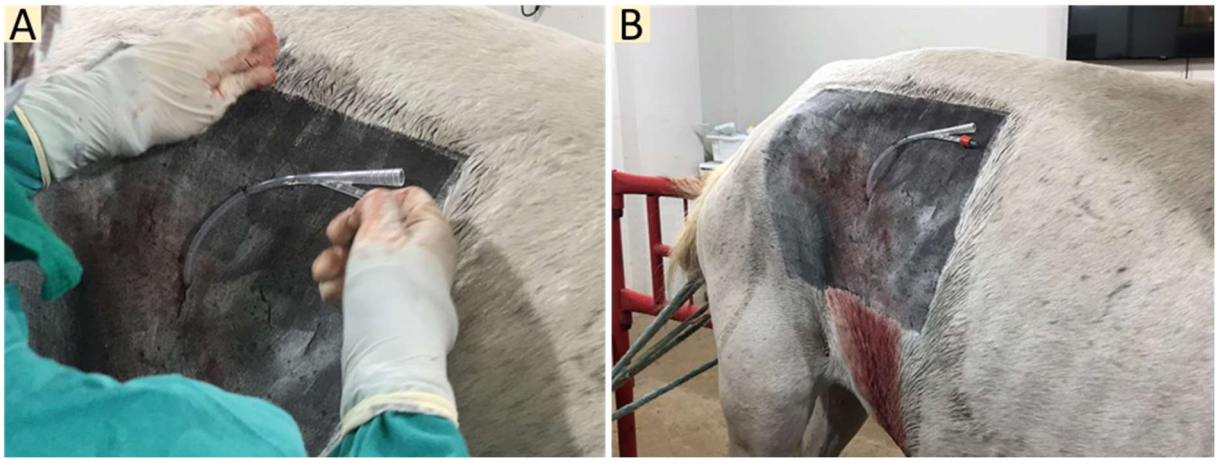
layer of cecum to the external abdominal oblique muscle, a puncture incision was made into the cecum (figure 2A) and a silicone foley catheter n. 18 was inserted (figure 2B). A pouch suture was made (figure 2C) around the foley catheter for definite fixation. The caudal portal was closed (figure 2D) with intradermal interrupted suture and the same was use to close incisional space in the skin above and under the foley catheter (figure 2E).

Figure 2. A) Puncture incision of cecum. B) Insertion of the foley catheter. C) Pouch suture around the catheter. D) First portal suture. E) Second portal suture. F) Catheter`s balloon filled with sodium chloride 0,9%.



The balloon in the catheter was filled (figure 2F) with 20 mL of sterile solution (sodium chloride 0,9%). The tip of the catheter was suture into the skin as shown in figure 3A and 3B. The site was then cleaned with sodium chloride 0,9% and chlorhexidine and a sterile gauze compress was placed over, leaving only the catheter tip exposed.

Figure 3. A) Skin suture for catheter fixation. B) Finalized procedure.



3.3 Postoperative management

When describing clinical information surgery related, the day of the procedure is “day 1” for all animals and following days are accounted from there. Pharmacological treatment after surgery consisted of 1.1 mg kg^{-1} SID of flunixin meglumine for 3 days and 15 mg kg^{-1} sulfadoxine in a single dose. All animals received tetanus antitoxin (5000 IU $animal^{-1}$). The wound and cannula management consisted of cleaning it twice a day with chlorhexidine 0,5% and sodium chloride 0,9%.

After cleaning, rifamycin spray was applied over fistula and sutures and a sterile gauze compress was placed. The adjacent skin areas were washed with neutral soap and water. These procedures were performed with 12h of interval for 22 days uninterruptedly, until the removal of the foley catheter. On day 22, all the catheters were removed and the wound was cleaned once a day using only sodium chloride 0,9% until complete healing by second intention.

3.4 Experimental design

This study consisted of a 6 x 2 Cross Over model, where six horses were submitted to both enteral fluid therapy (EFT) treatments at alternate times (table 1). The repetitions were performed seven days apart, being the first repetition immediately after surgery and the second, one week later. All animals were submitted to a fasting period of 24h before each repetition. Food and water remained withheld during EFT, totalizing a fasting period of 36 hours. After the treatment, food and water were provided *ad libitum*. Treatments consisted of the same enteral electrolyte solution (EES) administered in two different infusion rates, 10 mL kg^{-1} h^{-1} (treatment 1) and 15 mL kg^{-1} h^{-1} (treatment 2) for 12 hours. The EES composition was: 4,5g of sodium chloride, 0,5g of potassium chloride, 1g of calcium acetate, 0,2g of magnesium chloride and 5g of dextrose. Measured osmolarity was 238 mOsm L^{-1}.

Table 1. Animals' distribution along the repetitions and treatments applied in each one.

ANIMAL	A1	A2	A3	A4	A5	A6
REP. 1	10 mL kg^{-1} h^{-1}	15 mL kg^{-1} h^{-1}	10 mL kg^{-1} h^{-1}	15 mL kg^{-1} h^{-1}	10 mL kg^{-1} h^{-1}	15 mL kg^{-1} h^{-1}
REP. 2	15 mL kg^{-1} h^{-1}	10 mL kg^{-1} h^{-1}	15 mL kg^{-1} h^{-1}	10 mL kg^{-1} h^{-1}	15 mL kg^{-1} h^{-1}	10 mL kg^{-1} h^{-1}

The fluid therapy protocol was performed at days 1 and 7 for this experiment. All animals received the solution in continuous flow through the intracecal catheter (Foley catheter 100% silicon n. 18 Well Lead Medical Co.) attached to a system that consisted of a reservoir with 20-liter capacity and a 5-meter-long infusion set with a drip chamber and a flow regulator (figure 4). At the end of the fluid therapy period, the EFT system was detached from the foley catheter, and a lid was placed in order to seal it, preventing cecal content from leaking and air from entering.

3.5 Physical examination

Cardiac rate was obtained in beats per minute (bpm) through auscultation with stethoscope for one minute. The same technique was used to obtain the respiratory rate, in respiratory movements per minute (rmpm). Intestinal auscultation was performed dividing the abdomen into four quadrants, ventral and dorsal of left and right sides. After one minute of

auscultation, the motility of each quadrant was rated in a scale of one to three. The overall intestinal motility consisted of the summatory of all quadrants (resulting in a scale of four to twelve).

Mucosal quality was defined by color and humidity. For color, a numerical scale was attributed to quantify the evaluation, being one – pale, two – normal, three – red. As for humidity, the same process was applied but with number one meaning dry, two for tacky and three for normal. Capillary refill time was assessed by thumb pressing the gingival mucous and observing, time measured in seconds. Body temperature was obtained in Celsius degrees (ºC) by inserting a digital thermometer into the rectum for one minute. Thoracic circumference was measured around the thorax in the direction of wither and abdominal circumference was measured around the abdomen in the direction of flanks.

Feces samples were collected after spontaneous defecation. The samples were weighted and then put into a kiln with 80ºC temperature to undergo dehydration. The weighting of the samples was repeated every 12 hours until the result was the same for 3 consecutive evaluations. Feces humidity was determined by the following formula:

FH % water = [1 – (final weight / initial weight)] x 100

Figure 4 (A/B). Animal receiving enteral fluid therapy via intracecal route.

3.6 Laboratorial analysis

For blood collection, the mid-neck region was shaved and before every punction it was cleaned with 0,2% alcoholic chlorhexidine. Blood samples were obtained by jugular vein punction with a 30 mm x 0,8 mm caliber needle attached to a vacuum system and tubes containing: EDTA anticoagulant, for blood count; sodium fluoride, for plasmatic biochemistry; clog activator, for serum biochemistry. To perform blood gas analysis, a 2 mL blood sample was collected in a specific syringe containing lithium heparin anticoagulant.

The automatic cell count was performed by the HematoClin 2.8 Vet machine (BioClin Quibasa Ltd.). The blood smear was analyzed under the microscope for differential leukocyte count. Serum osmolarity was determined by Osmometer Model 3320 (Advanced Instruments Inc.). Biochemical analysis was performed with BioClin 2200 (BioClin Quibasa Ltda.) and HumaStar 300 SR (Human©).

The variables sodium, potassium, chloride, calcium, magnesium, phosphorus, fibrinogen, urea, creatinine, and total proteins were measured in serum. Lactate and glucose were measured in plasma. Acid-base balance and blood gas analysis were assessed by ABL80 Flex (Radiometer Medical ApS©), and the variables used were blood pH, pCO_2, $cHCO_3^-$, base excess (BE). The Anion Gap (AG) and Strong Ion Difference (SID) were calculated using the following formulas:

$$\mathbf{AG = (Na^+ + K^+) - (Cl^- + HCO_3^-)}$$

$$\mathbf{SID = (Na^+ + K^+) - Cl^-}$$

Urine samples were collected from spontaneous urination. Containers with a capacity of 1 liter were used and an aliquot of 20 mL was taken for analysis. Urinary pH was assessed with DLA-PH (Del Lab®), urinary specific gravity was determined using a refractometer ATC model RTP-12. After these processes, the sample was centrifuged to perform biochemical analysis of urea, creatinine, sodium, potassium, chloride, calcium, magnesium, and phosphorus.

3.7 Statistical analysis

Descriptive statistical analysis was represented by mean and standard deviation for continuous variables (mean ± SD), percentage for binomial variables (%). These data were obtained by SAS program (SAS/STAT, SAS Institute Inc., Cary, NC, USA, version 9.3). Inference statistical analysis was performed by ANOVA, through a repeated measures analysis, comparing mean and SD of animals (n = 6) into the treatments (n = 2), experimental times (n = 6) and repetitions (n = 2).

Statistical model was composed for the independent variables (treatment, time, treatment*time and repetition), covariable (animal into the time) and the dependent variables (clinical and laboratorial analysis). Comparation between means of groups was performed with Tukey test by SAS' Least Square Means (LSMeans) command. A significance level of 5% was used for all tests. Graphs were prepared using SigmaPlot (Systat Software GmbH, Erkrath, Germany, version 12.0).

4 VIDEO ASSISTED CECUM CANNULATION FOR FLUID THERAPY IN HORSES: MINIMALLY INVASIVE TECHNIQUE

4.1 Results

The sedation and anesthetic protocols were efficient for 100% of the horses (7/7), no animal showed signs of pain or discomfort during the procedure. All animals presented satisfactory recovery from sedation. Standing position and pneumoperitoneum were optimal for cecum visualization and manipulation. All seven animals were submitted to surgical procedure. The average surgery time was around 40 minutes.

The 24-hour fasting period was enough for reducing cecum content and making it better for visualization and manipulation in six of seven horses (85.71%). Horse 6 presented normal intestinal motility while in laparoscopy. When incised, the cecum of this horse had regular amounts of digestive content, differently from the other horses. Surgery proceeded as planned for Horse 6 and it was submitted to fluid therapy immediately after.

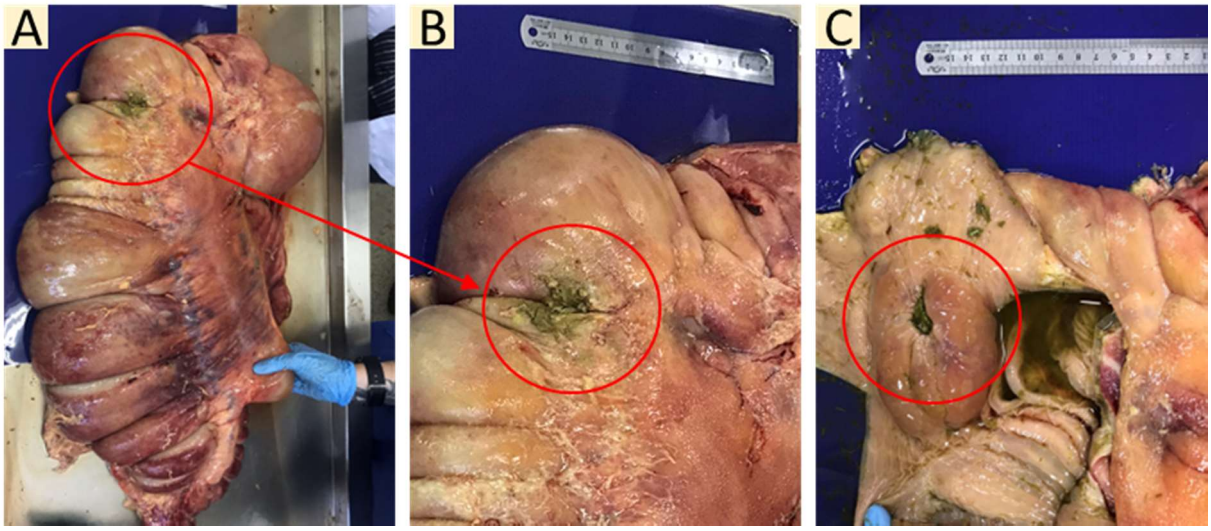
On the 3rd day after surgery, Horse 6 presented with fever, apathy and stopped eating. Laboratorial exams showed leukocytosis with band neutrophils. On day 4 the horse had a packed cell volume of 40%, dry and hyperemic mucous membranes with cyanotic halo, as well as leukopenia with band neutrophils. The horse was removed from experiment and put into intensive care. Treatment was initiated with 2.2 mg kg^{-1} SID of flunixin meglumine, 4.4 mg kg^{-1} SID ceftiofur, 6.6 mg kg^{-1} SID gentamicin, 25 mg kg^{-1} BID metronidazole and fluid therapy with Lactate Ringer (10 mL kg^{-1} h^{-1}).

The treatment failed to improve the horse's clinical conditions. At day 7, the horse was euthanized and necropsied. Necropsy revealed extensive abdominal swelling, large amounts of liquid inside peritoneum as well as some intestinal content. Surgery spot was located and showed no signs of the adherence expected between cecum and abdominal muscles (figure 4). It was not possible to determine the exact time when suture dehiscence happened.

The six remaining horses (85.71%) were successfully submitted to intracecal fluid therapy at all proposed repetitions. First one being immediately after surgery, and the second one being on the seventh day. Two other repetitions were successfully executed for another study, they took place at days 14 and 21. Difficulties or complications surgery-related did not

happen with any of the remaining horses. No other horse presented with fever or apathy on the following days.

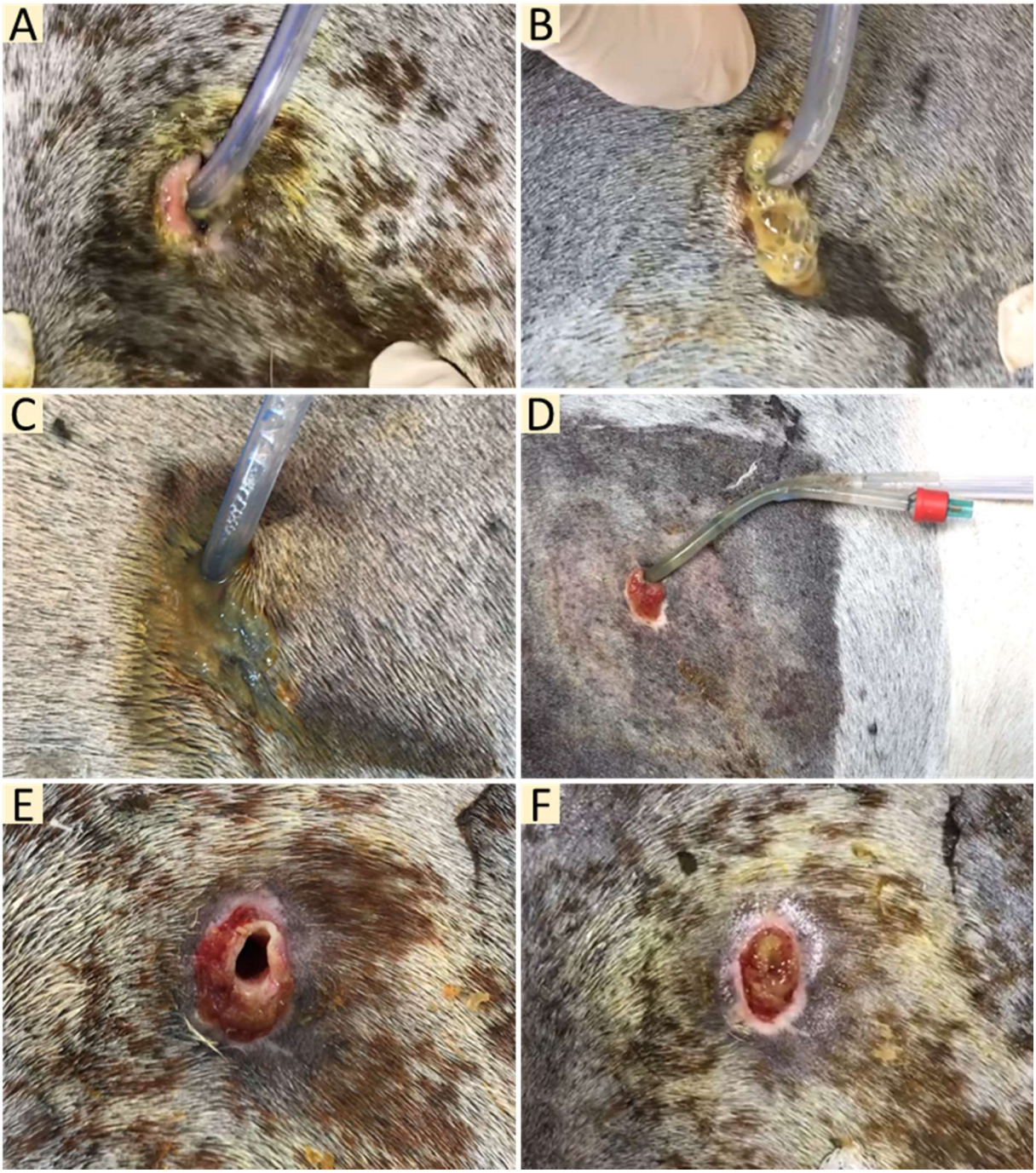
Figure 5. A) Horse 6`s cecum at necropsy. B) Cecum external face, ruptured suture spot. C) Cecum internal face, ruptured suture spot.



All horses had serous wound exudation in variable amounts on the first week (figure 6A). Wound purulent exudation (figure 6B and 6C) was observed later but without signs of systemic infection at laboratorial and physical exams. Wound cleaning and bandage management were efficient and helped with healing process of the wound around the foley catheter (figure 6D). There was not heat in the wound surroundings. Horses did not show signs of pain, neither of systemic infection.

On day 22, the catheter was still in place and without any other complications for five of the horses (71.42%). Horse number 5 removed its own catheter on day 19 and it was not replaced, since it was too close to the end of the study. After removing the foley catheter, the remaining wound was no larger than the tube itself (figure 6E). All horses had granulomatous tissue closing their wounds 24 hours after catheter removal (figure 6F). All wounds completely healed by second intention without complications. Seven months later, all remaining horses were still healthy and had not showed signs of colic.

Figure 6. A) Serous exudation. B/C) Purulent exudation. D) Wound healed around catheter. E) Wound immediately after catheter removal. F) Granulomatous tissue after 24 hours of catheter removal.



4.2 Discussion

The choice to perform endosurgery in this study was made as an attempt of minimizing trauma and disturbance to abdominal cavity, inflammatory adhesions, and postoperative pain

(TEIXEIRA et al., 2013). If a traditional laparotomy were to be performed, visualization would be limited and extra manipulation should be of need, increasing risks of adherences and other complications (STRATICÒ et al., 2022).

Horses and ponies submitted to cecum cannulation through traditional laparotomy in previous studies (MEALEY et al., 1995; BEARD; SLOUGH; GUNKEL, 2011; FIROUZABADI et al., 2017) were reported to show signs of abdominal discomfort. In this study, the horses ate and drank normally at all moments. They also moved freely around the stalls, as well as on the paddock, showing no signs of pain. Which indicates that the choice for video laparoscopy was efficient for avoiding side effects pain related.

The pneumoperitoneum and the position of the trocars on the right flank were satisfactory. Similar laparoscopy techniques have been used for abdominal access in sheep (SANTOS et al., 2018), stallions (VITORIA et al., 2019) and mules (PETRIZI et al., 2020). In these studies, as in this, trocars positions associated with pneumoperitoneum allowed comfortable visualization and manipulation of the desired structures. In this case, the cecum.

This allowed the surgeons to choose the best spot for cecum fixation and catheter placement. It is reported that horses might show signs of abdominal pain when using insufflation pressures of 15 mmHg for laparoscopy (DEVICK et al., 2018). With the pressure of 10 mmHg used in this study, the horses did not show signs of abdominal discomfort or distension that could be linked to the pneumoperitoneum. No signs of emphysema were seen as well.

One of the limitations for endosurgery is the familiarity with the equipment. Surgeon's ability with the video equipment and technique are determinant factors to surgery length (SANTOS et al., 2018; STRATICÒ et al., 2022). In this study, surgery time was around 40 minutes. For a first-time study, this was an optimal duration. It was enough time to safely perform all steps of cannulation without needing to change or add to the anesthetic protocol.

The silicon foley catheter is flexible and lengthy, and well as thin. The catheter was easily placed into the cecum and its soft nature helped it accommodate with gastrointestinal motility (MEALEY et al., 1995; DIAZ et al., 2010). Latex foley catheters have been used in sheep for rumenostomy in a laparoscopic procedure much like the one performed in this study (SANTOS et al., 2018). The authors state that sheep did not show discomfort with the catheter, like the horses in this study.

Cecum cannulations have been performed before with large rigid cannulas (FIROUZABADI et al., 2017), but reported intestinal content leaking as well as intense

inflammatory processes over the wound. Abomasal cannulas have been used as well (MONTEIRO et al., 2022). Although they are large, their flexible nature might have helped preventing such healing complications.

From the 7th day on, all remaining horses were allowed a morning walk in the paddock, with bandages securing their catheters. None of the catheters loosened or leaked any kind of content. It is important to say that the catheter must remain tightly sealed when not in use for fluid therapy. Air passage may allow ascendent flow of cecum content and the catheter will clog once it dries inside.

Incision related complications are frequent in traditional laparotomies. These complications can result in delay of wound healing. They can also increase treatment costs and hospitalization time. In some cases, it might be fatal (DÓRIA et al., 2020). The size of the incision in this study was smaller than 2 cm and it was sutured around the n. 18 foley catheter. Small size of the wound can be considered an advantage when it comes to healing.

Even though there was no content leaking from the cecum, subcutaneous tissue was in contact with mucosal surface as well as with the foley catheter. Therefore, allowing gut microbiota to interact with tissue around the wound, what could justify the purulent content draining from subcutaneous space in this study. Although, Ferreira et al. (2011) and Monteiro et al. (2022) have also sutured the cecum into the abdominal muscular layer and did not report wound infection. These authors' surgery was a traditional laparotomy with a considerably larger wound.

Removing food and water for 24 hours is standard recommendation for a diversity of standing procedures in horses. This period could be reduced to 18 or 12 hours for laparoscopy (ZEBELI et al., 2015). Cecum cannulation has been performed before with 24 hours of fasting (MONTEIRO et al., 2022), but also with 18 hours (FIROUZABADI et al., 2017), 8 hours (DIAZ et al., 2010) and even without any fasting (TEETER; NELSON; STILLIONS, 1968). None of these studies reported adversities related to the fasting period.

The fact that the fasting was not efficient for one horse in this study could be justified with Horse 6 being a large horse. Zebeli et al. (2015) suggest that, depending on dietary management, bigger horses might need longer fasting periods. However, as this was an experimental study, the fasting period was standardized for all animals.

Horse number 6 was the largest of the seven horses, weighing around 445 kg. All horses were fed in proportion to their weight. Nevertheless, Horse 6 was randomly assigned to the 15 mL kg^{-1} h^{-1} treatment on repetition 1, immediately after surgery. These factors combined could

have been a cause for cecum overweight. The rupture of Horse 6's tiflopexy could have happened because of cecum fluid impactation. This condition is frequently noted in horses that underwent surgical procedures in the gastrointestinal tract. Clinical signs of impactation can be subtle. The condition is often recognized only after systemic symptoms start to show (SHERLOCK, 2019).

Apart from complications found in Horse 6, it is safe to say that this minimally invasive technique is safer and has easier postoperative management and care than a traditional laparotomy. It is still an abdominal surgery and has its risks for horses, although they might occur less frequently. Surgeons must evaluate each animal before deciding which technique to use. Obtained results indicate that horses were in good welfare state throughout experimental period and months after.

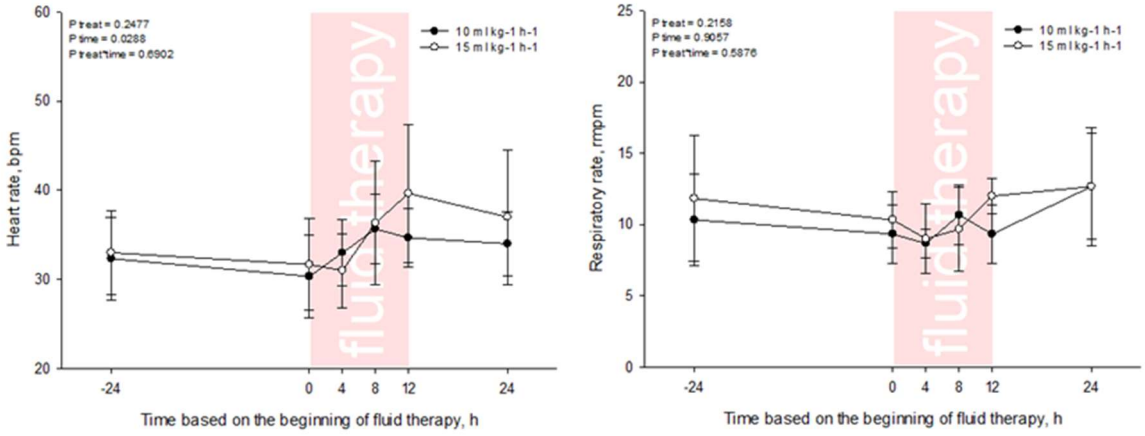
5 INTRACECAL FLUID THERAPY IN HORSES: EFFECTS OVER PHYSICAL AND HEMATOLOGICAL PARAMETERS

5.1 Results

All animals were successfully submitted to both treatments and evaluated at all experimental times. Numerical representations of all data are displayed in Table 2, 3 and 4, available in Addendum 1. Graphical representations show means and standard deviations for variables over experimental times. P values for treatments, time, and treatments over time are also displayed.

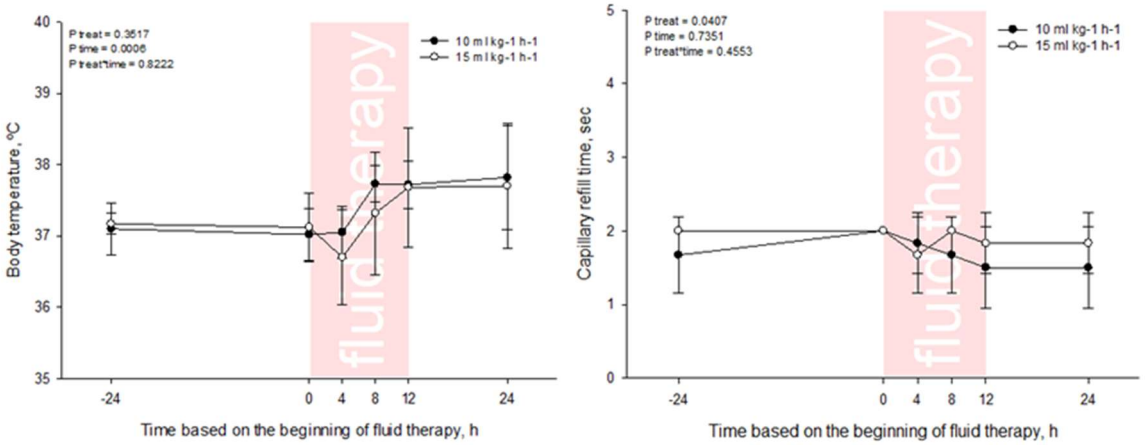
Heart rate had a statistically relevant rise over time ($p=0.0288$), with T8 being the highest moment for treatment 1 and T12 for treatment 2. For this variable, there was no statistical difference between treatments. Respiratory rate did not show any statistical variation (figure 7).

Figure 7. Graphical representation of heart rate and respiratory rate of horses submitted to intracecal fluid therapy with 10 mL kg-1 h-1 and 15 mL kg-1 h-1 rates over experimental time.



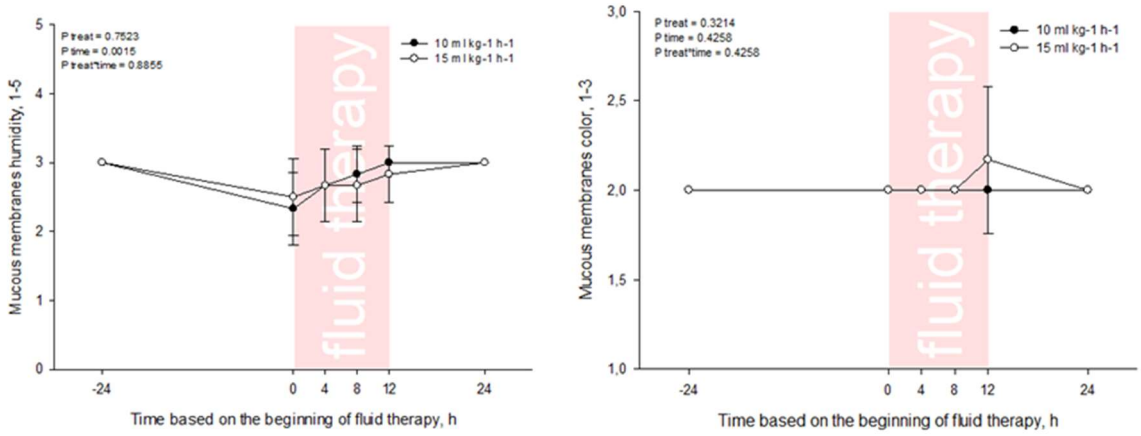
Body temperature had a statistically significant raise over time (p=0.0006), with T12 and T24 being the highest points on both treatments. Capillary refill time did not show significant changes over time neither for different treatments (figure 8).

Figure 8. Graphical representation of body temperature and capillary refill time of horses submitted to intracecal fluid therapy with 10 mL kg-1 h-1 and 15 mL kg-1 h-1 rates over experimental time.



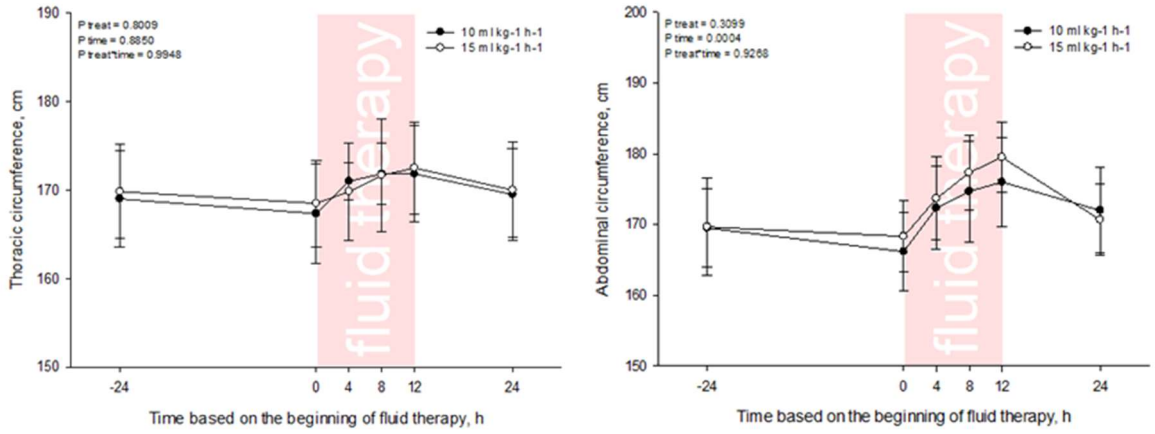
The humidity degree for mucous membranes did show statistically significant alterations over time (p=0.0015), with the humidity lowering at T0 and progressively rising again until T12, then stabilizing until T24. As for mucous membranes color, it did not show any statistically significant differences (figure 9).

Figure 9. Graphical representation of humidity degree and color of mucous membranes of horses submitted to intracecal fluid therapy with 10 mL kg-1 h-1 and 15 mL kg-1 h-1 rates over experimental time.



The changes in thoracic circumference were not statistically relevant. Differently, the changes of abdominal circumference over time have a significance of p=0.0004, with the higher values being at the end of fluid therapy for both treatments (figure 10).

Figure 10. Graphical representation of thoracic and abdominal circumferences of horses submitted to intracecal fluid therapy with 10 mL kg-1 h-1 and 15 mL kg-1 h-1 rates over experimental time.



There were no statistical differences for intestinal motility and feces humidity degree (figure 11). Hematocrit and total serum protein variations did not have statistical significance as well (figure 12).

Figure 11. Graphical representation of intestinal motility and feces humidity degree of horses submitted to intracecal fluid therapy with 10 mL kg-1 h-1 and 15 mL kg-1 h-1 rates over experimental time.

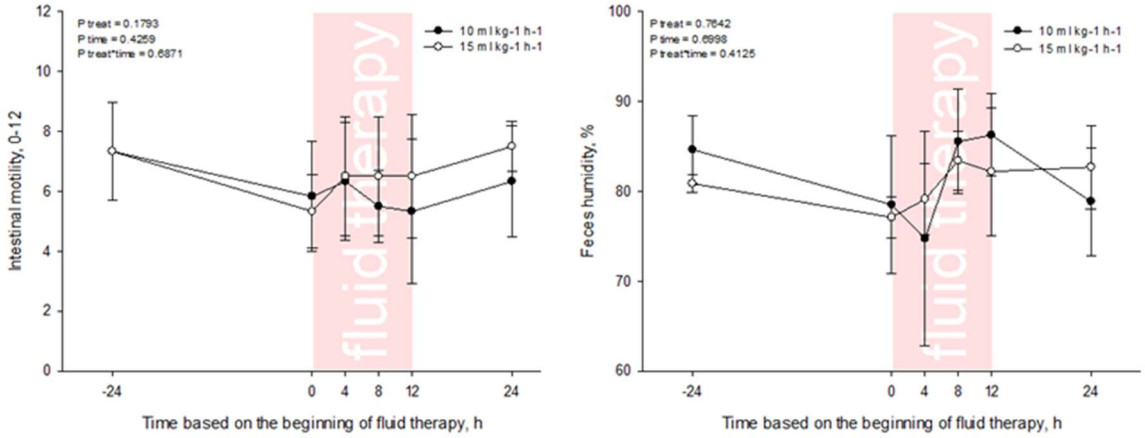
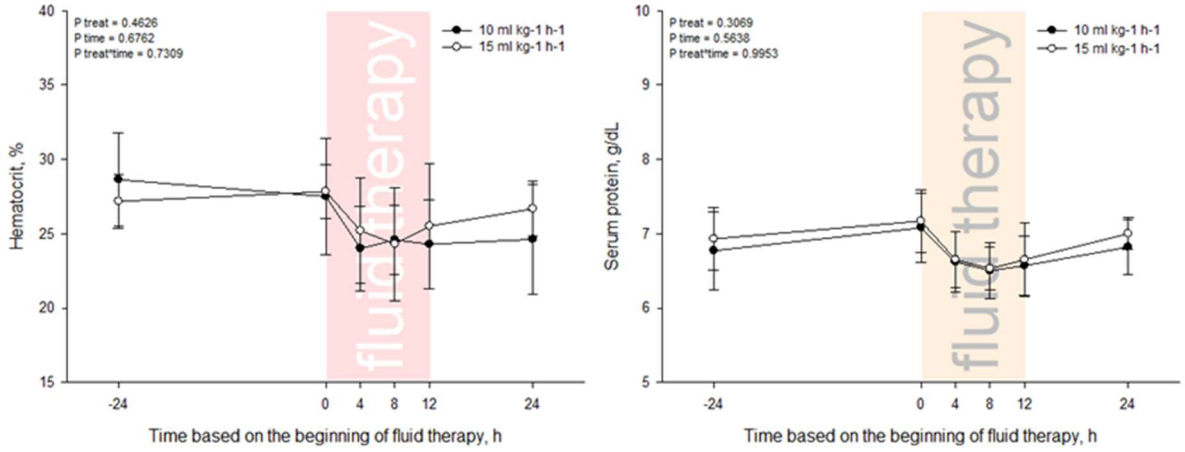


Figure 12. Graphical representation of hematocrit and total serum protein of horses submitted to intracecal fluid therapy with 10 mL kg-1 h-1 and 15 mL kg-1 h-1 rates over experimental time.



5.2 Discussion

Horses have been reported to show abdominal discomfort when submitted to intracecal fluid therapy administered in boluses (FERREIRA et al., 2011). It was expected that the continuous flow administration of the enteral fluid therapy (EFT) would prevent this kind of discomfort from happening. However, a significant increase in abdominal circumference was observed during intracecal fluid therapy in this study.

The abdominal circumference increase happens because enteral electrolyte solutions (EES) need time to be absorbed through intestinal mucosa (DIAS et al., 2019). Horses submitted to nasogastric EFT with different EES also had an increase in abdominal circumference. The authors point out that animals showed behavioral changes related to the discomfort. Despite this, their horses did not have statistically significant changes in heart rate, respiratory rate, and body temperature (RIBEIRO FILHO et al., 2015).

Enlargement of abdominal circumference in horses receiving nasogastric EFT for 8 hours was also reported, without signs of discomfort (DIAS et al., 2019). On the other hand, Ribeiro Filho et al. (2017) did not report any changes in the abdominal circumference for another group of horses submitted to EFT for 12 hours.

The raise observed in heart rate in this study accompanies that of abdominal circumference. However, no animal showed behavior related to abdominal pain, such as digging or looking at the flank. It is possible that heart rate elevation is a product not only of discomfort provoked by abdominal distension. But rather, a combination of this and the environment. The increases in heart rate can be stress related, as described by Ribeiro Filho et al. (2015) in their animals.

During this experiment, the animals were kept in the stalls, without food, and being handled for sample collection every four hours. Besides, the collection times with the higher values for heart rate were T8 and T12. Respectively, these took place at 3:00pm and 7:00pm. Those were the warmest hours of the day, considering climate conditions for geographical location and time of the year. As well, at these times the animals were hit directly by sunlight.

As for body temperature, it also accompanies the raise in abdominal circumference and heart rate. But the elevation remains until T24. The lower temperatures happened when food was withheld and the animals had just started receiving intracecal fluid therapy. When heart rate rises, so does body temperature, also accompanying the environment. When free access to food is returned, the animals started eating and digestive processes occur, which can explain the maintenance of higher body temperatures until T24.

The lowering of mucous membranes humidity degree at T0 corresponds to the 24-hour period where the animals were maintained without food and water. Then, it is possible to see it progressively rising again while the animals were receiving fluid therapy. Dry mucous membranes are one of the physical indicators of dehydration (BYARS; GONDA, 2014). It is safe to assume the proposed fasting was enough to cause mild dehydration. In addition, that

both 10 mL kg^{-1} h^{-1} and 15 mL kg^{-1} h^{-1} rates were efficient in rehydrating the horses, as there was no difference between treatments.

Ribeiro Filho et al. (2015), when administering nasogastric EFT, reported significant increases in intestinal motility, even hypermotility. The authors did not submit their horses to fasting prior to fluid therapy, which might have contributed to the motility pattern found. Nevertheless, the administration of the EES through an esophageal tube into the stomach, rather than the cecum, may have more stimuli over gastrocolic reflexes (GOFF, 2015).

When submitted to 96 hours of intracecal fluid therapy, without access to food, horses were reported to have intestinal hypomotility (FERREIRA et al., 2011). Although the changes of intestinal motility in this study were not statistically significant, it is possible to relate them to the presence or absence of food. The lowering of the gastrointestinal activity accompanies the fasting period, from T-24 to T0. Whereas when the food was returned, from T12 to T24, is possible to see it increasing again. The fact that the animals did not receive food and water (besides that of fluid therapy) for 36 hours (24 prior and 12 during fluid therapy) may also have influenced fecal content.

In this study, neither fasting nor fluid therapy had statistically significant effects over feces humidity degree. Although numerical changes are observed. The same was observed in weaned foals. When submitted to 12 hours of fasting, followed by 12 hours of nasogastric EFT, the foals did not show statistical changes in the degree of feces humidity (MONTEIRO et al., 2020). Horses submitted to nasogastric EFT without prior fasting did not have such changes as well (RIBEIRO FILHO et al., 2015). Differently, horses submitted to a 36-hour dehydration period had a significant reduction in feces humidity. This reduction was efficiently reverted by EFT over 8 hours (DIAS et al., 2022). The significance reached with dehydration might have enabled the differences seen by these authors after the fluid therapy period of their study as well.

Capillary refill time was not affected by dehydration, neither by intracecal fluid therapy administration in this study. Equally, Ribeiro Filho et al. (2015) did not find changes in this variable. On the other hand, Dias et al. (2019) reported that capillary refill time was increased by the dehydration period instituted, and then went back to normal values after 8 hours of EFT.

In this study, the changes in hematocrit and total serum protein (TSP) did not have statistical significances. Although, a rise is observed at T0, which can be related to hemoconcentration, and mild dehydration, caused by fasting period. And a decrease happens for both variables over the time of fluid therapy administration, until T12.

A similar response was reported by Ribeiro Filho et al. (2015) in their study, where the decreases in hematocrit and TSP were considered a signal of blood volume expansion caused by nasogastric EFT. Similarly, ponies submitted to intracecal fluid therapy in boluses over 72 hours were reported to have lowering of hematocrit values (MEALEY et al., 1995). The same pattern happened over the hematocrit and TSP of horses submitted to 36 hours of fasting and 8 hours of nasogastric EFT (DIAS et al., 2019).

It is important to clarify that, in the studies of Dias et al. (2019) and Dias et al. (2022), the fasting was not only 12 hours longer than the one of this study. It was also associated with two administrations of 1mg kg^{-1} of furosemide. Furosemide is a diuretic drug used to intensify urine production, thus helping with dehydration. However, furosemide's mechanism of action can also increase urine excretion of potassium, chloride, and calcium (KOGIKA; YAMATO, 2017), which is why it was not used in this study.

In this study, even for variables that showed statistically significant changes, the means for all times were in between reference ranges for the species (WEISS; WARDROP, 2010; FEITOSA, 2014). Overall, it is safe to say that intracecal fluid therapy was efficient in maintaining or improving hemodynamic status of horses. This was accomplished without generating much discomfort or stress. Similarly, it was reported before with intracecal fluid therapy studies conducted by Mealey et al. (1995) and Ferreira et al. (2011).

6 BIOCHEMICAL, URINARY AND ACID-BASE PROFILE IN HORSES SUBMITTED TO INTRACECAL FLUID THERAPY

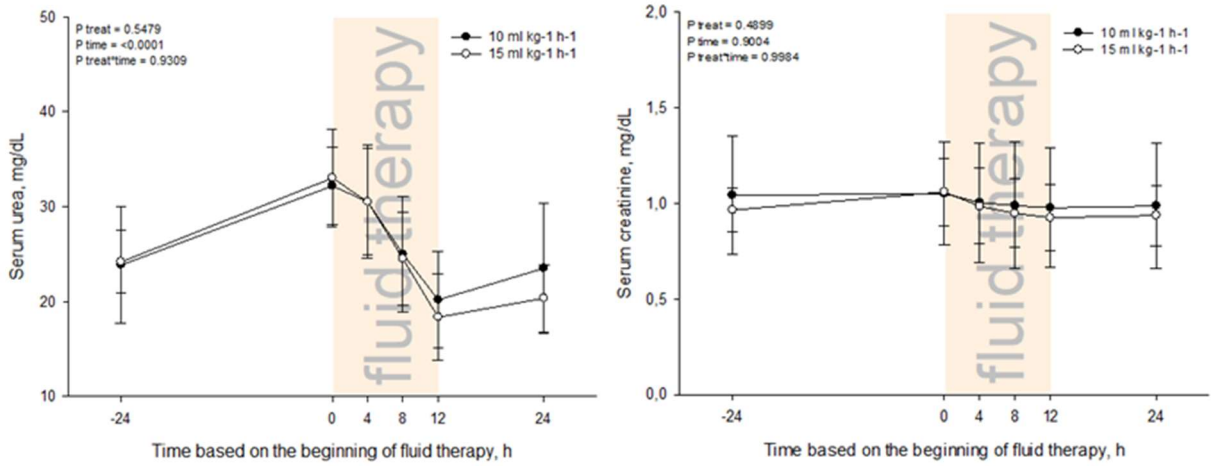
6.1 Results

All animals were successfully submitted to both treatments and evaluated at all experimental times. Numerical representations of all data are displayed in Table 5, 6 and 7, available in Addendum 1. Graphical representations show means and standard deviations for variables over experimental times. P values for treatments, time, and treatments over time are also displayed.

6.1.1 Serum and plasma biochemistry

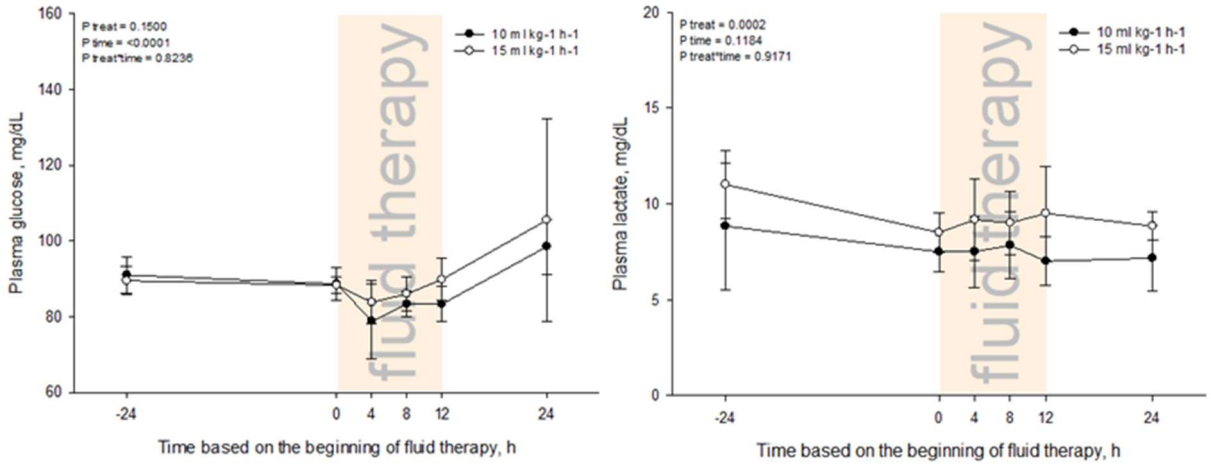
Urea changed significantly over time ($p<0.0001$), with an increase at T0 and decreasing during fluid therapy. Treatments did not have difference for this variable. Creatinine remained stable and showed no variations in any evaluation (figure 13).

Figure 13. Graphical representation of serum urea and creatinine of horses submitted to intracecal fluid therapy with 10 mL kg-1 h-1 and 15 mL kg-1 h-1 rates over experimental time.



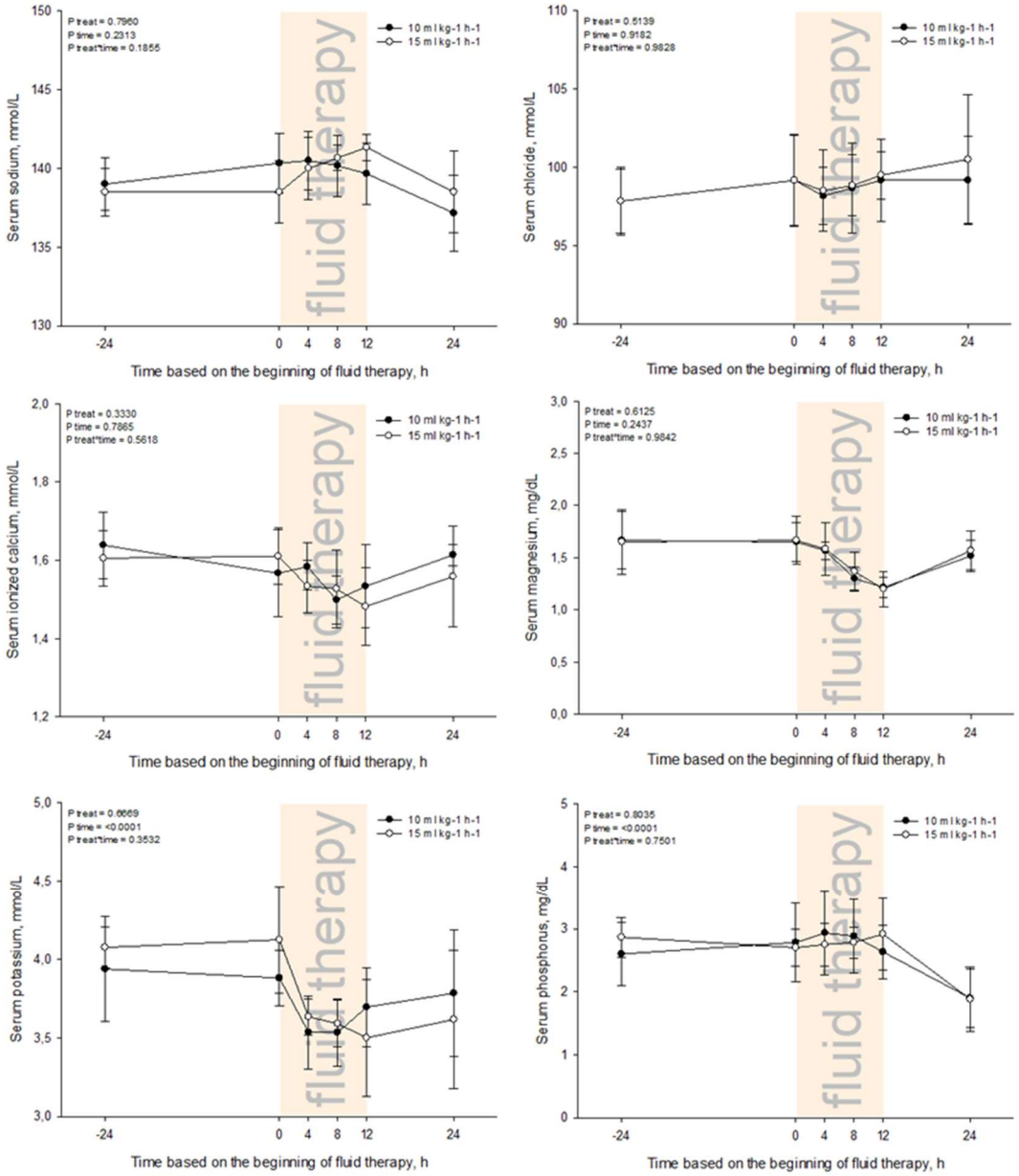
Glucose showed significant variations over time ($p<0.0001$), with highest values at T24 for both treatments. Lactate was always higher ($p=0.0002$) for treatment 2 comparing with treatment 1 but did not show variations over time (figure 14).

Figure 14. Graphical representation of plasma glucose and lactate of horses submitted to intracecal fluid therapy with 10 mL kg-1 h-1 and 15 mL kg-1 h-1 rates over experimental time.



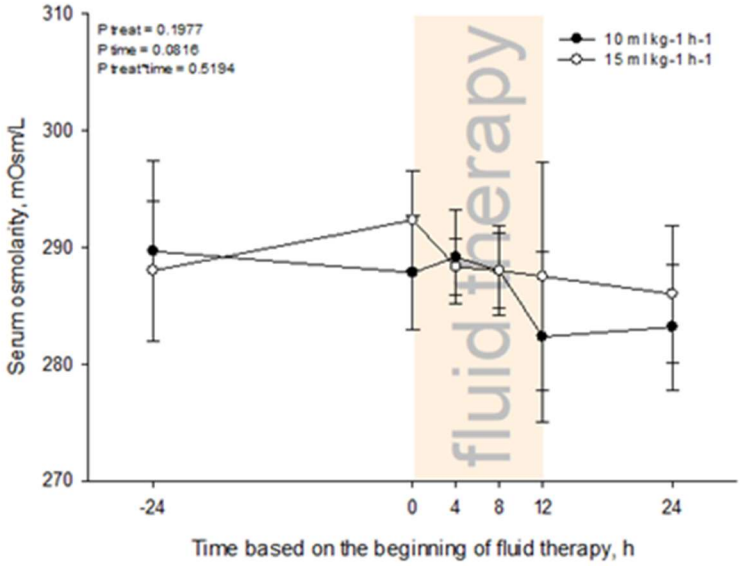
The electrolytes sodium (Na^+), chloride (Cl^-), ionized calcium (iCa^{++}) and magnesium (Mg^{++}) showed no statistical variations in any comparison. The potassium (K^+) significantly changed over time ($p<0.0001$), with visible decrease during fluid therapy. Phosphorus (P) also varied along time ($p<0.0001$), with a decrease after the end of fluid therapy, at T24 (figure 15).

Figure 15. Graphical representation of Na^+, Cl^-, iCa^{++}, Mg^{++}, K^+, and P of horses submitted to intracecal fluid therapy with 10 mL kg^{-1} h^{-1} and 15 mL kg^{-1} h^{-1} rates over experimental time.



Serum osmolarity did not present statistically significant variations over time, neither when comparing treatments (figure 16).

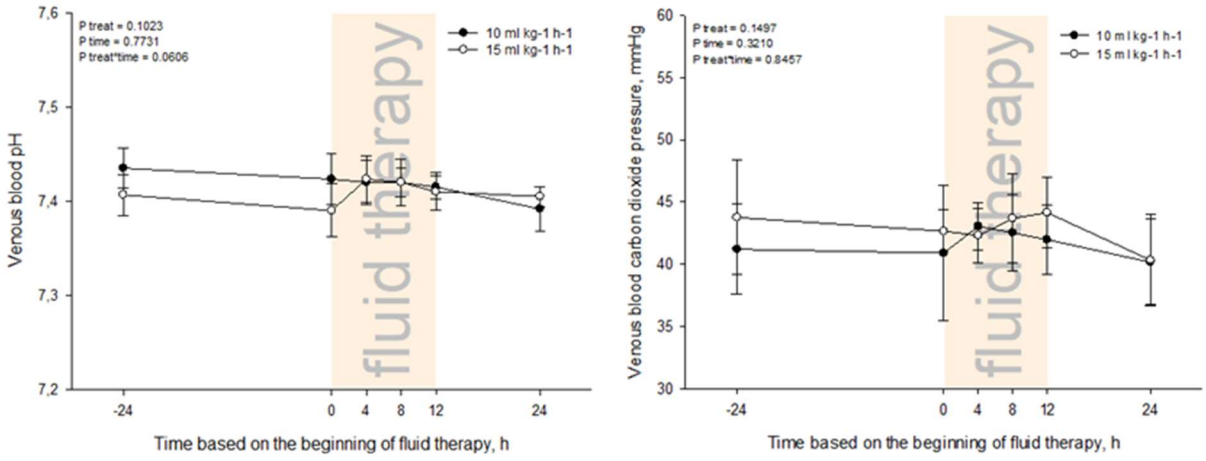
Figure 16. Graphical representation for serum osmolarity of horses submitted to intracecal fluid therapy with 10 mL kg-1 h-1 and 15 mL kg-1 h-1 rates over experimental time.



6.1.2 Venous blood gas analysis

Values of venous blood pH and carbon dioxide pressure (pCO_2) did not show statistically significant variations over experimental time, neither when comparing treatments (figure 17).

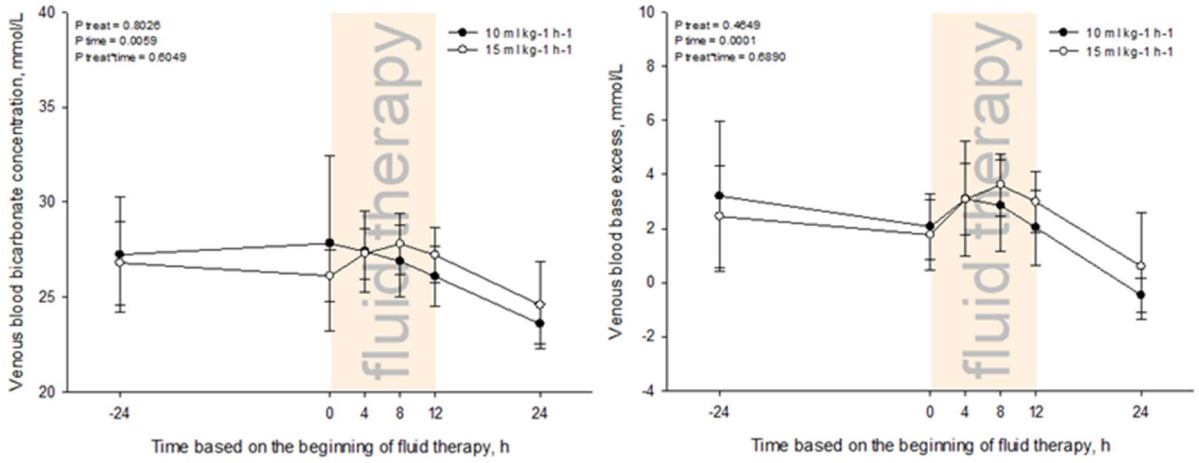
Figure 17. Graphical representation for venous blood pH and pCO_2 of horses submitted to intracecal fluid therapy with 10 mL kg-1 h-1 and 15 mL kg-1 h-1 rates over experimental time.



Bicarbonate concentration (HCO_3^-) and base excess (BE) presented significant differences over time, with p values of p=0.0059 and p=0.0001, respectively. Both variables

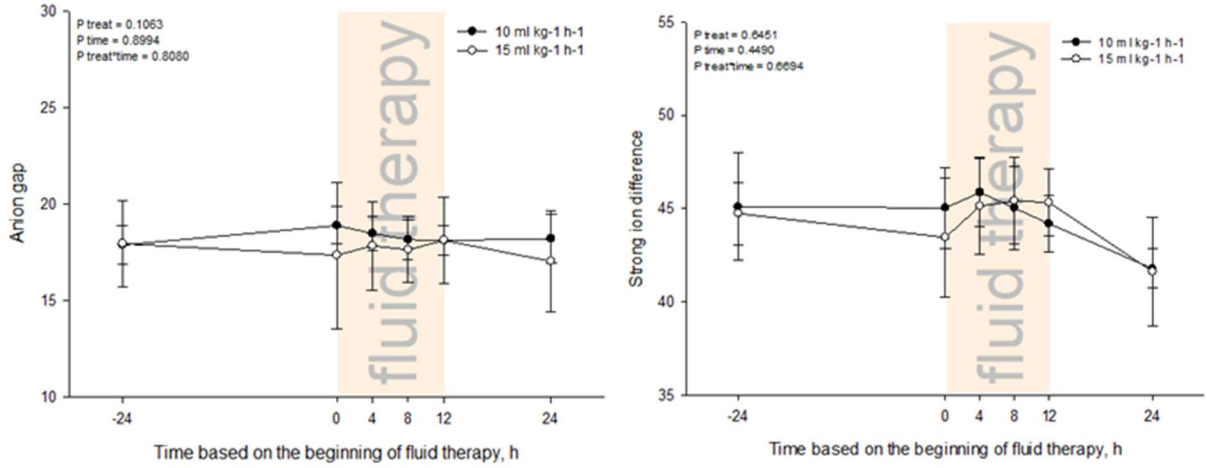
showed decreasing means over time starting at T8 and continuing after the ending of the treatment (figure 18).

Figure 18. Graphical representation for venous blood HCO_3^- and BE of horses submitted to intracecal fluid therapy with 10 mL kg-1 h-1 and 15 mL kg-1 h-1 rates over experimental time.



The calculated results for anion gap (AG) and strong ion difference (SID) did not show statistical significance in changes over time, neither when comparing treatments (figure 19).

Figure 19. Graphical representation for venous blood AG and SID of horses submitted to intracecal fluid therapy with 10 mL kg-1 h-1 and 15 mL kg-1 h-1 rates over experimental time.



6.1.3 Urinalysis and urine biochemistry

Figure 20 illustrate the color of collected urine samples before being submitted to laboratorial analysis. It was a visible marker of urine dilution. Still, as this qualitative data was

not registered before processing the samples for laboratorial analysis, it could not be submitted to statistics. Urine specific gravity showed a decrease over time during fluid therapy period, but it did not have statistical significance. On the other hand, the changes in urine pH were significant (p=0.0008). It is possible to see a decrease in pH values after fasting, followed by an increase during fluid therapy period and then another decrease after treatment, from T12 to T24 (figure 21).

Figure 20. Changes in urine color over time in a horse submitted to intracecal fluid therapy with a 15 mL kg-1 h-1 infusion rate.

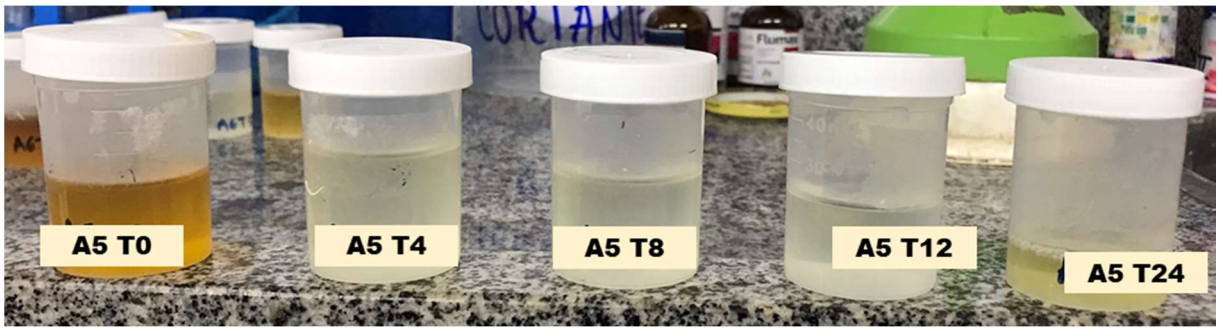
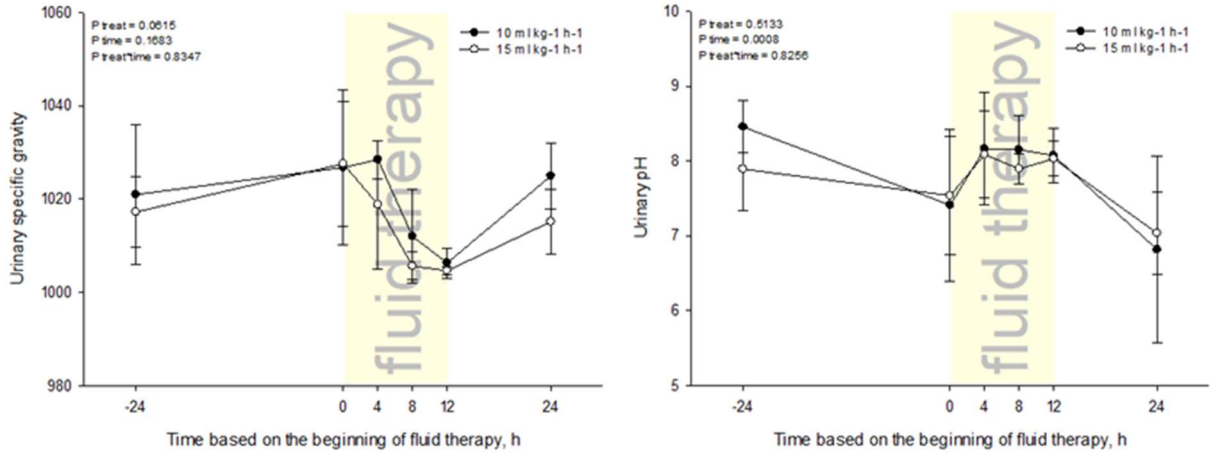


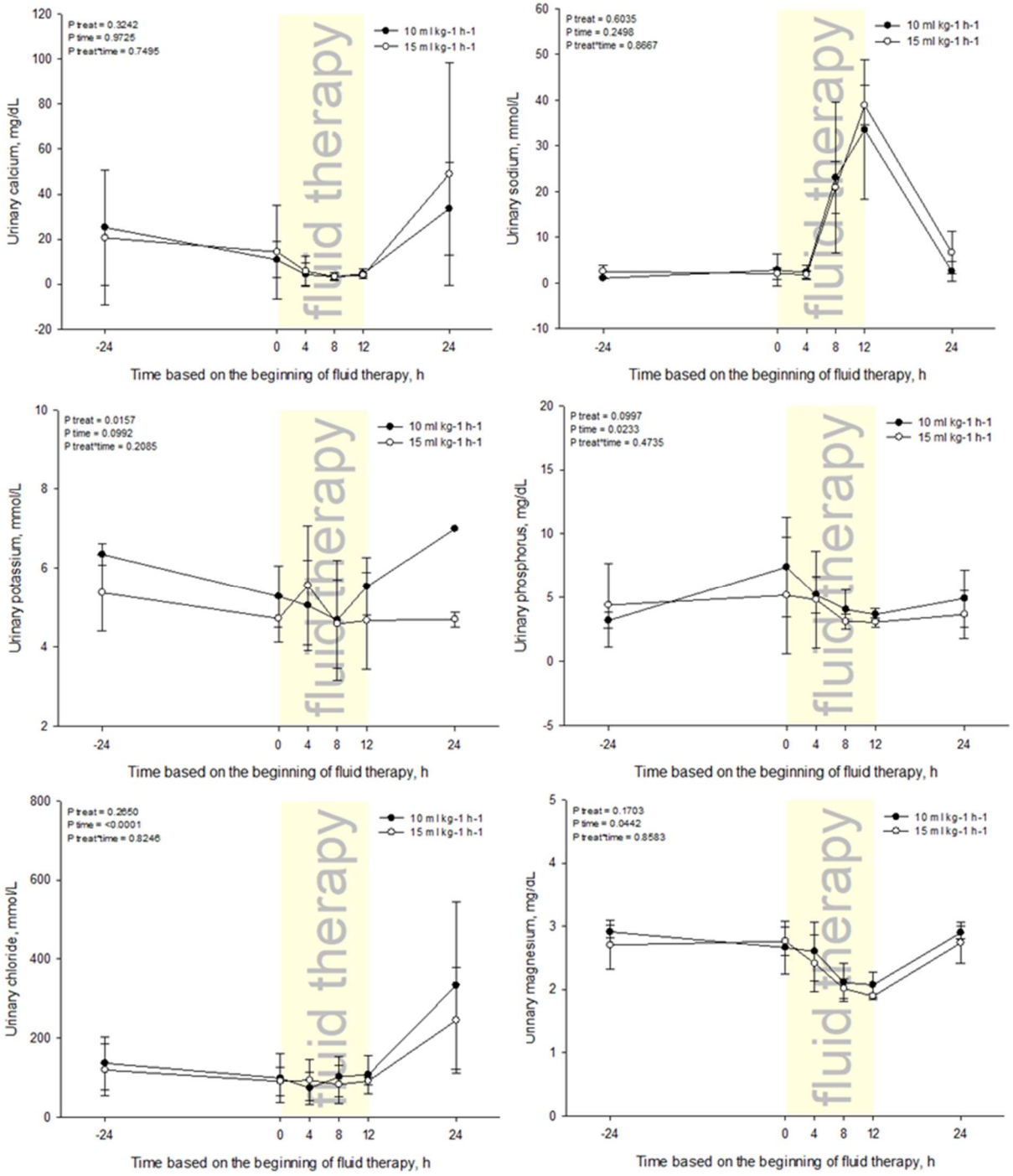
Figure 21. Graphical representation for urinary specific gravity and pH of horses submitted to intracecal fluid therapy with 10 mL kg-1 h-1 and 15 mL kg-1 h-1 rates over experimental time.



The excretion of ionized calcium (iCa^{++}) raises after the end of fluid therapy and sodium (Na^{+}) excretion increased during fluid therapy, both without statistical significance. Potassium (K^{+}) was statistically different when comparing treatments (p=0.0157), experimental times T-24 and T24 were higher for treatment 1 in comparison with treatment 2. Phosphorus (P_i) and chloride (Cl^{-}) had variations over time (p=0.0233 and p<0.0001, respectively). Chloride showed

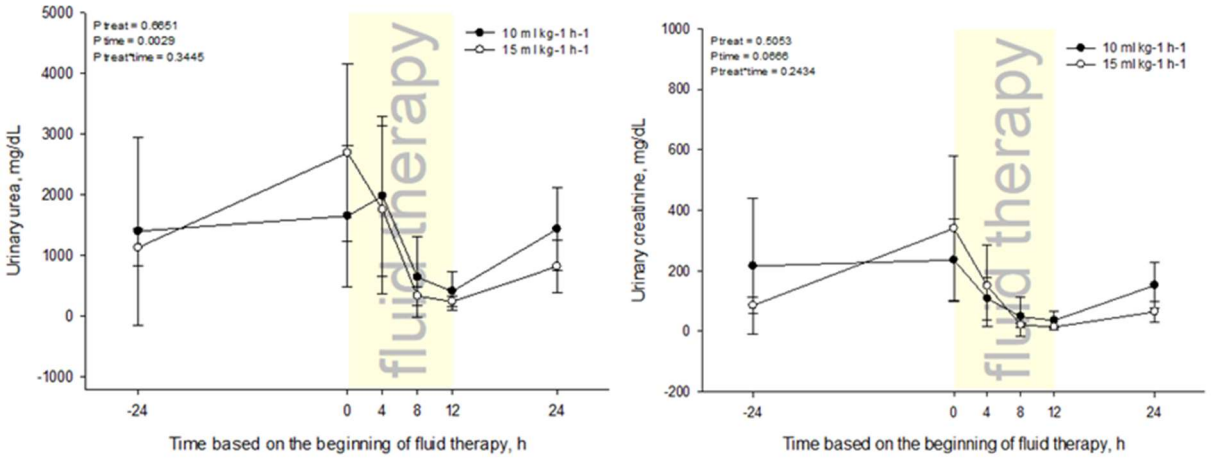
highest values at T24 for both treatments. Magnesium (Mg^{++}) also showed statistical (p=0.0442) variations over time (figure 22).

Figure 22. Graphical representation for urinary Ca^{++}, Na^{+}, K^{+}, P_i, Cl^{-}, and Mg^{++} of horses submitted to intracecal fluid therapy with 10 mL kg-1 h-1 and 15 mL kg-1 h-1 rates over experimental time.



Urea concentration significantly changed over time (p=0.0029), with notable decrease during fluid therapy period. Creatinine changes over time were not significant (figure 23).

Figure 23. Graphical representation for urinary urea and creatinine of horses submitted to intracecal fluid therapy with 10 mL kg-1 h-1 and 15 mL kg-1 h-1 rates over experimental time.



6.2 Discussion

The maintenance of serum osmolarity within reference values (CARLSON; BRUSS, 2008) was an expected result. This implies that horses' renal functions were working in order to maintain hemodynamic balance. Dias et al. (2021) reported hemoconcentration with higher serum osmolarity values after 36 hours of fasting. Although, these authors used furosemide within their dehydration protocol, which may be the reason for such alterations. Osmolarity maintenance can be correlated with the lowering in urinary specific gravity.

A numerical decrease is observed in specific gravity over fluid therapy period, although not statistically significant. Urine specific gravity lowering is a direct indicator of hydration status, hemodilution and urine dilution. Specific gravity lowering was reported in a variety of studies with adult horses and foals submitted to enteral fluid therapy (RIBEIRO FILHO et al., 2015; RIBEIRO FILHO et al., 2017; MONTEIRO et al., 2020; DIAS et al., 2021). This absence of significance is probably a result of individual variations that enlarge standard deviation. However, urine dilution was visible when collecting the samples after spontaneous urinations, as shown in figure 20.

Serum creatinine remained always a little lower than reference ranges. Although not pathological, this may indicate a need to increase protein supplementation into dietary

management (BRAUN; LEFEBVRE, 2008). Serum urea presented an elevation after the fasting period, and then a decrease during fluid therapy. The only moment were urea values were out of reference ranges was at T0. This is an indication of the dehydration suffered within the 24 hours of fasting, as well as of the hemodilution provoked during intracecal fluid therapy (BRAUN; LEFEBVRE, 2008).

Similar changes were found in studies with horses receiving EFT (RIBEIRO FILHO et al., 2015; RIBEIRO FILHO et al., 2017; DIAS et al., 2021). Horses' hydration status was even maintained until T24, which is 12 hours after the end of treatments. It is notable that the final values are still lower than the initial ones, thus reaffirming the hydration potential of intracecal fluid therapy.

Urinary excretion of urea and creatinine decreased over time, especially during fluid therapy. This was reported before in horses receiving enteral fluid therapy (RIBEIRO FILHO et al., 2017). Though only urea changes were statistically significant, both variables are an indicator of urine dilution (BRAUN; LEFEBVRE, 2008) caused by the administration of the enteral electrolyte solution (EES). Dias et al. (2021) described similar results for urea serum concentration and urea urinary excretion. Both for dehydration and fluid therapy effects.

All horses of this study underwent 36 hours of fasting (24h prior to and 12h during the treatment). Although significant, the variations over time in glucose levels were always within reference ranges (KANEKO, 2008). Hypoglycemia was not observed in any horse. This may suggest that hindgut microbiota efficiently processed the energy source provided by the solutions. Gomes et al. (2014a) and Dias et al. (2021) affirm that nasogastric administration of EES was also efficient in restoring and maintaining plasma glucose levels of horses.

In addition, the glucose peak seen in T24 for both treatments corresponds to the evaluation performed after the return of food access. Foals submitted to 12 hours of fasting were reported to have lowered values of glucose. The foals received nasogastric enteral fluid therapy (EFT) for 12 hours and efficiently recovered their glucose levels (MONTEIRO et al., 2022b).

The fact that treatment 2 had all values for lactate higher than treatment 1 is much likely a mathematical situation, rather than a clinical one. Especially, since the differences started at T-24, before the animals were even submitted to treatments, and lasted without variations until T24. Nevertheless, lactate values for both treatments were within reference ranges (KANEKO; HARVEY; BRUSS, 2008) at all times. Similar lactate results were described in adult horses (RIBEIRO FILHO et al., 2014) and in foals (MONTEIRO et al., 2022b) submitted to EFT with

different compositions. The finding indicates that the provoked dehydration was not too intense as to instigate anaerobic metabolism (DIAS et al., 2021).

Serum Na^+ showed no significant variations during the experiment and all values were within reference ranges (CARLSON; BRUSS, 2008). Unaltered serum sodium concentrations were also found in horses submitted to a 36 hours dehydration protocol (DIAS et al., 2021). These horses then received three fluid therapy treatments, two EES and Lactate Ringer. Like in this study, all treatments used by Dias et al. (2021) efficiently rehydrated horses without changing serum sodium statuses.

Despite not having statistical significance, a big raise is observed in Na^+ urinary excretion during fluid therapy. Foals submitted to EFT for 12 hours showed an increase in urinary sodium excretion (MONTEIRO et al., 2020). Adult horses had sodium excretion increased by dehydration protocol, but also by fluid therapy with Lactate Ringer (DIAS et al., 2021). Differently, urine excretion of sodium in horses that receive three EES with various carbohydrate precursors did not change (RIBEIRO FILHO et al., 2017)

Sodium is highly absorbed through cecum and colon mucosal surfaces (FIELDING, 2015d). Which means the Na^+ present in the EES could have been entirely absorbed by the animals. In order to maintain blood balance, the kidneys need to regulate Na^+ via urine excretion (FIELDING, 2015d). Horses are very good in reabsorbing Na^+ (SCHOTT II; ESSER, 2020). This means the increased excretion was probably due to its' concentration in the EES. This finding signalizes that the amount of Na^+ in the formulation could be lowered over next studies.

Serum Cl^- did not have statistically significant variations, remaining always within reference ranges (FIELDING, 2015b). Differently, horses submitted to dehydration protocol with furosemide showed significantly decreased serum Cl^- values. The authors credit this finding to the effect of furosemide. Moreover, they claim both EFT and intravenous fluid therapy were able to bring values back to normal (DIAS et al., 2021). Cl^- is absorbed in several portions of the large intestine along with sodium. In addition, kidneys will reabsorb about 90% of Cl^- that goes under glomerular filtration (CARLSON; BRUSS, 2008; FIELDING, 2015b).

In this study, urinary excretion of Cl^- was constant for most experimental times, but suffered a considerable increase at the last evaluation, 12 hours after the end of intracecal fluid therapy. Even with the extensive urinary excretion of Cl^- at T24, it is possible to see a slight increase of its serum concentration at the same time. This could be related to the high concentration of Cl^- in the formulation, as reported before for other experiments with EES (GOMES et al., 2014b; RIBEIRO FILHO et al., 2014). Some fluids administration increase

serum concentration as well as renal excretion of Cl^- (FIELDING, 2015d; PALMER, 2015). Horses that received 8 hours of Lactate Ringer were also reported to have increased urinary excretion of Cl^- in order to balance the large amount of this electrolyte in the solution (DIAS et al., 2021).

Serum iCa^{++} values remained within reference ranges (AGUILERA-TEJERO, 2015) and did not change over time. This indicates the iCa^{++} composition of the EES was satisfactory. Dias et al. (2021) reported the same, when EES were more efficient in restoring iCa^{++} serum concentrations of horses than Lactate Ringer. Horses are highly efficient in absorbing iCa^{++} through their intestines; and around 75% of dietary calcium is absorbed. Any excesses are excreted in urine (AGUILERA-TEJERO, 2015; MULLEN, 2022).

During fluid therapy, the values for iCa^{++} urinary excretion were uniform for all horses. However, at T-24 and T24 the standard deviations expand. This iCa^{++} urinary excretion elevation, although not statistically significant, might be a response to food ingestion behavior of the horses (AGUILERA-TEJERO, 2015; MULLEN, 2022). Since the administration of the solution was controlled, but the food was offered in the trough.

Serum Mg^{++} concentrations were always below reference ranges (CARLSON; BRUSS, 2008) and even suffered a slight decrease during fluid therapy, although not statistically significant. Serum Mg^{++} usually relates to dietary management. Around 60% of its absorption happens in the small intestine, whereas only 5% in the large intestine (STEWART, 2015). Based on this, it is safe to assume the supplementation of Mg^{++} via intracecal fluid therapy may not be as successful as via nasogastric EFT. Previous studies reported the need to increase Mg++ concentrations of EES (RIBEIRO FILHO et al, 2014). Like in this study, Dias et al. (2021) reported that both EES used by the authors, as well as Lactate Ringer, did not have sufficient Mg^{++} in their compositions to supplement fastened horses.

On the other hand, the curve for Mg^{++} urine excretion follows the exact same pattern as serum concentration, suggesting that maintenance of tightly balanced conditions. Another hypothesis might be that literature reference ranges are not representative for this study's population, as there was no clinical manifestation of hypomagnesemia. Since the renal reabsorption of Mg^{++} is around 80% (STEWART, 2015), if the animals were in need of this electrolyte, the renal excretion should have been progressively reducing.

Serum concentration of K^+ suffered a considerable decrease during fluid therapy. Anorectic horses usually present with hypokalemia (MULLEN, 2022). The values for K^+ in this study suggest that intracecal fluid therapy was not sufficient to maintain blood levels, as

the horses underwent 36 hours without food. Ribeiro Filho et al. (2014) also suggest the use of higher K^+ concentrations in EES for anorectic animals.

Horses submitted to a similar fasting period also showed decreased values of K^+ (DIAS et al., 2021). However, differently from this study, the K^+ concentration of those horses was efficiently restored by fluid therapy, since Dias et al. (2021) used nasogastric and intravenous routes. This must be related to the fact that the absorption of K^+ happens mainly in the small intestines rather than the large (FIELDING, 2015c). Regardless the decreasing, K^+ values remained within the reference ranges at all times (CARLSON; BRUSS, 2008).

As for urinary excretion, there were significant differences between treatments, mainly at T-24 and T24. When horses are submitted to long periods without food, renal reabsorption of K^+ is increased (SCHOTT II; ESSER, 2020), this may explain why the excretion of this electrolyte was decreased at T0 and then increased again after food was returned. Ribeiro Filho et al. (2017) attribute the lowering in K^+ excretion found during fluid therapy in their study to urine dilution, therefore resulting in decreased K^+ urine concentration.

Serum P_i concentrations found in this study were always under reference ranges for horses (CARLSON; BRUSS, 2008). Since the EES used for treatments did not contain a phosphorus provider, the changes in this element are due to its interaction with other electrolytes. They are also related to hemoconcentration or hemodilution (RIBEIRO FILHO et al., 2014; DIAS et al., 2021). Significant changes in P_i concentrations happened after the end of fluid therapy, with a decrease between T12 and T24.

Animals that have low values of Mg^{++} usually have low P_i as well, due to the closeness of these electrolytes' metabolism (TORIBIO, 2015). This study's findings are in correspondence with the affirmation. The kidneys are the primarily regulators of P_i excretion and reabsorption (TORIBIO, 2015). The curve pattern for urine excretion of P_i is opposing the one for serum. Meaning that whenever blood values of P_i were low, renal excretion of this electrolyte reduced.

Venous blood pH and pCO_2 remained within reference ranges and did not differ statistically (CARLSON; BRUSS, 2008). Concentration of HCO_3^- and BE significantly decreased in both treatments. Starting at the 8th hour of fluid therapy and until 12 hours after. The mobilization of the buffering system in order to regulate pH may be the answer to this. The organism's mechanism for regulation of acid-base status is highly sensitive (PALMER, 2015).

As mentioned before, it is possible that Cl^- intake with the EES was too great. In addition, the administration of EES containing carbohydrates may lead to gut microbiota fermentation

and subsequently organic acid production. This could justify the organism need to recruit HCO_3^- (GOMES et al., 2014b). Still, the only moment where HCO_3^- and BE were under reference ranges (CARLSON; BRUSS, 2008) was at T24.

When submitted to fasting for 12 hours, weaning foals had significant increases in blood pH values. The author affirms this was caused by dehydration, and HCO_3^- retention, in response to hypochloremia. In addition, they had increases in pCO_2, as a compensatory mechanism for the mild blood alkalemia (MONTEIRO et al., 2022b).

Urinary pH changes are expected as the kidneys work towards maintenance of acid-base balance. Kidneys achieve this by regulating excretion and absorption of many components (SCHOTT II; ESSER, 2020). One of the major mechanisms is the control of H^+ and Cl^- excretion and reabsorption (PALMER, 2015). The pattern seen in this study, where urinary pH decreases, Cl^- excretion is intensified, and blood HCO_3^- reduces (all at T24) remembers that of renal tubular acidosis (PALMER, 2015).

However, as there were no findings indicating renal disease in the horses, it is likely that this was an attempt to regulate acid-base balance. For instance, mild aciduria may occur as a result of H^+ excretion regulatory mechanism (DIAS et al., 2021). EES with different carbohydrates did not change significantly the urine pH of adult horses (RIBEIRO FILHO et al., 2015), although they were capable of causing mild aciduria.

Since the majority of components used for calculations of AG and SID did not have statistical variation, it was expected that these variables would have the same behavior. Although, SID has a slight reduction at T24, at the same moment where Cl^- is at its highest value. Decreases in SID values usually relate to Cl^- and its contribution do acidification (PALMER, 2015).

7 CONCLUSIONS

These conclusions make inferences about the two main problems addressed: 1) video assisted cecum cannulation for fluid therapy in horses: minimally invasive technique and 2) intracecal fluid therapy in horses: effects over physical and hematological parameters and biochemical, urinary and acid-base profile.

Therefore, the described technique is suitable for manipulation and cannulation of the cecum, in addition to being safe for the animals. It can be performed more quickly than traditional laparotomy and is relatively safer. In addition, it allows the immediate postoperative use of the intracecal route for fluid administration, where the catheter can be left in place for long periods with proper care to maintain the surgical wound.

Administration of intracecal enteral electrolyte solution does not cause harmful physical changes. Both infusion rates, 10 mL kg^{-1} h^{-1} and 15 mL kg^{-1} h^{-1}, are clinically safe in terms of clinical estimates. The proposed intracecal enteral electrolyte solution is efficient for restoring blood volume, without causing acid-base imbalances, in addition to promoting urine dilution and an increase in stool moisture.

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ADDENDUM 1

Table 2. Mean values ± standard deviation for heart rate (HR), respiratory rate (RR), body temperature (BT), thoracic circumference, abdominal circumference, mucous membranes humidity (MMH), mucous membranes color (MMC), capillary refill time (CRT), intestinal motility (IM) and feces humidity (FH) in horses submitted to enteral fluid therapy in continuous flow via intracecal route.

VARIABLE	INFUSION RATE	TIME					
		T-24h	T0h	T4h	T8h	T12h	T24h
HR bpm	10 mL kg^{-1} h^{-1}	32,33 ± 4,63 bc	30,33 ± 4,63 c	33 ± 3,74 bc	35,67 ± 3,88 bac	34,67 ± 3,27 bac	34 ± 3,58 bac
	15 mL kg^{-1} h^{-1}	33 ± 4,69 bc	31,67 ± 5,13 bc	31 ± 5,13 bc	36,33 ± 6,98 bac	39,67 ± 7,74 a	37 ± 7,56 ba
RR rmpm	10 mL kg^{-1} h^{-1}	10,33 ± 3,2 a	9,33 ± 2,07 a	8,67 ± 1,03 a	10,67 ± 2,07 a	9,33 ± 2,07 a	12,67 ± 3,72 a
	15 mL kg^{-1} h^{-1}	11,83 ± 4,40 a	10,33 ± 1,97 a	9 ± 2,45 a	9,67 ± 2,94 a	12 ± 1,26 a	12,67 ± 4,13 a
BT ºC	10 mL kg^{-1} h^{-1}	37,1 ± 0,36 bdc	37,02 ± 0,36 d	37,05 ± 0,36 dc	37,73 ± 0,26 ba	37,72 ± 0,33 ba	37,82 ± 0,73 a
	15 mL kg^{-1} h^{-1}	37,17 ± 0,15 bdac	37,12 ± 0,48 bdc	36,7 ± 0,66 d	37,32 ±0,86 bdac	37,68 ± 0,84 bac	37,7 ± 0,87 bac
Th. Circ. cm	10 mL kg^{-1} h^{-1}	169 ± 5,44 a	167,33 ± 5,61 a	171 ± 2,1 a	171,83 ± 3,49 a	171,83 ± 5,46 a	169,5 ± 5,21 a
	15 mL kg^{-1} h^{-1}	169,83 ± 5,31 a	168,5 ± 4,89 a	169,83 ± 5,46 a	171,67 ± 6,38 a	172,5 ± 5,21 a	170 ± 5,37 a
Ab. Circ. cm	10 mL kg^{-1} h^{-1}	169,5 ± 5,5 dec	166,17 ± 5,6 e	172,33±5,85bdec	174,67±7,12bdac	176 ± 6,32 bac	172 ± 6,07 bdec
	15 mL kg^{-1} h^{-1}	169,67 ± 6,89 dec	168,33 ± 4,97 de	173,67±5,85bdac	177,33 ± 5,32 ba	179,5 ± 4,89 a	170,67±5,01bdec
MMH 1-3	10 mL kg^{-1} h^{-1}	3 ± 0 a	2,33 ± 0,52 c	2,67 ± 0,52 bac	2,83 ± 0,41 ba	3 ± 0 a	3 ± 0 a
	15 mL kg^{-1} h^{-1}	3 ± 0 a	2,5 ± 0,55 bc	2,67 ± 0,52 bac	2,67 ± 0,52 bac	2,83 ± 0,41 ba	3 ± 0 a
MMC 1-3	10 mL kg^{-1} h^{-1}	2 ± 0 b	2 ± 0 b	2 ± 0 b	2 ± 0 b	2 ± 0 b	2 ± 0 b
	15 mL kg^{-1} h^{-1}	2 ± 0 b	2 ± 0 b	2 ± 0 b	2 ± 0 b	2,17 ± 0,41 a	2 ± 0 b
CRT sec	10 mL kg^{-1} h^{-1}	1,67 ± 0,52 a	2 ± 0 a	1,83 ± 0,41 a	1,67 ± 0,52 a	1,5 ± 0,55 a	1,5 ± 0,55 a
	15 mL kg^{-1} h^{-1}	2 ± 0 a	2 ± 0 a	1,67 ± 0,52 a	2 ± 0 a	1,83 ± 0,41 a	1,83 ± 0,41 a
IM 4-12	10 mL kg^{-1} h^{-1}	7,33 ± 1,63 ba	5,83 ± 1,83 ba	6,33 ± 1,97 ba	5,5 ± 1,22 ba	5,33 ± 2,42 b	6,33 ± 1,86 ba
	15 mL kg^{-1} h^{-1}	7,33 ± 1,63 ba	5,33 ± 1,21 ba	6,5 ± 1,97 ba	6,5 ± 1,97 ba	6,5 ± 2,07 ba	7,5 ± 0,84 a
FH %	10 mL kg^{-1} h^{-1}	84,63 ± 3,77 a	78,51 ± 7,63 a	74,74 ± 11,88 a	85,53 ± 5,83 a	86,27 ± 4,57 a	78,86 ± 5,98 a
	15 mL kg^{-1} h^{-1}	80,86 ± 0,98 a	77,1 ± 2,31 a	79,13 ± 4 a	83,4 ± 3,33 a	82,2 ± 7,13 a	82,69 ± 4,65 a

Table 3. Mean values ± standard deviation for red blood cells (RBC), hemoglobin (Hb), hematocrit (Ht), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), total protein (TP), fibrinogen (Fb) and platelets (Plt) in horses submitted to enteral fluid therapy in continuous flow via intracecal route.

VARIABLE	INFUSION RATE	TIME					
		T-24H	T0H	T4H	T8H	T12H	T24H
RBC 10^6	10 mL kg^{-1} h^{-1}	6,11 ± 0,40 ba	6,03 ± 0,27 a	5,38 ± 0,59 bc	5,22 ± 0,29 bc	5,21 ± 0,55 c	5,49 ± 0,29 bac
	15 mL kg^{-1} h^{-1}	5,65 ± 0,49 bac	5,83 ± 0,77 ba	5,35 ± 0,72 bc	5,11 ± 0,79 c	5,27 ± 0,83 c	5,54 ± 0,51 bac
Hb g dL^{-1}	10 mL kg^{-1} h^{-1}	9,62 ± 1,01 bac	9,87 ± 0,86 a	8,78 ± 0,84 bac	8,32 ± 0,82 bc	8,28 ± 0,93 c	8,67 ± 0,89 bac
	15 mL kg^{-1} h^{-1}	9,5 ± 1 bac	9,68 ± 1,12 ba	8,7 ± 0,72 bac	8,28 ± 1 bc	8,43 ± 1,17 c	9,2 ± 0,73 bac
Ht %	10 mL kg^{-1} h^{-1}	28,63 ± 3,15 a	27,5 ± 3,94 a	24 ± 2,83 a	24,58 ± 2,33 a	24,28 ± 2,97 a	24,62 ± 3,68 a
	15 mL kg^{-1} h^{-1}	27,17 ± 1,83 a	27,83 ± 1,83 a	25,2 ± 3,52 a	24,3 ± 3,8 a	25,5 ± 4,18 a	26,67 ± 1,86 a
MVC fL	10 mL kg^{-1} h^{-1}	43,32 ± 3,09 a	43,87 ± 3,17 a	44,02 ± 3,42 a	42,13 ± 2,59 a	41,5 ± 1,08 a	42,42 ± 2,93 a
	15 mL kg^{-1} h^{-1}	44,13 ± 4,25 a	44,2 ± 3,87 a	44,18 ± 3,91 a	43,58 ± 4,03 a	41,78 ± 1,09 a	42,4 ± 2,95 a
MCH pg	10 mL kg^{-1} h^{-1}	15,93 ± 0,93 a	16,7 ± 1,24 a	16,37 ± 0,99 a	15,9 ± 1,02 a	15,87 ± 0,94 a	15,92 ± 0,89 a
	15 mL kg^{-1} h^{-1}	16,85 ± 1,78 a	16,95 ± 1,05 a	16,78 ± 0,99 a	16,68 ± 1,03 a	16,33 ± 1,07 a	16,63 ± 1,44 a
MCHC g dL^{-1}	10 mL kg^{-1} h^{-1}	36,9 ± 2,49 a	37,37 ± 3,25 a	36,92 ± 2,52 a	37,93 ± 3,09 a	38,38 ± 1,95 a	37,33 ± 3,25 a
	15 mL kg^{-1} h^{-1}	38,45 ± 3,39 a	38,2 ± 4,45 a	37,17 ± 3,71 a	37,77 ± 3,76 a	38,58 ± 3,62 a	39,4 ± 3,75 a
TP g dL^{-1}	10 mL kg^{-1} h^{-1}	6,77 ± 0,52 a	7,08 ± 0,47 a	6,62 ± 0,4 a	6,5 ± 0,38 a	6,57 ± 0,4 a	6,82 ± 0,37 a
	15 mL kg^{-1} h^{-1}	6,93 ± 0,42 a	7,17 ± 0,42 a	6,65 ± 0,38 a	6,53 ± 0,29 a	6,65 ± 0,5 a	7 ± 0,21 a
Fb g dL^{-1}	10 mL kg^{-1} h^{-1}	0,37 ± 0,23 a	0,3 ± 0,24 a	0,37 ± 0,15 a	0,37 ± 0,2 a	0,37 ± 0,2 a	0,4 ± 0,13 a
	15 mL kg^{-1} h^{-1}	0,4 ± 0,13 a	0,4 ± 0 a	0,33 ± 0,1 a	0,37 ± 0,08 a	0,3 ± 0,11 a	0,33 ± 0,1 a
Plt 10^3	10 mL kg^{-1} h^{-1}	145,67 ± 38,36 ba	144,67 ± 30,85 ba	144,33 ± 23,31 ba	135,67 ± 32,77 b	139,67 ± 7,53 ba	144,17 ± 31,49 ba
	15 mL kg^{-1} h^{-1}	159,17 ± 39,58 ba	157,67 ± 26,85 ba	146 ± 34,62 ba	153,83 ± 28,2 ba	186,17 ± 68,08 a	179,17 ± 76,25 ba

Table 4. Mean values ± standard deviation for total white blood cells (WBC) followed by the percentage (%) of neutrophils, lymphocytes, monocytes, basophils, eosinophils and band neutrophils in horses submitted to enteral fluid therapy in continuous flow via intracecal route.

VARIABLE	INFUSION RATE	TIME					
		T-24H	T0H	T4H	T8H	T12H	T24H
WBC	10 mL kg^{-1} h^{-1}	11400 ± 3960,43 a	9437,67 ± 2285,61 a	9768,33 ± 3914,13 a	10250 ± 2965,64 a	11833,33 ± 4563,62 a	12308,33 ± 5203,31 a
	15 mL kg^{-1} h^{-1}	10978,33 ± 3045,52 a	9393,33 ± 2528,93 a	8576,67 ± 2557,83 a	9155 ± 1826,82 a	10450 ± 1852,3 a	12488,33 ± 2423,56 a
Neutrophils	10 mL kg^{-1} h^{-1}	51,83 ± 7,08 c	53,33 ± 8,33 c	58,67 ±10,76 bac	59,83 ± 6,55 bac	66 ± 8,07 ba	66,67 ± 11,24 a
	15 mL kg^{-1} h^{-1}	53,67 ± 9,14 bc	51 ± 15,17 c	53,17 ± 14,16 c	52,33 ± 12,09 c	63,33 ±12,93 bac	59,67 ± 10,6 bac
Lymphocytes	10 mL kg^{-1} h^{-1}	36,38 ± 9,54 a	36 ± 9,27 a	35,33 ± 13,17 a	31,83 ± 9,26 a	27,33 ± 4,08 a	26,5 ± 12,24 a
	15 mL kg^{-1} h^{-1}	38,83 ± 10,72 a	41,5 ± 11,36 a	40,67 ± 12,04 a	40,67 ± 9,67 a	32 ± 11,95 a	34,5 ± 8,41 a
Monocytes	10 mL kg^{-1} h^{-1}	4,83 ± 4,17 a	3,5 ± 3,45 ba	1,83 ± 2,14 b	3 ± 2,97 ba	3,14 ± 0,98 ba	4,5 ± 2,07 a
	15 mL kg^{-1} h^{-1}	1,83 ± 0,98 b	1 ± 1,26 b	1,33 ± 1,21 b	1,5 ± 1,05 b	2,5 ± 1,52 ba	1,83 ± 1,33 b
Basophils	10 mL kg^{-1} h^{-1}	1,33 ± 1,51 ba	1,17 ± 0,98 ba	0,5 ± 0,84 ba	1 ± 0,89 ba	0,33 ± 0,82 ba	0,33 ± 0,82 ba
	15 mL kg^{-1} h^{-1}	0,5 ± 0,55 ba	0,33 ± 0,52 ba	0 ± 0 b	1,33 ± 1,21 a	0,33 ± 0,52 ba	0,67 ± 0,82 ba
Eosinophils	10 mL kg^{-1} h^{-1}	4,67 ± 2,73 ba	4,33 ± 3,08 bac	2,83 ± 2,32 bac	3,33 ± 2,66 bac	2,83 ± 2,99 bac	1 ± 0,89 c
	15 mL kg^{-1} h^{-1}	4,5 ± 3,73 ba	5,67 ± 5,13 a	3,83 ± 1,94 bac	3,33 ± 2,16 bac	1,67 ± 0,52 bc	3,33 ± 3,44 bac
Band neutrophils	10 mL kg^{-1} h^{-1}	0,5 ± 1,22 b	1 ± 1,67 ba	0,83 ± 1,6 ba	1 ± 2 a	0,5 ± 1,22 ba	1 ± 1,26 ba
	15 mL kg^{-1} h^{-1}	0,33 ± 0,82 b	0,33 ± 0,82 ba	0,5 ± 0,84 ba	1 ± 1,67 a	0,17 ± 0,41 ba	0 ± 0 b

Table 5. Mean values ± standard deviation for serum and plasma biochemistry: urea, creatinine, glucose, lactate, ionized calcium (iCa^{++}), phosphorus (P), magnesium (Mg^{++}), chloride (Cl^{-}), sodium (Na^{+}), potassium (K^{+}) and serum osmolarity in horses submitted to enteral fluid therapy in continuous flow via intracecal route.

VARIABLE	INFUSION RATE	TIME					
		T-24H	T0H	T4H	T8H	T12H	T24H
Urea mg dL^{-1}	10 mL kg^{-1} h^{-1}	23,83 ± 6,11 dc	32,17 ± 4,12 a	30,5 ± 5,61 ba	25 ± 6,1 bc	20,17 ± 5,12 dc	23,5 ± 6,86 dc
	15 mL kg^{-1} h^{-1}	24,17 ± 3,31 dc	33 ± 5,14 a	30,5 ± 5,96 ba	24,5 ± 4,93 c	18,33 ± 4,55 d	20,33 ± 3,56 dc
Creatinine mg dL^{-1}	10 mL kg^{-1} h^{-1}	1,04 ± 0,31 a	1,05 ± 0,27 a	1,01 ± 0,31 a	0,99 ± 0,33 a	0,98 ± 0,31 a	0,99 ± 0,33 a
	15 mL kg^{-1} h^{-1}	0,97 ± 0,12 a	1,06 ± 0,18 a	0,99 ± 0,2 a	0,95 ± 0,18 a	0,93 ± 0,17 a	0,94 ± 0,14 a
Glucose mg dL^{-1}	10 mL kg^{-1} h^{-1}	91 ± 4,82 bc	88,67 ± 4,37 bcd	78,83 ± 9,83 d	83,33 ± 3,39 cd	83,33 ± 4,63 cd	98,5 ± 7,26 ba
	15 mL kg^{-1} h^{-1}	89,5 ± 3,78 bcd	88,33 ± 2,25 bcd	83,83 ± 5,85 cd	86 ± 4,43 cd	89,83 ± 5,56 bc	105,5 ± 26,67 a
Lactate mg dL^{-1}	10 mL kg^{-1} h^{-1}	8,83 ± 3,31 bdc	7,5 ± 1,05 bdc	7,5 ± 1,87 bdc	7,83 ± 1,72 bdc	7 ± 1,26 d	7,17 ± 1,72 dc
	15 mL kg^{-1} h^{-1}	11 ± 1,79 a	8,5 ± 1,05 bdc	9,17 ± 2,14 bac	9 ± 1,67 bdac	9,5 ± 2,43 ba	8,83 ± 0,75 bdc
iCa^{++} mmol L^{-1}	10 mL kg^{-1} h^{-1}	1,64 ± 0,09 a	1,57 ± 0,11 a	1,58 ± 0,06 a	1,5 ± 0,06 a	1,53 ± 0,11 a	1,61 ± 0,03 a
	15 mL kg^{-1} h^{-1}	1,61 ± 0,07 a	1,61 ± 0,07 a	1,53 ± 0,07 a	1,53 ± 0,1 a	1,48 ± 0,1 a	1,56 ± 0,13 a
P mg dL^{-1}	10 mL kg^{-1} h^{-1}	2,6 ± 0,51 a	2,78 ± 0,63 a	2,93 ± 0,66 a	2,88 ± 0,58 a	2,63 ± 0,43 a	1,9 ± 0,46 b
	15 mL kg^{-1} h^{-1}	2,87 ± 0,31 a	2,7 ± 0,29 a	2,75 ± 0,34 a	2,78 ± 0,25 a	2,92 ± 0,58 a	1,88 ± 0,51 b
Mg^{++} mg dL^{-1}	10 mL kg^{-1} h^{-1}	1,67 ± 0,27 ba	1,65 ± 0,19 ba	1,57 ± 0,08 ba	1,3 ± 0,11 b	1,22 ± 0,1 ba	1,52 ± 0,15 ba
	15 mL kg^{-1} h^{-1}	1,65 ± 0,31 ba	1,67 ± 0,23 ba	1,58 ± 0,25 a	1,37 ± 0,19 ba	1,2 ± 0,17 ba	1,57 ± 0,19 ba
Cl^{-} mmol L^{-1}	10 mL kg^{-1} h^{-1}	97,83 ± 2,14 a	99,17 ± 2,93 a	98,17 ± 1,83 a	98,67 ± 2,88 a	99,17 ± 2,64 a	99,17 ± 2,79 a
	15 mL kg^{-1} h^{-1}	97,83 ± 2,04 a	99,17 ± 2,86 a	98,5 ± 2,59 a	98,83 ± 1,94 a	99,5 ± 1,52 a	100,5 ± 4,14 a
Na^{+} mmol L^{-1}	10 mL kg^{-1} h^{-1}	139 ± 1,67 ba	140,33 ± 1,86 a	140,5 ± 1,87 a	140,17 ± 1,94 a	139,67 ± 1,97 ba	137,17 ± 2,4 b
	15 mL kg^{-1} h^{-1}	138,5 ± 1,52 ba	138,5 ± 1,97 ba	140 ± 2 a	140,67 ± 0,82 a	141,33 ± 0,82 a	138,5 ± 2,59 ba
K^{+} mmol L^{-1}	10 mL kg^{-1} h^{-1}	3,94 ± 0,33 bac	3,88 ± 0,17 bdac	3,54 ± 0,23 e	3,53 ± 0,21 e	3,7 ± 0,25 dec	3,78 ± 0,4 bdec
	15 mL kg^{-1} h^{-1}	4,07 ± 0,13 ba	4,12 ± 0,34 a	3,63 ± 0,12 dec	3,59 ± 0,15 de	3,5 ± 0,37 e	3,62 ± 0,44 dec
Osmolarity mOsm L^{-1}	10 mL kg^{-1} h^{-1}	289,67 ± 7,74 ba	287,83±4,83bdac	289,17 ±4,02 bac	288 ± 3,22 bdac	282,33 ± 7,34 d	283,17 ± 5,38 dc
	15 mL kg^{-1} h^{-1}	288 ± 6 bdac	292,33 ± 4,27 a	288,33±2,42bdac	288 ± 3,85 bdac	287,5 ±9,77 bdac	286 ± 5,87 bdc

Table 6. Mean values ± standard deviation for pH, carbon dioxide pressure (pCO_2), bicarbonate concentration (HCO_3^-), base excess (BE), anion gap (AG) and strong ion difference (SID) in horses submitted to enteral fluid therapy in continuous flow via intracecal route.

VARIABLE	INFUSION RATE	TIME					
		T-24H	**T0H**	**T4H**	**T8H**	**T12H**	**T24H**
pH	10 mL kg^{-1} h^{-1}	7,44 ± 0,02 a	7,42 ± 0,03 a	7,42 ± 0,02 a	7,42 ± 0,02 a	7,42 ± 0,01 a	7,39 ± 0,02 a
	15 mL kg^{-1} h^{-1}	7,41 ± 0,02 a	7,39 ± 0,03 a	7,42 ± 0,02 a	7,42 ± 0,02 a	7,41 ± 0,02 a	7,41 ± 0,01 a
pCO_2 mm Hg	10 mL kg^{-1} h^{-1}	41,22 ± 3,61 ba	40,90 ± 5,44 ba	43,05 ± 1,88 ba	42,53 ± 3,08 ba	41,98 ± 2,8 ba	40,17 ± 3,44 b
	15 mL kg^{-1} h^{-1}	43,77 ± 4,61 ba	42,67 ± 1,72 ba	42,32 ± 2,17 ba	43,7 ± 3,62 ba	44,15 ± 2,87 a	40,33 ± 3,65 ba
HCO_3^- mmol L^{-1}	10 mL kg^{-1} h^{-1}	27,23 ± 3,03 a	27,83 ± 4,62 a	27,4 ± 2,15 a	26,88 ± 1,89 ba	26,08 ± 1,56 bac	23,58 ± 1,06 c
	15 mL kg^{-1} h^{-1}	26,8 ± 2,19 ba	26,12 ± 1,35 bac	27,3 ± 1,33 a	27,8 ± 1,6 a	27,22 ± 1,47 a	24,58 ± 2,31 c
BE mmol L^{-1}	10 mL kg^{-1} h^{-1}	3,2 ± 2,77 a	2,07 ± 1,22 ba	3,1 ± 2,13 a	2,85 ± 1,68 a	2,03 ± 1,39 ba	-0,47 ± 0,63 c
	15 mL kg^{-1} h^{-1}	2,45 ± 1,89 ba	1,77 ± 1,29 ba	3,08 ± 1,31 a	3,62 ± 1,15 a	2,98 ± 1,14 a	0,6 ± 1,98 bc
AG	10 mL kg^{-1} h^{-1}	17,87 ± 1,02 a	18,88 ± 0,97 a	18,47 ± 0,86 a	18,15 ± 1,03 a	18,11 ± 0,76 a	18,2 ± 1,24 a
	15 mL kg^{-1} h^{-1}	17,94 ± 2,25 a	17,34 ± 3,79 a	17,83 ± 2,3 a	17,62 ± 1,7 a	18,12 ± 2,22 a	17,03 ± 2,62 a
SID	10 mL kg^{-1} h^{-1}	45,1 ± 2,88 a	45,05 ± 2,16 a	45,87 ± 1,82 a	45,03 ± 2,24 a	44,2 ± 1,52 a	41,78 ± 1,06 a
	15 mL kg^{-1} h^{-1}	44,74 ± 1,68 a	43,46 ± 3,2 a	45,13 ± 2,6 a	45,42 ± 2,31 a	45,33 ± 1,79 a	41,62 ± 2,93 a

Table 7. Mean values ± standard deviation for urinary analysis: specific gravity, pH, urea, creatinine, calcium (Ca^{++}), phosphorus (P), magnesium (Mg^{++}), chloride (Cl^{-}), sodium (Na^{+}) and potassium (K^{+}) in horses submitted to enteral fluid therapy in continuous flow via intracecal route.

VARIABLE	INFUSION RATE	TIME					
		T-24H	T0H	T4H	T8H	T12H	T24H
Specific gravity	10 mL kg^{-1} h^{-1}	1021 ± 15,1 ba	1026,8 ± 16,65 a	1028,5 ± 4,12 a	1012 ± 10,04 ba	1006,33 ± 3,2 b	1025 ± 7,07 ba
	15 mL kg^{-1} h^{-1}	1017,25±7,63 ba	1027,6 ± 13,45 a	1018,8±13,75 ba	1005,67 ± 2,94 b	1004,67 ± 0,82 b	1015,2 ± 6,87 ba
pH	10 mL kg^{-1} h^{-1}	8,46 ± 0,34 a	7,41 ± 1,02 bc	8,17 ± 0,75 ba	8,15 ± 0,46 ba	8,07 ± 0,37 ba	6,82 ± 1,25 c
	15 mL kg^{-1} h^{-1}	7,89 ± 0,56 ba	7,54 ± 0,78 bc	8,09 ± 0,58 ba	7,9 ± 0,2 ba	8,03 ± 0,23 ba	7,04 ± 0,55 c
Urea mg dL^{-1}	10 mL kg^{-1} h^{-1}	1402,97 ± 1550,94 ba	1654,34 ± 1166,55 bac	1980,38 ± 1315,26 a	644,57 ± 663,53 bc	414,33 ± 317,08 c	1438,05 ± 673,66 bac
	15 mL kg^{-1} h^{-1}	1135,19 ± 307,49 bac	2696,39 ± 1452,33 a	1757,33 ± 1380,08 a	337,66 ± 149,84 bc	244,39 ± 83,53 c	823,18 ± 435,82 bc
Creatinine mg dL^{-1}	10 mL kg^{-1} h^{-1}	215,37 ± 224,37ba	235,54 ± 136,7 ba	107,61 ± 69,97 bac	48,23 ± 65,06 bc	35,7 ± 30,82 c	151,77 ± 76,04 bac
	15 mL kg^{-1} h^{-1}	84,99±28,19 bac	340,07±239,34 a	149,74±135,75bac	20,54±7,65 bc	14,26±1,97 c	64,18±35,56 bc
Ca^{++} mg dL^{-1}	10 mL kg^{-1} h^{-1}	25,2 ± 25,55 a	10,86 ± 8,06 a	4,34 ± 4,93 a	3,27 ± 1,14 a	4,68 ± 2,05 a	33,57 ± 20,65 a
	15 mL kg^{-1} h^{-1}	20,6 ± 29,99 a	14,30 ± 20,75 a	5,75 ± 6,8 a	3,33 ± 1,82 a	3,97 ± 0,78 a	48,95 ± 49,52 a
P mg dL^{-1}	10 mL kg^{-1} h^{-1}	3,2 ± 0,61 bdc	7,4 ± 3,89 a	5,21 ± 1,43 bac	4,06 ± 1,52 bdc	3,68 ± 0,45 dc	4,93 ± 2,27 bdac
	15 mL kg^{-1} h^{-1}	4,4 ± 3,25 bdc	5,17 ± 4,55 ba	4,83 ± 3,81 bac	3,1 ± 0,62 dc	3,06 ± 0,36 d	3,67 ± 1,88 bdc
Mg^{++} mg dL^{-1}	10 mL kg^{-1} h^{-1}	2,91 ± 0,1 a	2,66 ± 0,42 bac	2,6 ± 0,46 a	2,11 ± 0,31 bc	2,07 ± 0,2 c	2,9 ± 0,1 bac
	15 mL kg^{-1} h^{-1}	2,71 ± 0,39 ba	2,76 ± 0,22 ba	2,41 ± 0,45 bac	2,02 ± 0,15 c	1,89 ± 0,05 c	2,74 ± 0,33 bac
Cl^{-} mmol L^{-1}	10 mL kg^{-1} h^{-1}	136,51 ± 67,53 b	98,84 ± 61,29 b	73,7 ± 41,18 b	102,03 ± 50,28 b	107,6 ± 48,48 b	333,51±212,52 a
	15 mL kg^{-1} h^{-1}	119,35 ± 65,92 b	90,44 ± 35,7 b	93,35 ± 51,94 b	82,79 ± 47,51 b	91,27 ± 10,33 b	245,05±133,45 a
Na^{+} mmol L^{-1}	10 mL kg^{-1} h^{-1}	1 ± 0 a	2,8 ± 3,49 a	2,25 ± 1,5 a	23 ± 16,42 a	33,5 ± 15,24 a	2,5 ± 2,12 a
	15 mL kg^{-1} h^{-1}	2,5 ± 1,29 a	2 ± 1,22 a	1,8 ± 0,84 a	20,83 ± 5,17 a	38,83 ± 4,31 a	6,6 ± 4,72 a
K^{+} mmol L^{-1}	10 mL kg^{-1} h^{-1}	6,35 ± 0,26 ba	5,28 ± 0,78 bc	5,05 ± 1,14 bc	4,68 ± 1,52 c	5,53 ± 0,73 bac	7 ± 0 a
	15 mL kg^{-1} h^{-1}	5,38 ± 0,96 bac	4,72 ± 0,58 c	5,56 ± 1,51 bac	4,58 ± 1,13 c	4,67 ± 1,22 c	4,7 ± 0,19 c