The Vet Education Live Web-Seminar (Webinar) Series 2013

“Updates in Equine Colic”

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Colic

- Broad definition used to describe abdominal pain
- Defining cause determines most effective treatment, allows accurate prediction of prognosis and advice on disease prevention
  - Knowledge of local environmental factors and conditions will impact initial differential diagnosis
  - Ancillary diagnostic tests will improve definition of cause
  - Collection of prognostic indicators will allow better case management and client communication of case outcomes
- Importance?\textsuperscript{a,b}
  - 4-10 cases per 100 horses
  - 10-15% cases had prior episodes
  - 80-85% cases had no specific diagnosis identified - responded to medical treatment or resolved spontaneously
  - 67% treated by veterinarian
  - 80% cases treated with drugs
  - 75% mild: no treatment or resolved after only one treatment
  - 1.4% surgery
  - 6.7% fatality rate

\textbf{Figure 2. Percentage of Equid Deaths (Including Euthanasia) for Equids Aged More than 30 Days, by Cause of Death}

<table>
<thead>
<tr>
<th>Cause of Death</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colic</td>
<td>14.6%</td>
</tr>
<tr>
<td>Injury/wounds/trauma</td>
<td>32.5%</td>
</tr>
<tr>
<td>Lameness, leg, or hoof problems</td>
<td>16.3%</td>
</tr>
<tr>
<td>Old age</td>
<td>7.7%</td>
</tr>
<tr>
<td>All other/unknown</td>
<td>28.9%</td>
</tr>
</tbody>
</table>

Important to obtain some baseline information on horse prior to visit as this data may already give you a high index of suspicion of a single disease and treatment options. This can be difficult due to:
- Skill of receptionist
- Level of panic/expertise of client
- Time/location

Formulation of a basic checklist for calls may be useful

Signalment (Age, Sex, Breed)
- Significant number of diseases have increased occurrence in horse with specific signalment components. Examples include:
  - Parascaris equorum = <1yr
  - Enteroliths = Arabian
- Reproductive status (pregnant, multiparous) also has an impact on disease incidence e.g. colon displacement/torsion post partum
- Increased risk of mortality in draft horses >680kg – relationship to bodyweight applies to other breeds e.g. warmbloods?
- Age of animal
  - Influences disease incidence, but also factors such as immunity, metabolic function and occurrence of concurrent factors such as endocrine disease
  - Geriatric disease prevalence in one study
  - Parasite burden*: Age does not affect fecal egg counts (FECs) or time to egg reappearance after anthelmintics, PPID horses have higher FECs before & after ivermectin treatment
  - “Immunosenescence”: decline in function and regulation of immune system with age – well documented in relation to vaccination
  - Despite this, compared to older studies, recent studies fail to demonstrate any difference in survival rates for geriatric horses (>16yr)

### Common Findings

<table>
<thead>
<tr>
<th>Condition</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overweight</td>
<td>26%</td>
</tr>
<tr>
<td>Underweight</td>
<td>4.5%</td>
</tr>
<tr>
<td>Hirsutism</td>
<td>22%</td>
</tr>
<tr>
<td>Heart murmurs</td>
<td>20%</td>
</tr>
<tr>
<td>Nasal discharge</td>
<td>18.5%</td>
</tr>
<tr>
<td>Abnormal thoracic auscultation</td>
<td>22%</td>
</tr>
<tr>
<td>Developed marked abnormalities on rebreathing bag</td>
<td>13.6%</td>
</tr>
<tr>
<td>Dental abnormalities</td>
<td>95.4%</td>
</tr>
</tbody>
</table>

Minimum data requirements for consult scheduling

**Age, Sex, Breed**

1° complaint
- Duration
- Severity
- Summary of signs

Colic: faeces, appetite, water intake

Medication
Pertinent changes in management or history
**History**

- Recent changes generally most significant
- Nutrition: grain, concentrates
- The D’s: Dentistry & Deworming
- Medication: NSAIDs, Antibiotics
- Patient disease history
- Other animals affected

<table>
<thead>
<tr>
<th>Temp</th>
<th>37.0 – 38.5 °C</th>
<th>GIT</th>
<th>+</th>
<th>2-3 ICS/1-1.5min</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR</td>
<td>36 ± 10</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>RR</td>
<td>12 ± 4</td>
<td></td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>MM</td>
<td>Pink, moist</td>
<td>Digital pulses/heat</td>
<td>WNL</td>
<td>WNL</td>
</tr>
<tr>
<td>CRT</td>
<td>&lt;2s</td>
<td></td>
<td>WNL</td>
<td>WNL</td>
</tr>
</tbody>
</table>

**Physical examination**

- Ideal to record baseline parameters prior to any medication and diagnostics, particularly HR and GIT sounds
- Evaluate colic signs – Does the horse have colic or signs mimicking colic e.g. recumbency? Is the colic the primary problem?
- Colic signs: identify ± grade (EAAPS)?

**Table 2.** Association with medical treatment ($P < 0.05$)

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Depression</td>
<td>A horse that is quieter than normal, dull, less responsive and disinterested in the environment, may have ears pulled back or down but ears are not pricked up forward and do not move readily to surrounding noise. May have lowered head carriage.</td>
</tr>
<tr>
<td>Flank watching</td>
<td>A horse that glances at its side or flank.</td>
</tr>
<tr>
<td>Weight shifting</td>
<td>A horse that moves his weight from one side to the other, usually with the forelimbs.</td>
</tr>
<tr>
<td>Restlessness</td>
<td>A horse that does not stand quietly but moves, apparently aimlessly, and appears agitated. Movements may be jerky with wide excursions of the head.</td>
</tr>
<tr>
<td>Kicking abdomen</td>
<td>A horse that kicks in the direction of its abdomen.</td>
</tr>
<tr>
<td>Pawing</td>
<td>Scrapping the ground with a forelimb.</td>
</tr>
<tr>
<td>Stretching</td>
<td>Most commonly, taking a stance as a male horse would to urinate, but not urinating.</td>
</tr>
<tr>
<td>Sternal recumbency</td>
<td>Lying on ground but on the sternum with the legs tucked under the body.</td>
</tr>
<tr>
<td>Lateral recumbency</td>
<td>Lying on ground but on the side.</td>
</tr>
<tr>
<td>Attempting to lie down</td>
<td>A horse that buckles the legs (crouches) and looks like it will lie down, but does not, or lies down but gets up immediately.</td>
</tr>
<tr>
<td>Collapse</td>
<td>Attempting to or succeeding to suddenly drop to the ground, usually as a prelude to rolling.</td>
</tr>
</tbody>
</table>
Equine acute abdominal pain scale version 1 (EAAPS-1): To grade the severity of pain the horse is showing, pick the most severe behaviour manifested, and the score for that particular behaviour is the pain score.

Equine acute abdominal pain scale version 2 (EAAPS-2): To grade the severity of pain the horse is showing, pick the most severe behaviour manifested, and then choose one or the other of the two scores for that particular behaviour based on the descriptions below the table.

\[\text{The lower score applies if the behaviour is seen \textit{RARELY} or \textit{OCCASIONALLY} and the higher score if seen \textit{FREQUENTLY} or if it is being performed \textit{VIOLENTLY}.}\]

\[\text{The lower score applies to a horse that circles in a stall, pivots around with the hind end, or moves for no apparent reason, but only occasionally, and the higher score applies to horses that moves as above, fairly continuously and aimlessly or moves in a jerky or violent manner.}\]

\[\text{The lower score applies to a horse that is alert, with raised head carriage and the higher score if horse’s head is resting on ground or facing the horse’s side.}\]

- **Areas of focus**
  - Abdominal profile/distension
  - Percussion
  - Jugular fill
  - Assessment of hydration status
- **Body posture/position** occasionally may assist to localise pain
- **Confounding factors**
  - Age: Geriatric (>16yr) more likely to be moderately painful and less likely to be bright and alert than mature horses; and less likely to have normal intestinal borborygmi – associated with more serious causes of colic? No demonstration of increased mortality, however
• Prognostic indicators
  ❖ Variable between studies and groups
  ❖ Clinical parameters linked to a poor prognosis

<table>
<thead>
<tr>
<th>Severity of pain (poor response to tx)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High heart rate (&gt;80 bpm)</td>
</tr>
<tr>
<td>Poor cardiovascular status (abnormal/cyanotic mucous membranes, skin tent, prolonged CRT (&gt;3s))</td>
</tr>
<tr>
<td>? Duration of signs/Duration before admission or treatment</td>
</tr>
</tbody>
</table>

2 Diagnostic Tests

• Often limited by condition of patient, client or environment
• Safety first – use appropriate restraint and medication – abort procedure if safety cannot be guaranteed

Nasogastric intubation
• Perform first if suspect gastric overload
  ❖ Relieve pressure prior to rupture
  ❖ Analgesia
• Equine stomach
  ❖ 170-180cm from nares
  ❖ Small relative to body size - capacity 8-15L
  ❖ Lies mostly on left above costochondral junction, with pylorus to right
  ❖ Emptying rate of liquids 30min, small solids 90min
  ❖ Well developed cardiac sphincter that prevents retrograde flow i.e. vomiting
• Gross characteristics
  ❖ Solids: composition (feed, grain, bedding), odour
  ❖ Gas: odour, volume
  ❖ Fluids: Reflux present/absent (<1L can be normal if indwelling tube or recent ingestion)
  ❖ Parasites
• Objective measurements
  ❖ Volume
  ❖ pH: acidic = gastric, alkaline = small intestine
• Record frequency of each attempt to reflux, volume obtained and clinical response
• Secure indwelling tube with tape if required or for transport with one way valve
• Diagnostic value
  ❖ Presence of gastric reflux is one of several combined indicators for surgery
  ❖ Volume of reflux has no prognostic value
  ❖ Presence of ileus (gastric reflux >2l) is common post operatively and its persistence is a common reason for death/euthanasia
  ❖ Presence of reflux predisposed horses to low Ca at time of admission
  ❖ Odds for developing ileus are 12 x higher for horses with very low serum Ca (<1.27 mmol/l – pH adjusted) and 10 x higher odds for fatal income – lack of response to Ca supplementation may indicate a worse outcome
**Rectal Exam**

- Safety first – palpation of painful structures can elicit significant motor response!
- Bowel distension, displacements, impactions, masses or hernias
- Taenial bands can be used to identify structures, but challenging – remember “4 on the floor, 1-2-3”

A: Spleen  
B: Nephrosplenic ligament  
C: Kidney  
D: Small colon  
E: Mesenteric root  
F: Kidney  
G: Small intestine  
H: Cecum  
I: Right dorsal colon  
J: Right ventral colon  
K: Left ventral colon  
L: Pelvic flexure  
M: Left dorsal colon

- Palpation areas of particular interest that may provide a diagnosis
  - Nephrosplenic space – use in conjunction with ultrasound to confirm nephrosplenic entrapment (left dorsal displacement of the colon, LDDC): palpation of large colon within the nephrosplenic space OR palpation of colonic bands coursing dorsally toward the nephrosplenic space
  - Pelvic flexure – most common site of impaction
  - Small colon
  - Caecum
  - Orientation and relationship of colon/caecum
• Diagnostic value
  - Can be difficult to interpret
  - Depth of equine abdomen or size of patient may preclude effective examination
  - Presence of abnormal findings on rectal examination is not necessarily associated with the need for surgery – reliant on examiner interpretation of whether palpation findings are consistent with a surgical lesion, high false positives possible without interpretation

Abdominocentesis
• Peritoneal fluid - lubricant that bathes surface of abdominal organs and reflects changes in health of organs, especially intestine
• Technique
  - Most ventral aspect of linea alba
  - Surgical prep, local anaesthesia
  - Teat cannula preferred
  - EDTA for cytology, plain tube for culture
• Analyze
  - Colour
  - Transparency
  - Protein
  - Cytology (cells, bacteria, feed material)

Figure 1. Classification trees for the assessment of the treatment type needed as proposed by CART at prevalences of surgical cases of 15%. Ellipses represent splitting nodes and the rectangles represent the terminal nodes. The numbers shown under each node designate cases reaching this node. The first number is that of cases requiring surgery and the second number records cases not needing surgical treatment. The percentage enclosed in ellipses and rectangles is the probability that surgery is needed, in the node. Terminal nodes in bold are surgical end categories. For prevalences of surgical cases other than 17%, CART operates with a corrective factor and therefore the proportion of surgical horses in each node does not correspond to the relevant probability.
  SE — sensitivity of the tree
  SP — specificity of the tree
  Pf — peritoneal fluid
  PCV — packed cell volume
• Diagnostic value
  ❖ Elevation of a single peritoneal fluid value in postpartum mare may be incidental; however, increases in 2 or more of: total protein > 3.0 g/dl; total nucleated cell count > 15 000 cells/μl; percentage of neutrophils > 80% is clinically significant.
  ❖ Higher grade associated with increased hazard.

<table>
<thead>
<tr>
<th>Fluid type</th>
<th>Colour</th>
<th>Transparence</th>
<th>Nucleated Cells/μl</th>
<th>Protein g/L</th>
<th>Cytology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transudate</td>
<td>Yellow</td>
<td>Clear</td>
<td>0-5000</td>
<td>&lt;20/25</td>
<td>Mononuclear cells, non-degenerate neutrophils, small numbers RBC’s</td>
</tr>
<tr>
<td>Modified Transudate</td>
<td>Yellow</td>
<td>Turbid</td>
<td>5000 - 10 000</td>
<td>&lt;20/25</td>
<td>Macrophages and non-degenerate neutrophils predominate</td>
</tr>
<tr>
<td>Exudate</td>
<td>Yellow to red</td>
<td>Cloudy</td>
<td>&gt;5000</td>
<td>&gt;25</td>
<td>Non-degenerate or degenerate neutrophils predominate</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Grade</th>
<th>Peritoneal Fluid Appearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Unattempted / unsuccessful</td>
</tr>
<tr>
<td>1</td>
<td>Normal color and volume</td>
</tr>
<tr>
<td>2</td>
<td>Normal color but increased volume</td>
</tr>
<tr>
<td>3</td>
<td>Turbid</td>
</tr>
<tr>
<td>4</td>
<td>Reddish/bright red</td>
</tr>
<tr>
<td>5</td>
<td>Green/brown containing intestinal material</td>
</tr>
</tbody>
</table>

- Increased mortality risk TP >30g/l

❖ Hb measurement versus visual assessment
  ✔ Mean [Hb] 0.0162mmol/l in horses requiring surgery
  ✔ Mean [Hb] 0.0047mmol/l horses amenable to medical treatment
  ✔ Minimum visual detection @ 0.085 mmol/l, consistent at 0.017 mmol/l

❖ Protein
  ✔ Identified in some studies as a predictor of outcome: 35 ± 2 g/l range for non-survivors versus 26 ± 5 for survivors

❖ Confounding factor is anterior enteritis fluid may be serosanguinous fluid, however leakage of protein creates increased concentrations in the peritoneal fluid prior to any increase in RBC or WBC
  ✔ Anterior enteritis – initial mild-moderately elevated TP followed by mild increase cell count (non-degenerate neutrophils)
  ✔ Intestinal obstruction mild-markedly elevated TP and cell count (degenerate neutrophils) with strangulating obstructions

❖ Enterocentesis will increase nucleated cell counts and TP for next 2 days and usually not associated with any adverse sequelae or requiring treatment

❖ ALP increased in peritoneal fluid may help in identifying ischemic or inflammatory bowel lesions – research only

• Lactate
  ❖ Accutrend Lactate Monitor (Roche) validated for horses ($250 for Monitor, $52 for 25 test strips)
  ❖ Monitor is most accurate at lactate concentrations of <5 mmol/L
  ❖ Peritoneal fluid lactate appears more useful and sensitive than blood lactate for prognostic purposes in horses with colic
**Ultrasound**

- Transabdominal and/or transrectal
- Evaluate excess peritoneal fluid, adhesions, masses, small intestinal distension, lack of intestinal motility, intussusceptions and position of structures (nephrosplenic entrapment)
- May be useful in foals and miniature horses where rectal exam not possible
- Limitations – depth of penetration, gas filled organs
- FLASH scan
  - Protocol for fast localised abdominal sonography of horses (FLASH) admitted for colic for clinicians without extensive ultrasound (US) experience with a 10.7 min mean time for positive and negative predictive values of requirement for surgery of dilated turgid small intestinal loops usingFLASH were 88.89% and 81.48%, respectively
  - 3–3.5 MHz transducer (microconvex and curvilinear)

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**Table 1**

<table>
<thead>
<tr>
<th>Side</th>
<th>Site</th>
<th>Scanning procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left</td>
<td>1. Ventral abdomen</td>
<td>Place the probe just caudal to the sternum and move caudally to assess the most gravity dependent area of the abdomen</td>
</tr>
<tr>
<td></td>
<td>2. Gastric window</td>
<td>Visualise the stomach at the level of the 10th ICS in the middle third (dorsal-ventrally) of the abdomen and then move the probe in the 2–3 ICS cranial and caudal to the 10th</td>
</tr>
<tr>
<td></td>
<td>3. Spleno-renal window</td>
<td>Place the probe between dorsal and middle third of the abdomen at the level of the 17th ICS</td>
</tr>
<tr>
<td></td>
<td>4. Left middle third of the abdomen</td>
<td>Freely move the probe around in the middle third of the abdomen</td>
</tr>
<tr>
<td>Right</td>
<td>5. Duodeno-jejunal loop</td>
<td>Place the probe in the 14–15th right ICS in the dorsal part of the middle third (dorsal-ventrally) of the abdomen</td>
</tr>
<tr>
<td></td>
<td>6. Right middle third of the abdomen</td>
<td>Freely move the probe around in the middle third of the abdomen</td>
</tr>
<tr>
<td></td>
<td>7. Cranial ventral thorax</td>
<td>Place the probe on the cranial ventral thorax just caudal to the triceps muscle</td>
</tr>
</tbody>
</table>

ICS – intercostal space.

• Diagnostic value
  ❖ Distended and non-motile SI loops were associated with strangulated obstruction\textsuperscript{w,y}
  ❖ Increased free peritoneal fluid, completely distended SI loops with abnormal motility and thickened loops were associated with definitive diagnosis involving SI\textsuperscript{w,y}
  ❖ Failure to visualise the left kidney was associated with nephroplenic entrapment \rightarrow use in association with rectal examination findings\textsuperscript{w,y}
  ❖ Thickened large colon (LC) was associated with LC torsion - colon wall thickness $\geq 9$ mm (sensitivity 67%, specificity 100%), identification of nonsacculated large colon in the left ventral portion of abdomen considered indicative of LC volvulus\textsuperscript{z,aa}
  ❖ Visualisation of colonic mesenteric vessels = 32.5x more likely to be diagnosed at surgery with either large colon right dorsal displacement or 180° large colon volvulus (sensitivity 67.7%, specificity 97.9%)\textsuperscript{bb}
  ❖ Specific anatomically identifiable abnormalities including:
    ✓ Sand
    ✓ Enteroliths
    ✓ Parascaris equorum
    ✓ Intussception – bulls eye
    ✓ Abscesses
    ✓ Haemoperitoneum
    ✓ Thickened small intestine

Radiography
• Uncommon
• Sand colic, enteroliths

Gastroscopy/endoscopy
• Ulcers, tumors, emptying defects, impactions, oesophageal obstruction
Packed cell volume and total protein
- Multiple studies have found increased mortality associated with PCV at admission, in conjunction with CRT and HR
- Cutoff value not clearly identified but high fatality if PCV >54% \(^{cc}\) one study, mean PCV of non-survivors was 45.5\(^{dd}\)
- Assess total protein as losses common due to protein losing enteropathy. Interpret with caution as estimate after correction of dehydration

Haematology
- Assess for evidence of haemoconcentration
- May find anaemia if blood loss present - haemoperitoneum
- Endotoxaemia profile – gram negative bacterial death
  - Leukopaenia due to neutropaenia most specific indicator ± bands and toxic changes
  - Rebound neutrophilia on recovery
  - Consider Salmonella → appropriate testing & biosecurity → antibiotic therapy controversial

Biochemistry
- ↑ serum GGT in horses with right dorsal displacement of the large colon (RDDLC) \(^{ee}\)
  - Associated with compression of the bile duct → extrahepatic bile duct obstruction

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**Fig 1.** The hepatoduodenal ligament (yellow) attaching the proximal duodenum to the liver. The bile duct (circled in blue) is coursing within the ligament from the liver to duodenum.

**Fig 2.** The hepatoduodenal ligament and mesoduodenum approaching the liver: RD colon, right dorsal colon; MD, mesoduodenum; HD, hepatoduodenal ligament.

\(^{ee}\) Gardner RB et al. Serum gamma glutamyl transferase activity in horses with right or left dorsal displacements of the large colon. JVIM 2005 19:5;761-4.

- Elevated Crea that fails to normalise within 72h → 3x increase in fatality \(^{ff}\)
- Hyperglycaemia associated with increased odds of non survival
  - >7.3 mmol/l in first 48h of hospitalisation \(^{gg}\)
  - Severe hyperglycaemia (>10.7mmol/l): mean of 13mmol/l for non-survivors and 7.6mmol/l for survivors \(^{dd}\)
• Multiple electrolyte abnormalities often reported in horses with colic - commonly ↓Na/Cl/P, ↑Na
• Calcium: Odds for developing ileus are 12 x higher for horses with very low serum Ca (<1.27 mmol/l – pH adjusted) and 10 x higher odds for fatal income – lack of response to Ca supplementation may indicate a worse outcome

Blood gas
• Common to see evidence of metabolic acidosis
• Increased anion gap (AG) linked to increased mortality - ↑ lactate
  - 81% survival AG 20 mEq/L → 47% survival AG 20 to 24.9 mEq/L → 0% survival ≥ 25 mEq/L
  - Mean AG non-survivors 21.1 mEq/L vs 14.4 mEq/L survivors

Other
• ↑ serum lactate = ↑ mortality
• Future applications

<table>
<thead>
<tr>
<th>Test</th>
<th>Cautionary result</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCV</td>
<td>&gt;54%</td>
</tr>
<tr>
<td>Haematology</td>
<td>Endotoxaemia leukocyte profile</td>
</tr>
<tr>
<td>Biochemistry</td>
<td>↑ GGT – right dorsal displacement of large colon</td>
</tr>
<tr>
<td></td>
<td>↑ Crea – failure to normalise within 72h</td>
</tr>
<tr>
<td></td>
<td>Hyperglycaemia &gt;10.7 mmol/l in first 48h</td>
</tr>
<tr>
<td></td>
<td>Ca &lt;1.27mmol/l</td>
</tr>
<tr>
<td>Anion Gap</td>
<td>&gt;20mEq/l</td>
</tr>
</tbody>
</table>
### NSAIDS

- Flunixin meglumine most effective for visceral (& ocular) pain
  - 1mg/kg dose IV/PO q 12h (q8h if required – monitor renal function): analgesic, anti-pyretic and anti-inflammatory
  - IV formulation given orally has bioavailability up to 97.9% : mean 71.9 – 85.8%
    - i.e. dose at 1 to 1.4x original IV dose orally
  - 0.5mg/kg dose: reduced analgesic, antipyretic and anti-inflammatory effects
  - 0.25mg/kg dose: “anti-endotoxic dose” → reduces inflammation associated with endotoxin, minimal to no analgesic or anti-pyretic effects
- AVOID IM administration – significantly linked to clostridial myonecrosis
- Reduced residence time and increased clearance by donkeys

- PBZ most effective for musculoskeletal pain
  - Beware that increasing dose from 2.2mg/kg to 4.4 mg/kg does not significantly increase analgesic effect, but duration!
  - Ideally doses no less than 12 hours apart
- Toxicity common due to misuse of NSAIDs
  - Non COX specific
  - DO NOT OVERDOSE → ceiling effect of analgesia. If your NSAID is not working, reconsider diagnosis, implement other analgesic protocol
  - Oral PBZ associated with right dorsal colitis

### α2 agonists

- Sedatives, but effective short duration analgesics
- Significant disadvantages
  - Profound decrease in GIT motility as well as CVS and respiratory depression
  - Upper airway obstruction can occur in horses with upper airway disease
  - Increased sweating and urine production
  - Rare: Violent behaviour “xylazine rage”
• Xylazine
  - 0.2-0.5mg/kg (1.1mg/kg = pre-anaesthetic)
  - Analgesia up to 90 minutes
  - IM bioavailability 48% of IV dose – increase IV dose up to 2 times for same effect
• Detomidine
  - 0.005-0.04mg/kg
  - Analgesia from 15-165 dependant on location (colorectal distension most effective)
  - In one study, 10x greater dose required for analgesia than that required for sedation!
  - IM bioavailability 40% of IV dose – increase IV dose up to 2.5 times for same effect
• Use in conjunction with opioids to improve analgesia and minimise side effects

Opioids
• Effective analgesics but significant side effects can overlap therapeutic dose rates: ataxia, agitation and hyperexcitability
• Best used as part of multimodal therapy - α2 agonists
• Butorphanol
  - Beware of IV administration without an α2 = excitement
  - 0.02-0.1 mg/kg IV/IM q 4-12h or 18μg/kg IV bolus then CRI 13-23μg/kg/h
• Morphine controversial as increases risk of colic due to suppression of GIT motility
• Fentanyl
  - Exceedingly high serum concentrations required to provide some analgesia and overlap into toxicity
  - Transdermal transdermal patch uptake very variable and disappointing results for visceral pain – for musculoskeletal cases, one 10mg patch per 150kg BW replaced every 48-72 h (9h to maximum serum levels)
• Tramadol
  - Very short half-life and oral bioavailability
  - No analgesia demonstrated with IV doses up to 1.6mg/kg

Na Channel blocker - Lignocaine
• Lignocaine = analgesic, prokinetic (small intestine), and anti-inflammatory
• 1.3mg/kg IV bolus followed by 0.05mg/kg/min CRI
• Toxicity: skeletal muscle tremors, blindness, anxiety, ataxia, seizures, collapse, ECG abnormalities, cardiac arrest
• Reduce dose rate if
  - Administering ceftiofur and flunixin as they decrease protein binding of lignocaine
  - General anaesthesia – reduced liver blood flow, interference with liver metabolic pathways. 0.65 mg/kg, IV, followed by an infusion of 0.025 mg/kg/min. Stop 30mins prior to end of anaesthesia
• Intrarectal
  - 14ml of 2% solution
  - Increases rectal wall compliance
### Anti-spasmodics
- Only indicated for spasmodic colic – in most cases GIT motility is already markedly reduced
- N-Butylscopolammonium bromide (Buscopan™)
  - Anticholinergic and antispasmodic
  - Short duration (up to 20mins)
  - 0.3mg/kg IV single dose
  - Most effective for colorectal and caecal distension

### Other analgesics
- NMDA receptor antagonists – Ketamine
  - Prevents central hypersensitivity
  - Used as part of multi-modal therapy
  - 0.4-0.8 mg/kg/h IV CRI
  - Used in conjunction with lignocaine during anaesthesia
  - Most clinical reports on musculoskeletal cases, no literature on visceral pain
- Acupuncture
  - No definitive proof of effect

<table>
<thead>
<tr>
<th>Drug</th>
<th>Dose</th>
<th>Route</th>
<th>Dose Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flunixin meglumine</td>
<td>1 mg/kg</td>
<td>IV</td>
<td>8-12h</td>
</tr>
<tr>
<td></td>
<td>0.5 mg/kg</td>
<td>PO</td>
<td>8-12h</td>
</tr>
<tr>
<td></td>
<td>0.25 mg/kg “Anti-endotoxic”</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>increase dose by up to 1.4x to match effect of IV dose PO</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phenylbutazone</td>
<td>2.2 mg/kg</td>
<td>IV/PO</td>
<td>12h</td>
</tr>
<tr>
<td></td>
<td>4.4 mg/kg (&lt;3 day duration)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Xylazine</td>
<td>0.2-0.5 mg/kg</td>
<td>IV/IM</td>
<td>As required</td>
</tr>
<tr>
<td></td>
<td><em>increase dose by up to 2.5x to match effect of IV dose IM</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Detomidine</td>
<td>0.005-0.04 mg/kg</td>
<td>IV/IM</td>
<td>As required</td>
</tr>
<tr>
<td></td>
<td><em>increase dose by up to 2.5x to match effect of IV dose IM</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Butorphanol</td>
<td>0.01-0.1 mg/kg</td>
<td>IV/IM</td>
<td>4-12h</td>
</tr>
<tr>
<td></td>
<td>18μg/kg IV bolus → CRI 13-23μg/kg/h</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fentanyl</td>
<td>10mg/150kg BW</td>
<td>Transdermal</td>
<td>48-72h</td>
</tr>
<tr>
<td>Lignocaine</td>
<td>1.3mg/kg IV bolus → 0.05mg/kg/min CRI</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>GA: 0.65 mg/kg, IV → CRI 0.025 mg/kg/min</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14ml of 2% solution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N-Butylscopolammonium bromide</td>
<td>0.3mg/kg</td>
<td>IV</td>
<td>Single dose</td>
</tr>
<tr>
<td>Ketamine</td>
<td>0.4-0.8 mg/kg/h</td>
<td>IV</td>
<td>CRI</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Drug</th>
<th>450kg Horse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flunixin meglumine</td>
<td>10mls IV (1 mg/kg, 50mg/ml)</td>
</tr>
<tr>
<td>Xylazine + Butorphanol</td>
<td>2mls IV (0.44mg/kg, 100mg/ml)</td>
</tr>
<tr>
<td>OR</td>
<td>0.4ml IV (0.01mg/kg, 10mg/ml)</td>
</tr>
<tr>
<td>Detomidine + Butorphanol</td>
<td>0.4ml IV (0.008 mg/kg, 10mg/ml)</td>
</tr>
<tr>
<td>OR</td>
<td>0.45ml IV (0.01mg/kg, 10mg/ml)</td>
</tr>
<tr>
<td>Lignocaine</td>
<td>29.25mls IV bolus (1.3mg/kg, 20mg/ml)</td>
</tr>
<tr>
<td></td>
<td>405ml/h CRI (20gm in 6L Hartmanns)</td>
</tr>
</tbody>
</table>
**Severity of pain (poor response to tx)**

High heart rate (>80 bpm)

Poor cardiovascular status (abnormal/cyanotic mucous membranes, skin tent, prolonged CRT (>3s))

? Duration of signs/Duration before admission or treatment

---

**Fluid type**

<table>
<thead>
<tr>
<th>Transudate</th>
<th>Colour</th>
<th>Transparency</th>
<th>Nucleated Cells/μL</th>
<th>Protein g/L</th>
<th>Cytology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow Clear</td>
<td></td>
<td>0-5000</td>
<td>&lt;20/25</td>
<td></td>
<td>Mononuclear cells, non-degenerate neutrophils, small numbers RBC’s</td>
</tr>
</tbody>
</table>

**Modified Transudate**

| Yellow Turbid    |        | 5000 - 10 000 | <20/25             |             | Macrophages and non-degenerate neutrophils predominate        |

**Exudate**

| Yellow to red   | Cloudy | >5000         | >25                |             | Non-degenerate or degenerate neutrophils predominate          |

---

**Plasma**

- Collect blood sample into a heparinized (GREEN top) tube
- Centrifuge blood to obtain plasma
- Set monitor to WHOLE BLOOD MODE
- Place one drop of plasma onto test

**Normal**: 0.59 ± 0.22 mmol/L

**Peritoneal Fluid**

- Collect abdominal fluid into a heparinized (GREEN top) tube
- Set monitor to WHOLE BLOOD MODE
- Place one drop onto test strip

**Normal**: 0.49 ± 0.27 mmol/L

**High negative predictive value for survival with cutoff values of:**

- < 2.2 mmol/L adults
- < 5 mmol/L foals
- < 6 mmol/L reported 95% survival

**Positive predictive value not as accurate, but the suggestion is that:** For each 1 mmol/L increase >6 mmol/L there is a 34% decrease in chances of survival

**No horse with a BPL concentration >8.60 mM survived**

**Increased mortality risk TP >30g/l**

---

**Temp** 37.0 – 38.5 °C

**HR** 36 ± 10

**RR** 12 ± 4

**GIT** + 2-3 ICS/1-1.5min

**MM** Pink, moist

**Digital pulses/heat**

**CRT** <2s

**WNL**

---

**Grade**

<table>
<thead>
<tr>
<th>Unattempted / unsuccessful</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal color and volume</td>
</tr>
<tr>
<td>Normal color but increased volume</td>
</tr>
<tr>
<td>Turbid</td>
</tr>
<tr>
<td>Reddish/bright red</td>
</tr>
<tr>
<td>Green/brown containing intestinal material</td>
</tr>
</tbody>
</table>

---

**Equine Colic Update – Rachel Tan**

17
### Table 1

Topographical locations of the abdomen assessed transcutaneously during fast localised abdominal sonography of horses (FLASH) with colic symptoms and procedure to scan each location.

<table>
<thead>
<tr>
<th>Side</th>
<th>Site</th>
<th>Scanning procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left</td>
<td>1. Ventral abdomen</td>
<td>Place the probe just caudal to the sternum and move caudally to assess the most gravity dependent area of the abdomen.</td>
</tr>
<tr>
<td></td>
<td>2. Gastric window</td>
<td>Visualise the stomach at the level of the 10th left ICS in the middle third (dorsal-ventrally) of the abdomen and then move the probe in the 2-3 ICS cranial and caudal to the 10th.</td>
</tr>
<tr>
<td></td>
<td>3. Spleno-renal window</td>
<td>Freely move the probe between dorsal and middle third of the abdomen at the level of the 15th ICS.</td>
</tr>
<tr>
<td></td>
<td>4. Left middle third of the abdomen</td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>5. Duodenal window</td>
<td>Place the probe in the 14-15th right ICS in the dorsal part of the middle third (dorsal-ventrally) of the abdomen.</td>
</tr>
<tr>
<td></td>
<td>6. Right middle third of the abdomen</td>
<td>Freely move the probe around in the middle third of the abdomen.</td>
</tr>
<tr>
<td></td>
<td>7. Cranial ventral thorax</td>
<td>Place the probe on the cranial ventral thorax just caudal to the triceps muscle.</td>
</tr>
</tbody>
</table>

ICS = intercostal space.

**Nasogastric tube in place**: YES NO

**Abnormal amount of free fluid**: YES NO

**Dilation of the stomach**: YES NO

**Duodenum**

- Normal
- Liquid content, non-turgid
- Dilated and turgid

**Motility**

- YES norm or >
- YES reduced
- NO absent

**Other loops of small intestine visible**

- Normal
- Liquid content, non-turgid
- Dilated and turgid

**Presence of thickened wall loops**: YES NO

**Colon**

- Normal
- Ventral liquid content (1)
- Lateral liquid content (4, 5 or 6)

**Motility**

- YES norm or >
- YES reduced
- NO absent

**Length of the US exam (min)** ................................

- L. Koay visualised: YES NO
- Thorax: free fluid: YES NO

### Test

<table>
<thead>
<tr>
<th>Cautionary result</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PCV</strong></td>
</tr>
<tr>
<td>&gt;54%</td>
</tr>
</tbody>
</table>

**Haematology**

- Endotoxaemia leukocyte profile

**Biochemistry**

- ↑ GGT – right dorsal displacement of large colon
- ↑ Crea – failure to normalise within 72h
- Hyperglycaemia >10.7 mmol/l in first 48h
- Ca <1.27 mmol/l

**Anion Gap**

- >20mEq/l
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ee. Gardner RB et al. Serum gamma glutamyl transferase activity in horses with right or left dorsal displacements of the large colon. JVIM 2005 19:5;761-4.
Evaluation of a protocol for fast localised abdominal sonography of horses (FLASH) admitted for colic

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b Equine Clinic, Department of Clinical Sciences of Companion Animals and Equids, Faculty of Veterinary Medicine, University of Liège, Sart-Tilman, 4000 Liège, Belgium
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A R T I C L E   I N F O

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Keywords:
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Equine Imaging
Ultrasound
Colic

A B S T R A C T

The aim of this prospective study was to establish a protocol for fast localised abdominal sonography of horses (FLASH) admitted for colic. The FLASH protocol was then presented to clinicians without extensive ultrasound (US) experience to determine whether they could learn to use it in less than 15 min. The clinical subjects comprised 36 horses that had been referred for colic over a 2 month period. Each horse was examined at admission and FLASH findings at seven topographical locations were compared to serial clinical examinations, surgical and non-surgical outcomes, or with post-mortem reports. FLASH was able to show free abdominal fluid and abnormal intestinal loops, with a mean time of 10.7 min required to complete the protocol. The positive and negative predictive values of requirement for surgery of dilated turgid small intestinal loops using FLASH were 88.8% and 81.48%, respectively. The results suggested that FLASH is a technique that can be used in an emergency setting by veterinarians without extensive US experience to detect major intra-abdominal abnormalities in horses with colic.

Introduction

Colic is a frequent cause of emergency calls for equine veterinarians, ranked first in importance among medical problems (Traub-Dargatz et al., 1991, 2001; Tinker et al., 1997). There are many causes for colic, ranging from mild to life-threatening or fatal diseases (Abutarbush et al., 2005). One of the main challenges for the equine clinician is early recognition of potentially fatal causes and identification of the need for abdominal surgery (Fischer, 1997).

Abdominal ultrasound (US) has been demonstrated to be accurate for detecting small intestine outflow obstructions (Klohn et al., 1996; Freeman, 2002a) and has become a part of the acute abdomen diagnostic work-up in many equine clinics. Although hand-held US equipment may increase the speed of US in equine patients, US evaluation of the entire equine abdomen is time consuming and difficult to carry out at admission or under field conditions. Focused abdominal US is used in humans and small animals to detect free fluid in emergency patients with blunt abdominal trauma (Boysen et al., 2004; Soudack et al., 2004; Kirkpatrick et al., 2005; Soundappan et al., 2005). The advantage is a rapid non-invasive technique that can be used for early evaluation and for triage following arrival at the emergency clinic (Blavas, 2001; Walcher et al., 2006; Helling et al., 2007; Lee et al., 2007).

A focused abdominal US procedure to be used in horses during admission at the emergency clinic has not been previously described. The aims of this study were: (1) to establish a protocol for fast localised abdominal sonography of horses (FLASH) admitted for colic; (2) to assess the usefulness of a fast US examination limited to specific abdominal regions; and (3) to determine whether FLASH can be performed by clinicians without extensive experience in equine abdominal US in less than 15 min.

Materials and methods

A prospective trial was undertaken on client-owned horses referred for colic at the University of Liège over a 2 month period. Horses were examined within 2 h of admission. Prior to perform FLASH on client-owned horses, five veterinary clinicians without extensive experience of equine abdominal US were trained for 1 h by an experienced radiologist. Horses were included in the study if one of the previously trained clinicians was available at the time of admittance. A table summarising the topographical locations examined with FLASH, normal reference values and examples of normal and abnormal images was given to the trainees.

A hand-held (SonoSite 180PLUS, Bothell) or a portable (Aloka SSD 900, Aloka Holding Europe) US machine, equipped with a 3–3.5 MHz transducer (microconvex and curvilinear, respectively), was used.

Seven topographical locations were assessed using alcohol and without clipping: (1) ventral abdomen; (2) gastric window; (3) spleno-renal window; (4) left middle third of the abdomen; (5) duodenal window; (6) right middle third of the abdomen; and (7) thoracic window. The operators were requested to assess the seven sites starting from the ventral abdomen. Table 1 describes topography and procedure to scan each site.

At each location at least one image was recorded. All recorded images were reviewed for presence or absence of free fluid and dilated turgid small intestinal loops by a board certified radiologist (VB). Because only static images were recorded, intes-
Tinal motility was not evaluated retrospectively. The time used to undertake FLASH was measured from when the probe was first placed on site 1 to completion of assessment of site 7. Preparation time for the horse or the US machine was not included.

The results of each FLASH examination were collected using a standardised form (Fig. 1). The ability of FLASH to detect free fluid, to see the left kidney, to evaluate small bowel filling, turgidity and motility and large intestinal content was assessed.

FLASH results were compared retrospectively with the findings from serial clinical examinations, surgical and non-surgical outcomes, or with post-mortem reports. Data collected about presence of free abdominal fluid and dilated turgid small intestinal loops were compared to the radiologist’s retrospective reading. Sensitivity, specificity, positive and negative predictive values of the presence of dilated turgid small intestinal loops for small intestinal obstruction and for requirement for surgery were calculated.

**Results**

Thirty-six horses were included prospectively (20 mares, 12 geldings, 4 stallions). The age of the horses (rounded to the nearest year) ranged from 2 to 28 years (mean 14 years). Warmbloods were the most represented (27 horses) and this reflected the hospital population.

The five clinicians trained for FLASH comprised three equine interns, one equine surgery resident and one radiology resident. The number of examinations undertaken by each operator varied considerably. The radiology resident performed most of FLASH examinations (20), one was done by the surgery resident and the remaining 15 were equally distributed among the interns. The time used for FLASH ranged between 7 and 17 min, with only three examinations lasting more than 15 min had been performed by two interns (16 and 17 min) and by the radiology resident (16 min).

All the operators were able to obtain US images without clipping. In two instances, there was a disagreement between the retrospective readings and the data collected. The disparity concerned the aspect of small intestinal loops that had been defined as dilated non-turgid by the examiners, and as turgid by the radiologist. There was no disagreement concerning detection of an abnormal amount of abdominal fluid.

Of the 36 horses, 23 had a medical colic (17 had a positive outcome, six were euthanased). Thirteen horses had a surgical colic (10 small intestinal obstructions, one colon displacement, two nephrosplenic entrapments). A definitive diagnosis was available for 10/23 medical cases. FLASH was able to show free abdominal fluid, abnormal small intestinal loops and abnormal colon content (Figs. 2–5). Free fluid was mainly detected ventrally. Sites where abnormal small intestinal loops were seen were not recorded. Abnormal large intestine content was mainly observed in site 1 or in sites 5–6 when the dorsal right colon or caecum were involved, respectively.

An increased amount of free fluid was seen in 10 horses (four with strangulated small intestinal obstruction, six with medical colic). In one horse with medical colic, free pleural fluid was also detected. The left kidney was seen in 29/36 horses, while 2/7 horses in which the left kidney was not seen had a nephrosplenic entrapment. In these horses, images obtained at the spleno–renal window demonstrated US features typical of nephrosplenic entrapment (gas-filled colon between spleen and left kidney obscuring the kidney, lateral spleen displacement; Fig. 6).

The duodenum was observed in all 36 cases and appeared normal in 31 horses. In five horses, the duodenum was fluid-filled, dilated, but non-turgid. Duodenal motility was considered absent in two horses with proximal enteritis.

The small intestine other than duodenum was seen in 27/36 horses (75%). In five horses it had a normal appearance, while 7/9 horses without visible small intestine had a medical colic with positive outcome. The remaining two horses had a small intestinal obstruction and a nephrosplenic entrapment, respectively. Four of the five horses with normal small intestine visible had a pelvic flexure impaction, while the fifth had a small intestinal obstruction.

Evidence of dilated turgid small intestinal loops on US images was associated with surgical colic due to small intestinal obstruction in eight horses and with proximal enteritis in one. Only in 2/10 horses with small intestinal obstruction the small intestine was not seen (one horse) or seemed normal (one horse). Non-turgid fluid-filled small intestinal loops were seen in two horses with simple large bowel displacement (one with nephrosplenic entrapment) and in 11 horses with medical colic. Total absence of small intestinal motility was reported in six horses (three small intestinal obstructions, three medical colics with negative outcomes). In all horses with small intestinal strangulated obstruction motility was reported as absent or reduced. Horses with large intestinal disease had small intestinal motility reported as normal. Thickening of the small bowel wall was reported in two cases with non-turgid and turgid small intestinal loops with respectively infiltrative bowel disease and strangulated small intestinal obstruction.

The colon was defined as normal in 31/36 horses. The only abnormality recorded for the colon was abnormal liquid content (five horses). Fluid content in a large intestine segment, while other portions had a normal appearance, was seen in four horses with colon impaction. No increased colon wall thickness was reported.

The presence of dilated turgid small intestinal loops was 80% sensitive and 96.15% specific for small intestinal obstruction. Positive and negative predictive value of this US sign for small intestinal obstruction were 98.89% and 92.59%, respectively. Sensitivity, specificity, positive and negative predictive values of dilated turgid small intestinal loops for surgical need were 61.54%, 95.65%, 88.89% and 81.48%, respectively, with 2/5 false negative having a nephrosplenic entrapment.

<table>
<thead>
<tr>
<th>Side</th>
<th>Site</th>
<th>Scanning procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left</td>
<td>1. Ventral abdomen</td>
<td>Place the probe just caudal to the sternum and move caudally to assess the most gravity dependent area of the abdomen</td>
</tr>
<tr>
<td></td>
<td>2. Gastric window</td>
<td>Visualise the stomach at the level of the 10th left ICS in the middle third (dorso-ventrally) of the abdomen and then move the probe in the 2–3 ICS cranial and caudal to the 10th</td>
</tr>
<tr>
<td></td>
<td>3. Spleno-renal window</td>
<td>Place the probe between dorsal and middle third of the abdomen at the level of the 17th ICS</td>
</tr>
<tr>
<td></td>
<td>4. Left middle third of the abdomen</td>
<td>Freely move the probe around in the middle third of the abdomen</td>
</tr>
<tr>
<td>Right</td>
<td>5. Duodenal window</td>
<td>Place the probe in the 14–15th right ICS in the dorsal part of the middle third (dorso-ventrally) of the abdomen</td>
</tr>
<tr>
<td></td>
<td>6. Right middle third of the abdomen</td>
<td>Freely move the probe around in the middle third of the abdomen</td>
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<td></td>
<td>7. Cranial ventral thorax</td>
<td>Place the probe on the cranial ventral thorax just caudal to the triceps muscle</td>
</tr>
</tbody>
</table>

ICS – intercostal space.
Focused assessment with sonography in trauma (FAST) was first described in human patients admitted at an emergency clinic for blunt abdominal trauma (Rozycki et al., 1993, 1995; McGahan et al., 1997). The aim of FAST is to detect free abdominal fluid (Kimura and Otsuka, 1991; Pearl and Todd, 1996; Soundappan et al., 2005) and, in humans, has a reported good sensitivity and specific-

![Standardised form used to collect data by each examiner.](fig1.png)

**Fig. 1.** Standardised form used to collect data by each examiner.

**Discussion**

Focused assessment with sonography in trauma (FAST) was first described in human patients admitted at an emergency clinic for...
ity ≥90% (Gruessner et al., 1989; Liu et al., 1993; Rozycki et al., 1993, 1995; McKenney et al., 1996; McGahan et al., 1997).

In FLASH, detection of an increased volume of abdominal fluid was only one of the aims of the focused abdominal US. A small amount of free anechoic abdominal fluid can normally be observed in the horse (Freeman, 2002b) and is routinely collected by non-US-guided abdominocentesis in patients admitted for colic. FLASH forms recorded only cases in which the amount of fluid was subjectively considered increased. No sensitivity or specificity of FLASH for fluid detection in comparison with abdominocentesis or other procedures was calculated, although this has been done for FAST in dogs (Soundappan et al., 2005) and humans (Gruessner et al., 1989; Liu et al., 1993; McKenney et al., 1996). Although some information about quantity and character of peritoneal fluid can be obtained by US (Reef et al., 2004), the type of fluid cannot accurately be determined and FLASH results should be interpreted in conjunction with peritoneal fluid analysis.

FAST in humans and dogs is routinely performed in less than 10 min (Kimura and Otsuka, 1991; Pearl and Todd, 1996; Blaivas, 2001; Soundappan et al., 2005; Helling et al., 2007; Lee et al., 2007). In the present study, the mean elapsed time was 10.7 min, with only three studies lasting more than 15 min. A time of 15 min was considered adequate for an examination to be performed at admission of an emergency patient while other procedures are undertaken on the horse, such as placement of an intravenous catheter or nasogastric tube, or rectal palpation in a stock.

Fig. 2. Ultrasonographic image obtained at site 1: an abnormal amount of anechoic free fluid is visible.

Fig. 3. Ultrasonographic image showing non-turgid fluid-filled small intestinal loops.

Fig. 4. Ultrasonographic image showing turgid small intestinal loops without wall thickening in a horse with small intestinal obstruction.

Fig. 5. Ultrasonographic image showing turgid small intestinal loops with marked wall thickening in a horse with strangulated small intestinal obstruction.
The small intestine was visible in most horses (duodenum in 100%, small intestine other than duodenum in 75% of the horses). These high percentages suggest that the windows chosen mostly covered the areas where small intestine might be observed in colic patients. However, because of the focused nature of FLASH and because horses did not undergo a complete abdominal US after FLASH, it cannot be excluded that dilated loops would have been seen in other locations in false negative cases.

In agreement with previous studies (Klohnen et al., 1996; Scharner et al., 2002), the presence of dilated turgid small intestinal loops was highly sensitive and specific (80% and 96.15%) for small intestinal obstruction and had high positive and negative predictive values (88.89% and 92.59%). Lower sensitivity and lower predictive values for surgical need are due to a relative high number of false negative results. Although the number of horses requiring surgery for large intestinal disease was very low, the inclusion of large intestine surgical disorders in the calculation of the diagnostic values for surgical need necessarily influenced the results.

Since a definitive diagnosis was not possible for a relatively high number of cases, it was difficult to evaluate the ability of FLASH to discriminate ileal impaction and proximal enteritis (that may show dilated turgid small intestinal loops at US) from surgical cases. Although certain tests, including degree of pain, response to analgesia, abdominal US, abdominal fluid colour and protein content, have been reported to be strongly predictive of the need for surgery, no single diagnostic test is 100% accurate (Nolen-Walston et al., 2007). It is therefore evident that additional diagnostic procedures, such as peritoneal fluid analysis, should always be included in assessing a colic patient, particularly in areas with higher incidence of ileal impactions (e.g. South-eastern United States) where it is important to differentiate these from strangulated small intestinal lesions (Plummer, 2009).

Images were reviewed by a Board certified radiologist to estimate the amount of free fluid and to interpret any changes in the small intestinal. In two cases, there was a disagreement between recorded data and retrospective interpretation concerning loop turgidity. Based on static images, it may not be easy to define if small intestinal dilated loops are turgid or not and lack of motility should therefore be used to discriminate between surgical versus non-surgical cases in horses with small intestinal disease (Klohnen et al., 1996; Freeman, 2002a).

We did not verify recorded results of large intestine wall thickness, despite this being a useful parameter to predict torsion in the large colon (Pease et al., 2004). We also did not observe a case of large colon volvulus, so it was impossible to evaluate the usefulness of FLASH to diagnose this condition.

Nephrosplenic entrapment was seen at the nephrosplenic window with the typical US appearance (Santschi et al., 1992; Reef et al., 2004). Inability to see the left kidney is not entirely reliable for a diagnosis of nephrosplenic entrapment (Scharner et al., 2002), although the additional use of rectal palpation can be used to exclude nephrosplenic entrapment.

Several studies about FAST in humans have highlighted its limitations and occasionally inability to detect serious injuries requiring surgery (McGahan et al., 1997; Shammuganathan et al., 1999; Brown et al., 2001; Nunes et al., 2001). Although operators with little experience can perform FLASH, better results are generally obtained with experience. Furthermore, FLASH will primarily be used in emergencies in well lit rooms, alongside other simultaneous procedures, on horses experiencing pain, with portable equipment and limited time, all of which will reduce the diagnostic accuracy of FLASH. In the current study, there were relatively few cases, some without a definitive diagnosis, which made conclusions about the utility of FLASH in specific diseases difficult and for this reason diagnostic values were only calculated for the most prevalent condition, namely, small intestinal obstruction.
Conclusions

This study suggests that FLASH is a technique that can be used in an emergency setting by veterinarians without extensive US experience to detect major intra-abdominal abnormalities in horses with colic. However, horses with persistent symptoms and negative FLASH should still undergo a comprehensive abdominal US examination (or serial exams) as a part of follow-up during clinical observation.

Conflict of interest statement

None of the authors of this paper has a financial or personal relationship with other people or organisations that could appropriately influence or bias the content of the paper.

Acknowledgments

The authors would like to thank the Interns who accepted to participate to the study and all the equine clinicians who supported the study.

References


# Colic Admission Form

**Date:** ........../......./........  **Time:** .................... AM/PM

**Client Name:** ........................................  **Horse Name:** ........................................

## Presenting complaint

## History

<table>
<thead>
<tr>
<th>Duration of current episode:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Onset (acute&amp;severe, low grade&amp;insidious, continuous/intermittent):</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description of behaviour/mentation during episode(s):</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Faecal consistency, amount, regularity:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Diet and management (including dental care, housing, pasture content):</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Medications (including anthelmintic administration, vaccination history):</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Prior episodes of colic or other diseases:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other animals affected?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other information:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>
Equine acute abdominal pain scale version 2 (EAAPS-2): Behaviour can be recorded and the final grade for the severity of is determined by selecting the most severe behaviour manifested, and then choosing one or the other of the two scores for that particular behaviour based on the descriptions below the table.

<table>
<thead>
<tr>
<th></th>
<th>Behaviours</th>
<th>Mild</th>
<th>→</th>
<th>→</th>
<th>→</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Depression</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>↓ Flank watching&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Weight shifting&lt;sup&gt;a&lt;/sup&gt;</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>↓ Pawing&lt;sup&gt;a&lt;/sup&gt;</td>
<td>–</td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stretching&lt;sup&gt;a&lt;/sup&gt;</td>
<td>–</td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>↓ Kicking abdomen&lt;sup&gt;a&lt;/sup&gt;</td>
<td>–</td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Restlessness&lt;sup&gt;b&lt;/sup&gt;</td>
<td>–</td>
<td>2</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sternal recumbency&lt;sup&gt;c&lt;/sup&gt;</td>
<td>–</td>
<td>–</td>
<td>3</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>↓ Attempting to lie down</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lateral recumbency</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>↓ Rolling</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>5</td>
</tr>
<tr>
<td>Severe</td>
<td>Collapse</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>5</td>
</tr>
</tbody>
</table>

<sup>a</sup> The lower score applies if the behaviour is seen RARELY or OCCASIONALLY and the higher score if seen FREQUENTLY or if it is being performed VIOLENTLY.

<sup>b</sup> The lower score applies to a horse that circles in a stall, pivots around with the hind end, or moves for no apparent reason, but only occasionally, and the higher score applies to horses that moves as above, fairly continuously and aimlessly or moves in a jerky or violent manner.

<sup>c</sup> The lower score applies to a horse that is alert, with raised head carriage and the higher score if horse’s head is resting on ground or facing the horse’s side.
### Diagnostic Tests

<table>
<thead>
<tr>
<th>Test</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rectal examination findings:</td>
<td></td>
</tr>
<tr>
<td>Nasogastric intubation:</td>
<td></td>
</tr>
<tr>
<td>Abdominocentesis:</td>
<td></td>
</tr>
<tr>
<td>Ultrasound examination:</td>
<td></td>
</tr>
<tr>
<td>Faecal examination:</td>
<td></td>
</tr>
<tr>
<td>Lactate: Blood</td>
<td></td>
</tr>
<tr>
<td>Peritoneal Fluid</td>
<td></td>
</tr>
<tr>
<td>Other:</td>
<td></td>
</tr>
</tbody>
</table>

**Veterinarian:**

**Student:**

---

Treatment during initial evaluation, including medication:
**Lignocaine bolus (1.3mg/kg)**

<table>
<thead>
<tr>
<th>BW (kg)</th>
<th>x 1.3</th>
<th>= 0 mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>450kg</td>
<td></td>
<td>585mg</td>
</tr>
<tr>
<td>500kg</td>
<td></td>
<td>650mg</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>mg</th>
<th>2% Lidocaine</th>
<th>450kg = 29.25mls</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>(20mg/ml)</td>
<td>500kg = 32.5mls</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>0 ÷ 20</th>
<th>= 0 mls</th>
</tr>
</thead>
</table>

**Lignocaine infusion (0.05mg/kg/min)**

<table>
<thead>
<tr>
<th>BW (kg)</th>
<th>x 0.05</th>
<th>= 0 mg/min</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Bottles</th>
<th>Vol</th>
<th>2% solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>100ml</td>
<td>20mg/ml</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Add into 5L LRS</th>
<th>20 000mg in 6L</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ie 3.33 mg/ml</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>mins</th>
<th>mg/min</th>
<th>mg/ml</th>
<th>mls/hr Lignocaine</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>0 ÷ 3.33</td>
<td>= 0</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>400kg</th>
<th>= 360ml/hr</th>
<th>16.6hrs</th>
<th>(20gms in 6L LRS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>450kg</td>
<td>= 405ml/hr</td>
<td>14.8hrs</td>
<td></td>
</tr>
<tr>
<td>500kg</td>
<td>= 450ml/hr</td>
<td>13.3hrs</td>
<td></td>
</tr>
<tr>
<td>550kg</td>
<td>= 495ml/hr</td>
<td>12.1hrs</td>
<td></td>
</tr>
</tbody>
</table>
This application, designed by a veterinary medicine specialist, will assist both students and practitioners to rapidly calculate fluid therapy requirements for the adult horse. Based on user input of patient body weight and other variables, fluid requirements can be obtained for maintenance, deficits and losses. In addition, calculations can be made for fluid rates (l/hr, drops/sec) and other fluids such as plasma and whole blood. Additional sections are included for other additives such as bicarbonate, potassium and practical composition of oral / enteral fluids.

Although designed specifically for horses, the calculations for most sections can be used for small animals. User data input for small animal weights will provide accurate data for these species, with maintenance fluid requirements set at 60ml/kg/day.

The App is designed for use on both tablets and mobile phones.
Equine Fluid Therapy

Complete the patient data in the white boxes. Horse bodyweight is required for all calculations. Fill individual section data boxes if required. When complete, CLICK on the pink boxes and results will appear in red text within the light green boxes.

Horse Bodyweight (kg)

Plasma Transfusion

For an average 450kg adult horse, 6 to 8L of plasma will increase total protein by 10g/l.

Desired total protein (g/l)

Total protein of recipient (g/l)

Total protein of donor (g/l)

Plasma volume required (litres)

Blood Transfusion

For an average 450kg adult horse, an empirical estimate can be used: 6 to 8L or half the blood volume lost or 1L per desired 1% increase in PCV.

Desired PCV (%)

PCV of recipient (%) PCV of donor (%)

Blood volume required (litres)

Colloids

Volume (l) of colloids required based on bodyweight.

CLICK for: Volume of 6% Hetastarch @ 10ml/kg (litres)

CLICK for: Volume of 10% Pentastarch @ 8ml/kg (litres)

Equine Fluid Therapy

Complete the patient data in the white boxes. Record a zero for any component not required. When complete, CLICK on the pink boxes and results will appear in red text within the light green boxes.

Horse Bodyweight (kg)

CLICK for: Maintenance Fluid Requirements (litres/day)

Fluid deficits are calculated by estimating dehydration as a percentage of bodyweight. The table below can be used as a guide.

Dehydration (%BW)

CLICK for: Total Deficit (l)

Ongoing Losses (l/hr)

CLICK for: Total losses over 24h (l)

Equine Fluid Therapy

Non-saline solutions for parenteral use should be used. They can be made readily available using everyday supermarket and chemical products. The table below provides weights to add to each litre of water to obtain an isotonic solution. Several solutions are given, which may be adjusted to the patient’s individual electrolyte requirements.

Ideally each product should be weighed, but in the field, an approximate dry volume of the product added to sterileley labelled 2L or 5L bottle with a 250ml or 500ml Graduated Cilimeter has been estimated. This can be added to 1L of water to approximate an isotonic solution. In addition, a comparison has been made of the electrolyte composition of each mixture compared to plasma.

The calculation below the table can be used to determine exact dry weights of electrolytes for a given volume of water.

<table>
<thead>
<tr>
<th>Formula</th>
<th>Electrolyte</th>
<th>Product</th>
<th>gm/L</th>
<th>Volume (ml) of dry electrolyte to add to 10L of water using a 30ml Terumo syringe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mix 1</td>
<td>NaCl</td>
<td>Woolworths Table Salt</td>
<td>8.8</td>
<td>80</td>
</tr>
<tr>
<td>Mix 2</td>
<td>NaCl 50%/KCI/KCl</td>
<td>Woolworths Table Salt</td>
<td>4.4</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>KCl</td>
<td>diet-Rite Lite Salt</td>
<td>4.4</td>
<td>34</td>
</tr>
<tr>
<td>Mix 3</td>
<td>NaCl</td>
<td>Woolworths Table Salt</td>
<td>5.9</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>KCI</td>
<td>agVantage KCI</td>
<td>0.3</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>NaHCO3</td>
<td>Woolworths Bicarbonate Soda</td>
<td>3.4</td>
<td>25</td>
</tr>
<tr>
<td>Mix 4</td>
<td>NaCl</td>
<td>Woolworths Table Salt</td>
<td>5.6</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>KCI</td>
<td>diet-Rite Lite Salt</td>
<td>0.9</td>
<td>1</td>
</tr>
</tbody>
</table>