Maggot Debridement Therapy of a Penetrating Abdominal Wound in the Equine Patient

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I. Introduction:

Abdominal wounds in horses present a number of challenges due to the abdomen's gravity dependent nature and high likelihood of contamination. However, these injuries are rarely immediately life threatening (8). Penetration of the abdominal cavity accompanied by prolapse of viscera greatly increases the chance of a fatal peritoneal infection. Closure of abdominal wounds should include the specific muscular layers and frequently requires some form of abdominal drain (8). This report deals specifically with maggot debridement therapy as a means of debridement and disinfection for a penetrating abdominal wound measuring 15 cm in diameter. Due to the large size of this wound and lack of viable tissue remaining to appose during surgery, numerous bandaging techniques and lavages were utilized including medicinal maggots.

II. Case Summary:

History and Presentation

Ruby, a nine-year-old Quarter Horse mare, presented to the MSU-CVM Equine Emergency Service on December 18th, 2016 at approximately 6:30 pm. Earlier in the day her trainer found her trapped between a manure spreader and tractor with a penetrating abdominal wound as well as numerous cuts on her legs. After freeing her, he wrapped her with a quilted leg wrap that was secured tightly to her abdomen with polo leg wraps. Upon presentation she was tachycardic with a heart rate of 56 beats per minute, and tachypnic with a respiratory rate of 56 breaths per minute. Her temperature was 100.9 F within normal limits. She was dehydrated with pale and tacky mucus membranes, but was standing and eating hay on the trailer. Auscultation of her heart and lungs revealed no murmurs or arrhythmias. She had a large wound on the ventral abdomen just caudal to the rib cage, numerous small lacerations on all four limbs,

and a degloving laceration on the right hind limb distal to the hock that exposed the cannon bone. The abdominal wound was right of midline and 15 cm in diameter. It penetrated the abdominal cavity and exposed the apex of the cecum. Abdominal fat was prolapsing from the wound and the broken ends of two costochondral cartilage fragments were palpable.

Surgery

A thoracic ultrasound ruled out the presence of a pneumothorax so an emergency laparotomy was advised. A jugular intravenous catheter was placed and Ruby received lactated Ringer's solution and hetastarch to improve her hydration status and stabilize her for surgery. Gentamicin and potassium penicillin were initiated pre-operatively to provide broad-spectrum antimicrobial coverage. Ruby was placed under general anesthesia and positioned in dorsal recumbency. Her numerous limb wounds were clipped and scrubbed. They were then probed with a sterile glove and metal probe and revealed no evidence of obvious joint involvement. The degloving laceration revealed exposed, yet intact, bone. However, all soft tissue layers were transected. The bone was curetted and the wound was lavaged. Due to the lack of available tissue, no attempt was made to close the injury at this time. All four legs were bandaged and the abdomen was clipped and sterilely prepped for exploratory surgery.

Exploratory surgery was completed through the traumatic abdominal wound and revealed no obviously damaged viscera; however, the wound edges were severely macerated. Two 6 inch segments of costochondral cartilage were removed and the abdominal cavity was generously lavaged. An abdominal drain was placed into the body cavity for continued post-operative lavage, and a penrose drain was placed under the skin flap to allow drainage from the wound and preserve the skin flap as long as possible. The macerated muscle layers were loosely apposed with widely-spaced cruciate sutures, and the subcutaneous tissues and skin were surgically

debrided and apposed as best as possible. Due to the contaminated nature of the wound as well as the lack of viable tissue to close, the largest concerns at this time were peritonitis and evisceration following complete wound dehiscence. Dimethyl sulfoxide and polymyxin B were administered during surgery and recovery. Ruby received constant rate infusions of dexmedetomidine, lidocaine, and dobutamine as well as doses of ketamine, butorphanol, and xylazine to maintain anesthesia and best control pain. Her lidocaine continuous rate infusion was maintained until December 29th for pain control and improved intestinal motility.

Monitoring and Supportive Care

Recovery from anesthesia took approximately three hours and Ruby was extremely reluctant to stand. Once standing, she knuckled forward on both hind limb fetlocks for approximately 30 minutes. A suspected myopathy was confirmed with a serum chemistry showing a CK of 67,000 U/L (reference range 57-283 U/L). Ruby was placed in a hernia belt, and stacked leg wraps were applied to both hind limbs once Ruby was able to leave the recovery stall.

Lactated Ringers solution supplemented with calcium gluconate, magnesium sulfate, and potassium chloride were administered post-operatively until December 22nd. She received methacarbamol on December 19th and 20th to help with post-operative pain and combat reoccurrence of hind limb myopathy. Serial blood work in the days following surgery revealed a leukopenia characterized by a neutropenia. Ruby experienced tachypnea and tachycardia starting December 22nd indicating possible endotoxic showers. She was given polymyxin B and placed in ice boots to combat endotoxemia and prevent laminitis. Aspiration pneumonia and a mild colitis were diagnosed via ultrasonography at this time. Chloramphenicol was added to Ruby's antibiotic regiment, and potassium penicillin was discontinued due to the concern of

antimicrobial induced colitis. Ruby received non-steroidal anti-inflammatory drugs from presentation until February 14th to control inflammation and pain. Gabapentin was given December 25th through December 27th for pain but was discontinued due to the sedative effects.

Ruby received Gastrogard for a month following surgery to combat the formation of gastric ulcers. On January 15th she was switched to misoprostol. Starting on December 25th she received Probios and Platimum Perfomance, both probiotics, as well as Accel in her grain to encourage intestinal health and ensure proper nutritional intake. Due to the continued presence of a mild anemia on blood work, Red Cell, an iron supplementation, was given January 11th through February 16th. Ruby lost approximately 160 pounds during her hospital stay and was placed on corn oil supplementation from January 13th until January 25th to increase caloric intake.

Abdominal Wound Care

Two days post-operatively (December 20th) the abdominal drain was removed and a closed, continuous suction system (WoundVac) was engaged to evacuate peritoneal fluid. This was utilized for 48 hours. The penrose drain was removed and cultured on December 20th as well. Culture and sensitivity results indicated chloramphenicol and gentamicin to be appropriate selections and no antibiotic changes were required.

On December 27th a breathable screen barrier was sutured to Ruby's ventrum in preparation of maggot debridement therapy due to the large amount of necrotic tissue within the wound. Two vials of 250-500 medical grade maggots were ordered from Monarch Lab in Irvin, CA. Ruby's abdominal bandage was removed, and her wound was flushed and cleaned using pulse vacuum. Disinfectant was not used on the wound prior to maggot placement due to its toxic nature to the maggots. On December 29th, 11 days after presentation, using aseptic technique, the maggots were placed on sterile gauze that were apposed to her abdominal wounds

by the sterilized screen barrier. Next, a sterile redi-roll was placed within Ruby's hernia belt, which was loosely applied as a final layer of protection. This bandage was left in place for 72 hours, until January 1st. Subjectively, the larva had doubled in size and the wound appeared to have been well debrided. Conventional wound care such as cold-hose therapy and bandage changes was continued in hospital for approximately 54 days. Gentamicin was discontinued at the time of maggot removal but chloramphenicol was administered for the next month.

Four weeks into Ruby's hospital stay, she had a persistent fever despite the improved condition of her abdominal wound and limb laceration. Continuous purulent drainage from a small laceration lateral to the main abdominal wound prompted an ultrasound. Hyperechoic structures were visible starting at the draining tract and moving cranially. An enlarged space between the muscle layers was visualized. Ruby was sedated and a line block was performed cranial to the draining wound. Six ossified costochondral cartilage fragments, varying in size from less than 1 cm to 6 cm in length, were removed from a 6 cm incision extending cranial from the draining lesion. More fragments were palpable but were not positioned to be removed from the initial incision.

The following day a 6 cm incision was made perpendicular to the previous day's incision and the tract was palpable towards the main abdominal wound. Six more fragments of the same size were removed using the same protocol. Both wounds were flushed and packed with sterile Kerlix. Removal of these fragments ended Ruby's fevers and purulent discharge from the lateral wound. Over the next two weeks the incisions were curetted and bandaged routinely. They were then cleaned and bandaged until they were completely granulated.

Once these wounds began to heal and the integrity of the largest abdominal wound was guaranteed, Ruby was given brief periods out of her hernia belt to allow the sores on her withers

time to heal. Silver sulfadiazine was applied to these sores. On February 10th a custom hernia belt for Ruby's particular injuries arrived. Ruby began wearing this belt daily and the abdominal wound continued to contract while the hernia present on her ventrum began to improve.

Limb Casting and Skin Grafts

Post-operatively, Ruby's right hind limb was kept in a standing wrap. On December 27th and January 1st pulse vacuum debridement was performed. A lower limb cast was applied January 12th and removed January 19th. The wound bed had entirely granulated and wound margins had contracted greatly during this time. A cast incorporating the foot was placed on January 20th and removed on the 26th. The wound had continued to granulate, yet the lower limb was swollen due to the constrictive nature of the cast.

Over the next week Ruby's leg was evaluated every 24 to 48 hours. Her limb was cold-hosed, and she was walked three times daily for 15 minutes to reduce inflammation and edema. On February 2nd it was determined that Ruby's leg had a healthy bed of granulation tissue that was suitable for skin grafts. The granulation bed was trimmed and aseptically cleaned in surgery preparation. This procedure was repeated on February 11th. On February 13th, 28 punch skin grafts were taken from the dorsal right neck after sterile preparation. Each graft was individually placed in a pocket prepared in the granulation tissue. A saline soaked Telfa with amoxicillin/clauvonic acid was placed on the graft site. Twenty-six of the graft source sites were closed and they were all sprayed with an antibiotic ointment. The sutures were removed 9 days later.

Ruby became intensely pruritic following her grafting procedure. In order to avoid self-induced trauma to the graft site, Ruby was tied in the stall and given flunixine meglumine and dexamethasone. Her daily walks were stopped at the time of grafting. She was initially given

acepromazine and then placed on alprazolam. This appeared to stop the traumatizing behavior. Routine evaluation of the grafting site revealed success as the punch grafts began to cover the granulation bed.

Discharge

Ruby was discharged from the hospital 69 days after her initial trauma with instructions to keep her in a hernia belt for a minimum of 4 months with a maximum of 2 hours outside the belt each day. At discharge, her abdominal wound measured 6.5 by 6.0 cm and was padded daily against her hernia belt. Continued drainage from her abdominal wound was minimal and normal for the extend of her initial injury. Following her grafting procedure Ruby developed a gait similar to string-halt in her right hind limb. Even though still evident, this was much improved at the time of discharge. Instructions were given to evaluate her gait after completion of abdominal healing. She was sent home on alpramozol to reduce self-induced trauma to her graft site and three doses of dexamethasone SP to help with pruritus.

III. Discussion

Maggot Therapy

Ruby's abdominal wound presented challenges due to its size, location, and severity. Risk factors for wound infection included the extensive amount of organic debris within the wound as well as inadequate healthy tissue to allow proper closure of the abdominal muscle layers. Maggot debridement therapy was utilized to help shorten the extensive debridement period while inflicting the least amount of wound manipulation. Ruby was a good candidate for maggot therapy due to the large amount of necrotic tissue in her wound as well as our ability to closely monitor her.

The Mayans and Aboriginal tribe of Australia were the first to describe maggot debridement therapy (7). Maggots were a mainstay of human treatment worldwide until antibiotics emerged on the scene (1). The surging concern with antibiotic resistance has brought maggot therapy back into the focus of the medical community. In 1990, the first controlled clinical trials were conducted, and in 2004 the FDA acknowledged maggots as a licensed medical device (13). Some even consider maggots superior when compromised blood flow makes systemic antibiotic application less efficacious for an infected wound (5).

The majority of maggot debridement therapy utilizes the green-bottle blowfly, *Lucilia sericata,* which is described as a "facultative ectoparasite responsible for cutaneous myiasis" (3). *Lucilia sericata* is aerobic in nature, which prevents deep penetration into living tissue (3). The larvae stage of *Lucilia sericata* only feeds on necrotic flesh making it appropriate for therapeutic myiasis contrary to *Cochliomyia hominivorax,* more commonly known as the screw worm, that feeds deep into living tissues (5).

Debridement

The common assumption that maggots "eat" the necrotic tissue is highly over simplified. The maggot excretes alimentary secretions and excretions, or "ASE," that begin to digest necrotic tissue outside of the maggot's body. This biological secretion includes carboxypeptidases A and B, leucine aminopeptidase, collagenase, and serine proteases (3). The effects of these enzymes result in a liquefied substance that the maggots ingest (3). This liquefied substance may be what Lepage speaks of when he references the development of a "reddish-brown" exudate by the second day of therapy and ties it to the removal of necrotic tissue (9). Two specific matrix metalloproteinases included in ASE are similar to the human body's trypsin and chymotrypsin, which play key roles in natural tissue repair (13). The release

of deoxyribonuclease in the plethora of enzymes allows larvae to break down microbial DNA adding to its aseptic properties (13).

The impressive microscopic mandibles of the maggot may not actually bite off dying flesh, but they are used to pull the maggot across the wound landscape while simultaneously spreading ASE. This physical abrasion helps to breakdown the tissue as well (13). This mechanical advantage is why medicinal maggots are listed as a medical device and not as a drug when classified by the Federal Drug Administration (13).

Two studies led by Dr. Ronald Sherman saw wounds treated with maggot therapy achieve complete debridement in less than 14 days and 4 times faster than conventional wound maintenance (12,14). The second study used a rate of 5 to 8 maggots per cm^2, the low end of typical dosage recommendations (14).

Disinfection

In addition to debridement, claims of disinfection properties are being researched. The maggots' secretion of sodium bicarbonate creates a basic environment that is not conducive to bacterial growth (3). Also, antibacterial substances were isolated in a microbe from the gut of a blowfly larval, leading to the assumption that such substances are present within green-bottle fly larvae as well (13).

The complete recovery of a 3-week old foal with methicillin-resistant *staphylococcus aureus* supports claims of a direct antibacterial effect, especially considering that antibiotics were discontinued during maggot therapy (9). The antibacterial properties of maggot therapy are less effective against gram-negative bacteria than gram-positive (9). A synergistic effect between maggot therapy and the administration of gentamicin occurs, as the combination provides broad-spectrum coverage for the animal (2).

An additional level of disinfection is achieved through the maggots' anti-biofilm activity (9). Theoretically, the physical movement of the maggot on the wound would cause biofilm disruption, meaning that free range maggot application provides better results than biobag application. However, it has been demonstrated that ASE itself disrupts and inhibits biofilm formation of *Staphylococcus aureus* and *Pseudomonas aeruginosa* making it highly likely to affect other bacteria in a similar way (10, 11).

Maggot Application

Maggot application comes in two forms: free range and bagged therapy (4). Ruby's application was considered free range because the larvae were not contained in a biobag wound dressing. Direct maggot contact with the tissue provides increased debridement though some discomfort has been reported (7). A biobag dressing contains hydrophilic polyurethane foam and the maggots are kept contained in the netting so that the maggots do not contact the skin directly. This limits the mechanism of debridement to the secretion of ASE since the maggots are barricaded from the wound by the netting (3).

Recommended dosages range from 5-10 to 8-12 maggot/cm^2 with wounds deeper than 2 cm being measured in 3 dimensions (3). With a diameter of 15 cm, the area of Ruby's wound was roughly 180 cm^2 without considering its depth. The maximum number of maggots placed would have been 1000 if all larvae survived shipping, resulting in a dosing rate of just over 5 maggots per square centimeter. Larvae survival is always questionable during shipping and, if application of maggots is going to be delayed for any longer than an overnight delivery, twice as many maggots as needed should be ordered (3). Length of treatment is most frequently reported as 72 hours, an appropriate interval for full larval development (5,9).

IV. Conclusion

Reports indicate that maggot therapy does not involve a residual effect so repeating treatment may provide some benefits and allow for the earlier discontinuance of antibiotics if no other infections persist in the body.(13). Sherman states that "maintenance debridement and maintenance disinfection can promote wound healing" over time. However, Choudhary et al contradicts this claim by reporting "large number of maggots for a short period should be used rather than a small number for an extended period" (3).

Future work on the use of maggot therapy in veterinary medicine should include a more precise dosage range as well as investigation into the benefits of maintenance debridement. Claims of growth stimulation, such as an increase in cytokine and cell proliferation, and disinfection are currently under investigation (9). Disinfection cannot be proven in Ruby's clinical case due the continuance of antibiotics during and after maggot therapy. Proof of growth stimulation would require biopsies of the wound, which were not performed. Certainly, as the push for judicious antibiotic use becomes greater, medical maggots appear to be a medical mechanism worth further investigation and broader utilization.

References:

1. Berglund, Cecilia. *The Use of Maggots in Canine, Feline, and Equine Wound Care*. N.p., 2013. Web. 15 Aug. 2017.

2. Bras, Raul J, and Scott Morrison. "AAEP." *Retrospective Case Series of 20 Horses (2002–2009) Sustaining Puncture Wounds to the Navicular Bursa With Maggot Debridement Therapy as an Adjunctive Treatment*, 2009. *Google Scholar.* Web. 15 Aug. 2017.

3. Choudhary, Vijayata, Mukesh Choudhary, Sunanda Pandey, Vandip D. Chauhan, and J. J. Hasnani. "Maggot Debridement Therapy as Primary Tool to Treat Chronic Wound of Animals." *Veterinary World* 9.4 (2016): 403-09. *Google Scholar*. Web. 15 Aug. 2017.

4. Čičková, Helena, Marek Čambal, Milan Kozánek, and Peter Takac. "Growth and Survival of Bagged Lucilia Sericata Maggots in Wounds of Patients Undergoing Maggot Debridement Therapy." *Evidence-Based Complementary and Alternative Medicine* 2013 (2013): 1-6. *Google Scholar*. Web. 25 July 2017.

5. Dar, Latief Mohammad, Syed Aashiq Hussain, Swaid Abdullah, Adil Rashid, Shradha Parihar, and Faroze Ahmad Rather. "Maggot Therapy and Its Implication in Veterinary Medicine: An Overview." *Jounal of Advanced Veterinary Research* 3 (2013): 47-51. *Advetresearch.com*. Web. 15 Aug. 2017

6. Hanson, R. Reid. "Complications of Equine Wound Management and Dermatologic Surgery." *Veterinary Clinics of North America: Equine Practice* 24.3 (2008): 663-696. *Google Scholar*. Web. 15 Aug. 2017.

7. Jurga F, Morrison SE: Maggot debridement therapy. Alternative therapy for hoof infection and necrosis. Hoofcare and Lameness 2004;78:28.

8. Knottenbelt, Derek C. *Handbook of Equine Wound Management*. Elsevier, 2003.

9. Lepage, O. M., A. Doumbia, M. F. Perron-Lepage, and M. Gangl. "The Use of Maggot Debridement Therapy in 41 Equids." *Equine Veterinary Journal. Supplement.* U.S. National Library of Medicine, Dec. 2012. Web. 14 Aug. 2017.

10. Lopp, Christine T., and Cathleen A. Mochal-King. "Peritonitis, as a Result of a Retrograde Postoperative Incisional Infection." *Journal of Equine Veterinary Science*, vol. 35, no. 11-12, 2015, pp. 966–972. Web. 20 July 2017.

11. Orsini, James A. "Update on Managing Serious Wound Infections in Horses: Wounds Involving Soft Tissues." *Journal of Equine Veterinary Science* 55 (2017): 18-26. *Google Scholar*. Web. 15 Aug. 2017.

12. Sherman, Ronald A. "Maggot versus conservative debridement therapy for the

treatment of pressure ulcers," *Wound Repair and Regeneration* 10 (2002) 208-214. *Google Scholar.* Web. 14 Aug. 2017.

13. Sherman, Ronald A. "Mechanisms of Maggot-Induced Wound Healing: What Do We Know, and Where Do We Go from Here?" *Evidence-Based Complementary and Alternative Medicine*, vol. 2014, 2014, pp. 1–13. *Google Scholar*. Web. 14 Aug. 2017.

14. Sherman, Ronald A., Frderick Wyle, and Michael Vulpe. "Maggot Therapy for treating Pressure Ulcers in Spinal Cord Injury Patient." *The Journal of Spinal Cord Medicine* 18.2 (1995): 71-74 *Google Scholar.* Web. 14 Aug. 2017.