How to Use Continuous-Rate Infusion Catheters for Treatment of Synovial Sepsis

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1. Introduction
Intrasynovial sepsis in horses results in severe lameness and can potentially be career- and/or life threatening. In foals, infectious arthritis secondary to the hematogenous spread of bacteria is the most common form of intrasynovial infections encountered, whereas traumatically induced septic tenosynovitis and infectious arthritis seem to be more common in adults.1–3 Successfully treating an infected synovial structure requires rapidly eliminating the infecting organisms from the synovial structure before irreversible damage occurs.1–3 Recommended treatments include systemic antimicrobials and anti-inflammatory medications, synovial and endoscopic lavages, and arthrotonomies.1–3 Local antimicrobial administration has also been used to improve drug delivery to the site of infection in the form of intra-articular injections,1 intraosseous perfusion,4 regional limb perfusion,5,6 antimicrobial-impregnated polymethyl methacrylate beads,7 antimicrobial-impregnated collagen sponges,8 and continuous-rate infusion (CRI) via indwelling synovial catheters.9–11 Direct intra-articular antimicrobial injections can deliver concentrations greater than 100 times the minimum inhibitory concentration (MIC) of commonly isolated bacterial pathogens.12 To continuously deliver and maintain high intrasynovial antimicrobial MICs, a commercially available continuous-rate infusion systema is available to treat a multitude of joints, tendon sheaths, and bursas (Fig. 1).10

2. Materials and Methods
Pre-CRI Catheter Placement
Synovial fluid should be aspirated for cytologic examination, bacterial culture, and sensitivity. Infected synovial structures should be drained, lavaged, and/or debrided before placing the indwelling, intrasynovial CRI system. The intrasynovial CRI catheter placement system comes with a 14-gauge trochar that contains a peel-away introducer; this trochar can be used only once to lavage a synovial structure for a thorough lavage just before inserting the CRI catheter.

The pump of the CRI system, which is an elastomeric balloon, should be filled with a concentration-dependent antimicrobial solution 10 to 15 minutes before placing the catheter to allow time for the solution to fill the delivery tubing. The CRI administration pump holds a maximum of 100 mL and delivers antimicrobials at a rate of 0.5 mL/h. It is recommended that the administration pump be filled with 48 mL of either 100 mg/mL gentamicin sulfateb or 250 mg/mL amikacin sulfatec, thus providing a 4-day supply of antimicrobials. The pump

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can be refilled if needed. It is likely that other antimicrobials (including time-dependent antimicrobials) could be used as the CRI perfusate based on bacterial culture and sensitivity results; however, no current referenced information is available. Avoid infusing air bubbles into the administration pump to prevent air from entering the flow control tubing within the CRI system. Air bubbles can obstruct the antimicrobial solution through the flow control tubing. Avoid infusing air bubbles into the administration pump to prevent air from entering the flow control tubing within the CRI system. Air bubbles can obstruct the antimicrobial solution through the flow control tubing.\(^9\) Before placing the CRI catheter, ensure that the antimicrobial solution is beading at the end of the infusion tubing and flowing correctly before placing it within the synovial structure.

CRI Catheter Placement

The intrasynovial catheter can be placed after synovial lavage while under general anesthesia or using sedation and local anesthesia. A synovial pouch should be chosen that positions the catheter away from weight-bearing surfaces wherever possible (i.e., the palmar metacarpal joint pouch, plantar tibiotarsal joint pouch, proximal aspect of digital flexor tendon sheath). Aseptic intrasynovial CRI catheter insertion is imperative.

Insert the trochar that contains the peel-away introducer into the infected synovial structure all the way to the hub; it is easier to thread the indwelling catheter if the introducer is fully inserted into the synovial structure. Remove the trochar and pass the crush-resistant 16-gauge indwelling catheter through the introducer until at least 5 cm of the catheter is estimated to be within the synovial structure. Once the catheter is placed, pull the blue tabs on the introducer apart, up, and out of the synovial structure (Fig. 2). Next, attach the CRI administration pump that contains antimicrobials and its infusion tubing to the CRI indwelling catheter. The indwelling catheter and infusion tubing should be secured to the skin with a 2-0 monofilament suture using a simple interrupted pattern (Fig. 3). A sterile, protective bandage is applied over the indwelling catheter and infusion tubing. The excess tubing can be rolled up and placed along the outside of the bandage; position the administration pump on the limb so the tubing is pointed down toward the insertion site to reduce air bubbles from entering the flow control tubing.
entering the tubing (Fig. 4). Additional bandaging can be applied to each side and over the top of the CRI administration pump. This will allow the pump to be secured to the bandage and will permit easy monitoring of the administration pump for functionality. The pump can be filled when necessary without removing the bandage from the catheter insertion site. In general, bandages should be changed every 2 to 3 days to check the entire system. In cases that require more aggressive wound therapy or synovial lavage, the bandages may need to be changed more frequently.

Most intrasynovial CRI catheters are left in place for 5 to 10 days. The longest time period that Les-cun et al. left an intrasynovial CRI catheter in place was 15 days.\textsuperscript{10} The catheter can be removed once treatment has been completed. A sterile bandage is then applied for at least 2 days depending upon the initial injury. Note that synovial fluid may be observed egressing from the catheter site after removal when the catheter has been in place for greater than 5 days.

3. Results and Discussion

Following appropriate medical or surgical therapies for infected synovial structures, the use of an indwelling, intrasynovial CRI catheter is an excellent adjunctive modality of therapy. It has been shown that the mean steady-state synovial fluid gentamicin concentration during continuous infusion is 1,069 μg/mL, which is greater than 100 times the MIC of commonly isolated equine bacterial pathogens.\textsuperscript{12} Because it is cost-effective and yields a high MIC, gentamicin is the author’s antimicrobial of choice when using the intrasynovial CRI system. This antimicrobial delivery method avoids repeated injections, articular damage that results from antimicrobial impregnated beads, damage associated with retrieval of nonabsorbable beads,\textsuperscript{7} and the anatomic limitations of regional limb perfusion.\textsuperscript{6} No significant effects on articular cartilage or synovial membrane histologic scores occurs with the continuous infusion of gentamicin.\textsuperscript{13} Two separate retrospective studies that investigated the efficacy of intrasynovial CRI antimicrobial infusion yielded resolution in 93% of horses with synovial infections.\textsuperscript{10,11}

The advantages of using an intrasynovial CRI catheter include its ease of placement, ability to maintain a high intrasynovial level of antimicrobials while periodically instilling other medications, and ease of removal when therapy is discontinued.\textsuperscript{10} If necessary, it is possible to lavage the infected synovial structure while the indwelling CRI catheter is in place; however, you cannot lavage directly through the catheter system because the intraluminal diameter of the indwelling CRI catheter is too small. Disadvantages of using this CRI catheter include the inability to aspirate synovial fluid through the lumen for synovial fluid analysis because of the small intraluminal diameter of the CRI catheter, unknown effect on articular cartilage if the indwelling catheter is placed against a weightbearing surface, and potential of developing an ascending infection. Indwelling CRI catheters should be placed within joints distant enough to avoid contact with weight-bearing articular surfaces.

The intrasynovial CRI system should be considered when acute synovial infections are refractory to systemic antimicrobial therapy, synovial lavage, drainage, and regional limb perfusion. Intrasynovial CRI catheters have proven to be very effective clinically, and the author recommends implementing them in cases that present with chronic and complicated synovial structure infections.\textsuperscript{10,11}

Acknowledgments

Declaration of Ethics

The Author declares that he has adhered to the Principles of Veterinary Medical Ethics of the AVMA.

Conflict of Interest

The Author declares no conflicts of interest.

References and Footnotes


†Gentamicin Sulfate, VetOne, Boise, ID 83705.

‡Amiglyde-V, Fort Dodge Animal Health, Fort Dodge, IA 50501.