Veterinary Anaesthesia and Analgesia
Formerly the Journal of Veterinary Anaesthesia

Veterinary Anaesthesia and Analgesia, 2013, **40**, 308–315 doi:10.1111/vaa.12016

RESEARCH PAPER

Variability of performance of wound infusion catheters

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Abstract

Objective To compare the distribution of flow from two commercial and one handmade multihole wound infusion catheters.

Study design Open label experimental measurement of flow distribution in a bench top apparatus of handmade (n = 10) and two commercial (n = 10 each) wound infusion catheters with 5–6″ (12–15.2 cm) long diffusion surfaces.

Methods The distribution of 6 mL of distilled water injected at three different injection speeds (0.5, 5, and 120 minutes) through individual triangular pieces of felt cloth fitted over six contiguous regions of the diffusion surface of each catheter was measured in triplicate.

Results The distribution of flow through the six regions was significantly more uniform at the two faster injection speeds. Ninety two per cent of the 120 minute infusion trials resulted in one or more regions producing negligible flow (<5% of total output), and in 16% of the 120 minute trials all the flow came from just one or two regions.

Conclusions Constant-rate infusions of 3 mL hour^{-1} provide erratic distribution of flow from wound infusion catheters in a bench top apparatus. Commercial catheters did not outperform handmade catheters.

Clinical relevance Uneven distribution of flow at low infusion speeds may contribute to inconsistent or unsatisfactory pain relief in patients treated with continuous wound infusions of local anesthetics.

Keywords analgesia, infusion catheter, local anesthetic, pain, postoperative analgesia, wound infusion.

Introduction

Placement of a wound infusion catheter directly into a surgical wound is technically straightforward and allows repeated or continuous administration of local anesthetic in the hours and days following surgical procedures. Infusion of local anesthetic directly into wounds has become a popular method of providing postsurgical analgesia in humans and in the past decade has been adopted as a useful method of postoperative pain treatment in animals (Buback et al. 1996; Radlinsky et al. 2005; Liu et al. 2006). The efficacy of wound infusion with local anesthetic has been extensively evaluated in humans; for example, a single manufacturer lists 47 positive clinical studies of their product line (http://www.iflo.com/clinical_library.php, accessed 12/18/2012). In contrast, very few studies of the procedure in companion animals have been performed or published. There have been two reports of studies evaluating the efficacy of the technique following total ear canal ablation in dogs; only one of these demonstrated a treatment benefit (Radlinsky et al. 2005; Wolfe et al. 2006). Two case series suggest that the procedure has measureable benefit to cats undergoing surgical removal of large fibrosarcomas and that the risk of serious complications is low (Davis et al. 2007; Abelson et al. 2009).

In theory, infiltration of all affected tissue by local anesthetic should provide extremely effective analgesia to surgical wounds, and it seems logical that the procedure should provide at least some relief in most patients. Indeed, the effectiveness of the procedure following a variety of soft tissue and orthopedic procedures in humans has been confirmed by systematic review and meta-analysis of published trial results (Liu et al. 2006). However, improvement in the postoperative experience has not been uniform between and within studies, and some clinical investigators have reported little or no measureable improvement in postoperative patient analgesia in animals or humans (Fredman et al. 2001; Radlinsky et al. 2005; Wu et al. 2005; Polglase et al. 2007). The expectation that this technique should provide analgesia is so strong that both reviewers and authors of some studies speculate that negative results may be attributable to a failure to properly assess patients or the assessment of inappropriate outcome measures (Rowlingson 2001; Radlinsky et al. 2005). In the study reported here we sought to investigate an alternative explanation, that variation in patient response may be due at least in part to failure of the catheter as a delivery system.

Wound infusion catheters typically are small-gauge sterile catheters with a sealed tip and multiple side fenestrations. Whereas multi-hole epidural or nerve block catheters commonly have just three side holes, wound infusion catheters typically have many more closely spaced holes over a diffusion surface that may be up to 23 cm long. To function properly each fenestration must be very small in diameter compared with the diameter of the lumen of the catheter itself. If this were not the case, and the first few holes encountered by fluid flowing through the catheter were large in diameter, then injected anesthetic would exit the catheter through these down the path of least resistance, leaving no flow available at more distal holes. Small fenestration diameters (170–750 μm) are employed to create relatively high resistance to flow through each; at clinically relevant injection pressures this should ideally maintain sufficient hydraulic pressure along the entire length of the diffusion surface of the device to provide for equal distribution of the drug. In some catheter designs other factors may also affect the distribution and flow of anesthetic. For example, catheters that incorporate an internal spiral wire to prevent kinking may have an even smaller effective fenestration diameter because the spiral wire occludes part of the fenestration orifice (Fig. 1). One catheter manufacturer inserts a space-occupying hollow fiber within the catheter lumen through the length of the fenestrated region to promote better distribution of drug (i-Flow corporation 2011).

Since 2003 surgeons in our institution have treated patients with hand-made wound infusion catheters created from 1.27 mm outer diameter polyethylene tubing (Intramedic PE 90 Polyethylene Tubing, I.D. 0.86 mm O.D. 1.27 mm; Becton Dickinson, MD). To create a catheter, a length of tubing is sealed at one end by melting the tip in a flame, and a blunt-tip Luer needle is heated to allow easy insertion into the other end with a tight fit. The catheters are fenestrated by piercing the tubing through-and-through with a 27 gauge needle at 5–10 mm intervals in a spiral pattern beginning 5 mm proximal to the sealed tip, to create infusion catheters in a variety of diffusion surface lengths (the distance from the hole closest to the Luer adapter to the tip of the catheter). The completed catheters are then gas sterilized and selected for each use by the surgeon based on length of the wound and desired total length.

In the years since we began using these catheters and during the course of a prospective clinical trial we observed and documented marked variation in patient wound tenderness despite apparent uniformity in the creation, insertion, and drug administration through the devices (Hardie et al. 2011).

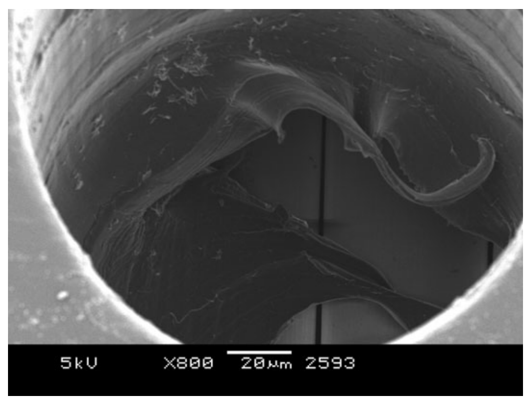

Figure 1 Scanning electron microscopy view (800 × magnification) of a fenestration in a sample of catheter model C. The flat coils of the incorporated spiral wire separated by small linear spaces are visible at the bottom of the hole. Thin, irregular flaps of material at the base of the hole are presumably left by the action of the drill used to create the hole; these partial obstructions of the lumen may also affect flow.

