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SHORT COMMUNICATION

A retrospective comparative provider workload analysis for femoral nerve and adductor canal catheters following knee arthroplasty

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Abstract Adductor canal catheters preserve quadriceps strength better than femoral nerve catheters and may facilitate postoperative ambulation following total knee arthroplasty. However, the effect of this newer technique on provider workload, if any, is unknown. We conducted a retrospective provider workload analysis comparing these two catheter techniques; all other aspects of the clinical pathway remained the same. The primary outcome was number of interventions recorded per patient postoperatively. Secondary outcomes included infusion duration, ambulation distance, opioid consumption, and hospital length of stay. Adductor canal patients required a median (10–90th percentiles) of 0.0 (0.0–2.6) interventions compared to 1.0 (0.3–3.0) interventions for femoral patients ($p < 0.001$); 18/23 adductor canal patients (78 %) compared to 2/22 femoral patients (9 %) required no interventions ($p < 0.001$). Adductor canal catheter infusions lasted 2.0 (1.4–2.0) days compared to 1.5 (1.0–2.7) days in the femoral group ($p = 0.016$). Adductor canal patients ambulated further [mean (SD)] than femoral patients on postoperative day 1 [24.5 (21.7) vs. 11.9 (14.6) meters, respectively; $p = 0.030$] and day 2 [44.9 (26.3) vs. 22.0 (22.2) meters, respectively; $p = 0.003$]. Postoperative opioid consumption and length of stay were similar between groups. We conclude that adductor canal catheters offer both patient and provider benefits when compared to femoral nerve catheters.

Keywords Adductor canal block · Femoral nerve block · Total knee arthroplasty · Workload · Perineural infusion

Despite evidence supporting the benefits of peripheral nerve blocks following total knee arthroplasty (TKA) [1–4], implementation in clinical practice remains inconsistent [5]. Femoral nerve catheters (FNC) are an effective analgesic technique for TKA patients; however, rising concerns over quadriceps weakness [6] and potential fall risk [7], given their associated complications and costs [8], may be influencing a move away from FNC. Adductor canal catheters (ACC) better preserve quadriceps strength [9–11] compared to FNC with greater early functional achievements in TKA patients within a clinical pathway [12]. Despite growing evidence to support ACC, implementation of this newer technique into clinical practice will be

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challenging. Reasons for implementation failure often include systems issues [13] such as resource availability and provider workload, which are not often measured in clinical studies. Although provider workload has been studied for obstetric analgesia [14], no such study has ever been conducted for perioperative perineural catheter-based pain management. Therefore, we designed this study to test the hypothesis that changing from FNC to ACC within an established clinical pathway will result in decreased provider workload during catheter maintenance.

With IRB approval and waiver of informed consent, we employed a database created for a previously-published retrospective cohort study of consecutive patients who underwent TKA over the course of 1 year [12]. We included patients who underwent unilateral primary TKA by a single surgeon, had placement of a perineural catheter, and were admitted postoperatively to the surgical ward in a convenience sample; all others were excluded. During the study interval, the regional analgesic technique changed from FNC to ACC, but all other aspects of the clinical pathway (surgical technique, physical therapy, nursing care, multimodal analgesic regimen) remained the same. All peripheral nerve catheters were placed preoperatively using previously-described ultrasound-guided techniques [15, 16] with short-axis imaging of the target nerve (HFL38, M-Turbo; FUJIFILM Sonosite, Bothell, WA) and in-plane needle/catheter guidance; all patients received a bolus of 20 mL mepivacaine 1.5 % via the placement needle to surround the target nerve followed by flexible catheter insertion (Arrow FlexTip Plus, Teleflex Medical, Research Triangle Park, NC) [12]. Adductor canal catheters were tunneled subcutaneously in a cephalad and lateral direction toward the anterior superior iliac spine to avoid direct compression by the tourniquet.

Intraoperatively, all patients received general anesthesia; however the specific anesthetic regimen was determined by each patient's primary anesthesiologist. A standard tricompartment knee arthroplasty was performed through a medial parapatellar incision under tourniquet control. Before surgical closure, all patients received local infiltration analgesia by the surgeon consisting of epinephrine-containing ropivacaine 0.2 % (150 mL) with ketorolac 30 mg [17]. On arrival to the post anesthesia care unit (PACU), perineural catheters were connected to a portable elastomeric infusion device (ON-Q C-bloc with ONDEMAND; I-Flow Corp, Lake Forest, CA) filled with 550 mL of ropivacaine 0.2 % set to deliver a basal rate of 6 mL/hr with a patient-controlled bolus of 5 mL and 30 min lockout. All patients were prescribed the same multimodal analgesic, nursing, and rehabilitative regimen [12] and evaluated daily by the regional anesthesiology and acute pain medicine team which consisted of the attending and fellow. Patients underwent twice-daily physical therapy including ambulation starting on postoperative day (POD) 1 without the aid of a knee immobilizer on the operative limb.

Table 1 Morphometric data and procedural information

	Femoral ($n = 22$)	Adductor canal ($n = 23$)
Age (years)	66 (52–86)	64 (55–71)
Female/male (#)	2/20	3/20
ASA physical status	3 (2–3)	3 (2–3)
Height (cm)	176 (166–183)	175 (163–194)
Weight (kg)	103 (72–130)	97 (79–154)
BMI (kg/m^2)	32 (26–40)	32 (24–46)
Length of stay (days)	3 (2–7)	3 (2–7)

Values are reported as median (10–90th percentiles) or number of subjects (#), as indicated

ASA American Society of Anesthesiologists

The primary outcome was the number of provider interventions recorded per patient during postoperative catheter maintenance. A "provider intervention" was defined as any bedside visitation by a health care provider (e.g., physician or nurse) beyond routine daily evaluation and requiring action such as modification of the perineural catheter dressing or a change in local anesthetic infusion rate from initial PACU settings. Secondary outcomes included duration of perineural infusion (days), daily ambulation distance (meters), daily opioid consumption (mg morphine equivalents), and hospital length of stay (days). Normality of distribution was determined for all scale variables using NCSS-PASS Statistical Software (Kaysville, UT). For normally-distributed data, single comparisons were performed using Student's t test; for non-normal continuous data, the Mann–Whitney U test was used. The Z test or Barnard's exact test ($n < 5$ in any field) were used for comparisons of categorical data. A two-sided $p < 0.05$ was considered statistically significant for the primary outcome.

From the initial database of 168 TKA patients [12], 45 cases were selected based on inclusion/exclusion criteria; 22 patients received FNC, and 23 patients received ACC (Table 1). ACC required 10 interventions vs. 32 for FNC (Table 2); this represented a median (10–90th percentiles) of 0.0 (0.0–2.6) interventions for the ACC group required compared to 1.0 (0.3–3.0) for the FNC group ($p < 0.001$); 18/23 adductor canal patients (78 %) compared to 2/22 femoral patients (9 %) required no interventions ($p < 0.001$). Patients in the ACC group retained their catheters for 2.0 (1.4–2.0) days vs. 1.5 (1.0–2.7) days for the FNC group ($p = 0.016$). Maximum ambulation distance [mean (SD)] was greater for ACC patients compared to the FNC group on POD 1 [24.5 (21.7) vs. 11.9 (14.6) meters, respectively; $p = 0.030$] and POD 2 [44.9 (26.3) vs. 22.0 (22.2) meters, respectively; $p = 0.003$]. Daily

Table 2 Types and number of perineural catheter-related interventions

	Femoral ($n = 22$)	Adductor canal ($n = 23$)
Catheter clamped due to weakness	3	0
Catheter removed due to weakness	1	0
Catheter clamped prior to physical therapy	20	5
Catheter unclamped due to pain	5	0
Catheter clamped at patient's request	0	2
Dressing change due to leakage	1	0
Pump replacement	1	0
Bedside evaluation due to catheter dislodgment	1	0
Bolus administered via catheter	0	1
Total	32	10

opioid consumption was similar between groups on POD 1 [94.6 (48.5) mg morphine equivalents for FNC and 78.2 (42.2) for ACC] and POD 2 [67.4 (31.8) mg morphine equivalents for FNC and 73.0 (48.4) for ACC].

For patients undergoing TKA, ACC may require fewer provider interventions per patient despite a longer infusion period when compared to FNC, thus decreasing workload when managing perineural catheters and local anesthetic infusions within an established clinical pathway. The present study is the first to demonstrate provider workload benefits in addition to patient benefits from changing regional analgesic technique.

Integration of research-derived evidence into clinical practice remains challenging. This concept of "change implementation failure" occurs in the healthcare setting in spite of support for evidence-based medicine [18]. Obstacles include systems issues such as workflow changes requiring new processes and skilled labor to perform them. Perceptions of "more work" can deter changes in clinical practice, leading to inconsistencies in care and perioperative pain management [5]. However, the results of the present study demonstrate that change (updating a TKA clinical analgesic pathway to incorporate ACC) decreases provider workload related to perineural infusion management, allowing providers to focus on other tasks.

Combining the present study's practice management perspective with data from clinical studies [10, 12, 19] reveals a growing body of evidence to support ACC as the regional analgesic technique of choice within a multimodal analgesic protocol for TKA patients. An effective multimodal analgesic protocol consists of multiple elements that address various mechanisms related to postoperative pain; while local infiltration analgesia administered by surgeons provides short-term pain relief for up to 12 h [20], continuous peripheral nerve blocks still play an important role in extending the duration of targeted local anesthetic effects in addition to systemic opioids and nonsteroidal anti-inflammatory drugs for acute pain management [12]. Establishing standardized clinical pathways for the perioperative pain management of joint replacement patients has been shown to shorten hospital length of stay, decrease perioperative adverse events, and improve outcomes [21, 22].

The median difference of one provider intervention per patient during postoperative catheter maintenance is clinically relevant, especially given that 78 % of adductor canal catheter patients required no interventions at all. A prior study has described the concept of a minimal clinically important difference (MCID), which is defined as "the smallest difference in a particular domain of interest leading to a change in treatment strategy" [23]. In a previous study involving TKA patients, over 40 % of patients receiving perineural ropivacaine via FNC required dose reduction on POD 1 due to quadriceps weakness [3]. Similarly, the majority of FNC interventions recorded in the present study involved stopping the local anesthetic infusion hours to allow resolution of quadriceps motor block prior to physical therapy per the clinical pathway; 91 % of femoral nerve catheter patients required at least 1 intervention. This essentially means that, for every femoral nerve catheter placed, the acute pain service can expect at least one call. In a high volume practice, busy anesthesiologists may not be able to respond in a timely fashion to requests for infusion changes or have the resources available to delegate the duty to another provider; for such practices, one intervention may represent the MCID. Fewer interventions translate into less provider time spent on perineural catheter-related tasks. There are indirect benefits for the physical therapist as well; quadriceps weakness from FNC with inability to ambulate generates unnecessary re-work for the physical therapist (i.e., contacting a provider to stop the perineural infusion then resuming therapy later in the day). Although not measured in the present study, we speculate that choosing interventions that improve clinical outcomes while decreasing overall provider workload may provide higher quality care at lower cost [24].

This study is limited by is its retrospective cohort design. We attempted to minimize bias in patient selection and differences in surgical technique by selecting consecutive patients who underwent unilateral primary TKA performed by a single surgeon; these criteria also limited our sample size. Further, the use of a single Veterans Administration hospital with an academic affiliation and

predominantly male patient population affects the generalizability of our results. The number of interventions may also be practice-specific. For example, local anesthetic infusions at our institution must be temporarily stopped when they cause quadriceps motor weakness in anticipation of physical therapy because patients are expected to ambulate starting the morning of POD 1 without the aid of a knee immobilizer. Practices that utilize knee immobilizers [25] or have developed other means to overcome patients' quadriceps weakness during physical therapy may not have the same need to pause FNC infusions. In addition, the provider performing the intervention (e.g., nurse or physician) may vary based on the practice. However, while the type of provider is important for assigning the specific cost center, decreasing overall bedside interventions regardless of provider may positively affect health care costs across an institution.

In conclusion, changing from FNC to ACC within a clinical pathway for TKA results in fewer perineural catheter-related provider interventions per patient in addition to patient benefits.

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