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## Best Practice

# Implementation and Postoperative Management of Continuous Adductor Canal Catheters for Total Knee Arthroplasty to Reduce Surgical Backlog Related to the COVID-19 Pandemic: An Acute Pain Service Nursing Perspective and Educational Resource

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## A B S T R A C T

**Keywords:**

acute pain service (APS)  
 surgical backlog strategies  
 continuous adductor canal catheter (CACC)  
 nursing educational resource

**Purpose:** In response to the surgical backlog created by the COVID-19 pandemic and to spare valuable hospital resources, we developed and implemented a continuous adductor canal catheter (CACC) program for total knee arthroplasty (TKA) patients. CACC's offer superior analgesia, decrease opioid use, and increase patient satisfaction while simultaneously promoting a decreased length of hospital stay and even same day discharges. The implementation of analgesia protocols using continuous peripheral nerve catheters and isometric pumps has been described for other surgical procedures and populations; however, the role of the Acute Pain Service Nurse (APS RN) in the implementation of such a program has not been described.

**Design:** An best practice initiative for TKA patients receiving CACC was developed and implemented for patients recovering both in the hospital and at home.

**Methods:** We describe the development and implementation of a CACC program for TKA patients in response to the surgical backlog created by the COVID-19 pandemic from the perspective of the APS RN. We provide a detailed narrative description of our postoperative assessment and experience, and offer practical insights for the postoperative care of these patients. We share the educational resources and assessment tools we developed to ensure consistent, safe, and effective clinical management of CACC patients in the hospital and at home.

**Findings:** CACCs via elastomeric pumps have been shown to offer significant advances to pain control following TKA, decrease opioid use, enable earlier discharge, and improve patient satisfaction, all of which we observed unequivocally in our patients. In our experience, implementation of a daily telephone follow up by an APS RN for discharged TKA patients with a CACC was crucial for patient safety, patient satisfaction, and reducing emergency phone calls and emergency room visits.

**Conclusions:** We anticipate this description will provide an invaluable educational resource for other Acute Pain Service programs as similar outpatient peripheral nerve catheter programs are developed in response to the pandemic.

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In march of 2020, in response to COVID-19 and to preserve essential hospital resources, the American College of Surgeons recommended halting all elective surgeries until the spread of COVID-19 was controlled. The global number of surgeries cancelled during the first 12 weeks of the COVID-19 pandemic was estimated at 28,404,603.<sup>1</sup> Total knee arthroplasty (TKA), a high-

volume elective procedure, saw pause in response to the spread of COVID-19, and it is estimated that 205,128 TKA would have been performed during the initial 12-week halt of surgeries in the United States alone.<sup>2</sup>

It was estimated that countries would require 45 weeks to clear the surgical backlog created during those first 12 weeks of cancellations if surgical capacity was increased by 20% following the pandemic.<sup>1</sup> Thus, it was critical that institutions planned initiatives that could safely address the surgical backlog created by the pandemic. One such initiative was the development and implementation of analgesia protocols using continuous peripheral nerve catheters to allow safe, earlier discharge of TKA patients. This allowed more

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surgeries to continue while still preserving bed space for COVID-19 patients. Additionally, this initiative reduced opioid use, a parallel global priority.

Although the implementation of analgesia protocols using continuous peripheral nerve catheters has been described for other surgical procedures and populations.<sup>3,4</sup> However, the role of the Acute Pain Service Nurse (APS RN) in the implementation of such a program has not been described. Studies show that compliance with new evidence-based practice changes is improved by enhancing nurses' understanding and knowledge of the new initiative.<sup>5-7</sup> To maximize the success of program implementation, we developed standardized nursing procedures related to the management and follow-up of patients receiving a continuous peripheral nerve local anesthetic infusion, as well as educational and assessment resources to guide nursing practice. By implementing this program, we sought to enable earlier patient discharge, decrease opioid consumption, improve patient's postoperative experience, minimize the incidence of adverse events, and promote nursing compliance and consistent patient care.

In this paper, we describe the development and implementation of a continuous adductor canal catheter (CACC) program for TKA patients. The program was created in response to the surgical backlog created by the COVID-19 pandemic. We provide a detailed description of our postoperative assessment and experience and offer practical insights for the postoperative care of these patients. We share the educational resources and assessment tools we developed to ensure consistent, safe, and effective clinical management of CACC patients in the hospital and at home. We anticipate this will be an invaluable educational resource for other Acute Pain Service programs as similar outpatient peripheral nerve catheter programs are developed in response to the pandemic.

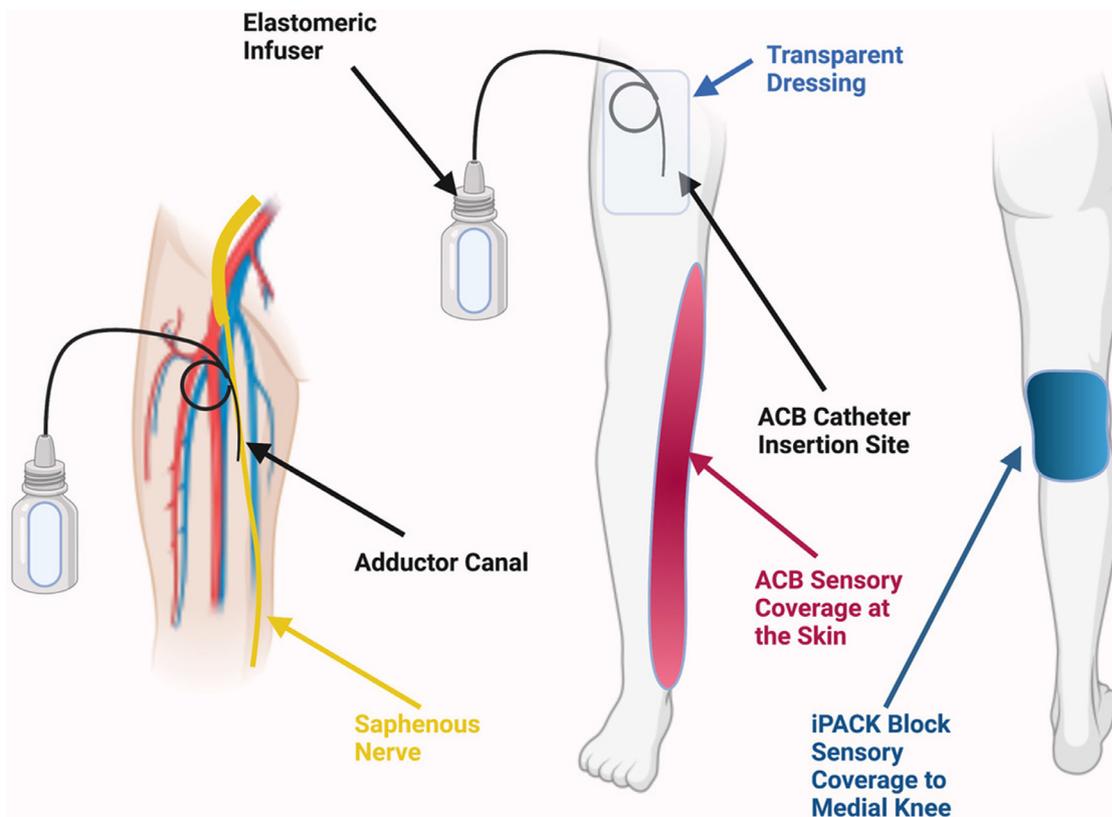
## Background

### Peripheral Nerve Blocks

Pain management strategies for TKA have become increasingly focused on the parallel goals of reducing opioid use and preserving patient mobility. The adductor canal block (ACB) and infiltration between the Popliteal Artery and Capsule of the posterior Knee (iPACK) block are among the new initiatives gaining popularity as effective analgesic strategies following TKA. In brief, adductor canal and iPACK blocks involve the deposition of local anesthetic around the nerve bundles and terminal nerves respectively, that are responsible for the sensory innervation of the surgical site.

The ACB targets the saphenous nerve, nerve to vastus medialis, and branches of the obturator nerve found in the adductor canal with minimal compromise of the motor function of the quadriceps muscle.<sup>8,9</sup> Clinically, ACBs provide analgesia to the anterior and medial aspects of the knee joint. ACBs are performed under ultrasound guidance and can either be a single shot technique with a one-time injection of local anesthetic or a catheter technique where a catheter is inserted at the time of the initial injection to allow for a continuous infusion of local anesthetic (Figure 1).<sup>8</sup> In the literature, continuous adductor canal catheters (CACC) have been shown to provide superior analgesia, decrease length of hospital stay, increase the degree of maximum knee flexion postoperatively, decrease health care costs, and lower opioid requirements.<sup>10,11</sup> This nonopioid method of analgesia is therefore recommended for extended pain relief and for enhanced recovery after TKA.<sup>10,11</sup>

Since posterior knee pain is not covered by the ACB, the addition of a single shot iPACK block can further optimize posterior pain control for up to 36 hours, decrease opioid requirements, and promote early ambulation.<sup>12</sup> The iPACK block targets the terminal articular



**Figure 1.** Schematic representation of the Adductor Canal Block (with catheter and infuser) and iPACK blocks. Created with BioRender.com. This figure is available in color online at [www.jopan.org](http://www.jopan.org).

sensory branches, without involvement of the motor branches, of the tibial and common peroneal nerves.<sup>12</sup> Clinically, the iPACK block provides analgesia to the posterior aspect of the knee joint.

While continuous peripheral nerve blocks have enormous potential for reducing opioid consumption and enabling early discharge, they are not without risks. Complications associated with continuous local anesthetic infusion via CACCs include drug leakage, catheter disconnection/dislodgement/migration/blockage, elastomeric pump malfunction, local anesthetic toxicity, catheter site infection, bleeding from the catheter site, motor function impairment/falls, and inadequate analgesia.<sup>13,14</sup> Nevertheless, the literature supports that the incidence of adverse events is low and that CACCs remain a safe and effective analgesia technique.<sup>13–15</sup>

### Elastomeric Infusors

To support same day discharge, elastomeric infusors (Figure 1) are being used to facilitate the continuous delivery of local anesthetic out of the hospital.<sup>16</sup> There are several commercialized elastomeric infusion pumps available offering a variety of volume options and infusion rates, including both fixed and adjustable rates.

### Implementation

In the operating room, patients received a CACC in combination with an iPACK block, as well as either a spinal or general anesthetic. Following the procedure, the attending anesthesiologist reassessed the CACC under ultrasound guidance to rule out intraoperative dislodgement and started a 0.2% ropivacaine infusion via an elastomeric infuser. Patients were prescribed a

standard multimodal analgesia regimen consisting of scheduled doses of acetaminophen and celecoxib for 7 days (unless contraindicated), and oxycodone 5 mg tabs “as needed” while in hospital and on discharge. Thereafter, patient follow-up was taken over by the APS RN with back up provided by the attending anesthesiologist who inserted the CACC.

### Education

During the presurgical clinic visit, patients received information about the CACC and elastomeric pump from an anesthesiologist and given an educational pamphlet (Table 1). This pre-op education was reinforced and an opportunity for questions provided immediately before the insertion of the catheter in the block room by the attending anesthesiologist. Postoperatively, before being discharged home, CACC education was revisited by either the attending anesthesiologist or the APS RN. Key elements included the partial analgesia afforded by the CACC and the concomitant need for multimodal analgesia, including cold therapy; the pain scale (Numerical Rating Scale (NRS) or Visual Analogue Scale (VAS))<sup>17</sup> and when to take an opioid; expected locations of pain; common or serious complications including insertion site leakage and local anesthetic systemic toxicity; expectations regarding postoperative activity level with the CACC, and finally a reminder that they would receive a daily visit (inpatient) or phone call (outpatient) from the APS RN for the duration of the local anesthetic infusion. Discharged patients were aware that they would be removing the catheter themselves with the phone support of the APS RN once the infusion was completed, and were given contact information for the anesthesiologist on call via the hospital operator in case of emergency.

**Table 1**  
Patient Education. Highlights of Content Covered in Educational Pamphlet Given to Patients

Questions	Information Provided
What is a continuous peripheral nerve block?	A continuous peripheral nerve block delivers pain medication near specific groups of nerves to provide targeted pain relief at the surgical location.
What are the benefits?	Superior analgesia, decrease in opioid requirements, decreased opioid-related side effects, earlier ambulation/participation in physiotherapy, shorter hospital stay, improved patient satisfaction.
What are the risks?	Nerve blocks are safe and have been used for many years. Complications are infrequent but may include bleeding, infection, nerve damage, or adverse effect from local anesthetic. The most common complication is that the catheter becomes dislodged or begins to leak before the infusion being complete.
How/when is the nerve block inserted?	The nerve block and catheter will be inserted pre operatively. Pain medication and local anesthetic will be given to ensure comfort during the procedure. Once the nerve block is completed, you will proceed to the operating room.
What is a continuous adductor canal catheter?	A continuous adductor canal catheter is a small tube inserted into your thigh to deliver freezing medication to a group of nerves that normally deliver pain signals from your knee to your brain. The tube is connected to a small infuser that will provide local anesthetic medication (freezing) to your knee for 3 to 4 days, greatly reducing the pain that you will experience after surgery.
How do I care for the catheter?	Do not get the bandage, catheter, or infuser wet (no showering/bathing), keep the infuser bottle with you at all times at waist level (using provided carrying pack), keep the infuser out of direct sunlight and do not expose to extreme heat/cold. If the catheter dislodges/becomes disconnected, DO NOT reconnect, call the anesthesiologist and direction will be provided on removing the catheter.
Will I need to take additional pain medication?	Even with an effective continuous adductor canal catheter, it is normal to have mild to moderate pain. Your surgeon will provide you with a prescription for several pain medications to manage pain after surgery. Please read and follow the instructions carefully.
Can I walk/perform exercises with the catheter?	Yes, you can do some activities and exercises as recommended by physiotherapy. It is very important not to do more than the prescribed exercises even if you are feeling well and comfortable as this could result in increased swelling, pain, and bleeding at your surgical site.
When do I remove the catheter?	You will receive daily phone calls from the Acute Pain Service nurse. We will discuss when it is time to remove the catheter and walk you through the process of removing the catheter over the phone.
What can I expect after I remove the catheter?	It is normal to experience pain in your knee for days to weeks after your surgery. When the catheter is removed, your lower leg will become gradually less numb, and pain may increase slightly. Continue to take pain medications as prescribed by your surgeon.
How do I get in touch with the anesthesiologist?	The Acute Pain Service nurse will call you every day that the catheter is in place to check on your recovery and answer any questions you may have. Please write down your questions to be answered during your follow up call.
Call the anesthesiologist or go to the nearest emergency department if:	Pain/swelling at the catheter site, ringing in ears, metallic taste in mouth, numb tongue, seizures. Contact information for hospital operator with direction for patients to identify as a ‘nerve catheter patient’ and ask for the anesthesiologist on call. Hospital operators were updated on this practice initiative.

**Continuous Outpatient TKA Follow Up Form**

- Copy of patient's home script should be attached to this form  
 - Anesthetic: GA // Spinal Adductor Cath iPACK - Procedure: \_\_\_\_\_

Patient Sticker

Surgical Date and Time: \_\_\_\_\_ Discharge Date and Time: \_\_\_\_\_ LOS: \_\_\_\_\_  
 Surgeon: \_\_\_\_\_ Anesthesiologist: \_\_\_\_\_

**Postoperative Day**

Postoperative Day	POD 1	POD 2	POD 3	POD 4	POD 5
Avg Pain score (VAS 0-10) at rest/activity	_____	_____	_____	_____	_____
Pain Location front of knee, behind knee, upper thigh, lower thigh, other	_____	_____	_____	_____	_____
Pain interfering with sleep?	<input type="checkbox"/> YES <input type="checkbox"/> NO				
Opioids taken / 24 hours	_____	_____	_____	_____	_____
Morphine equivalents/24hrs	_____	_____	_____	_____	_____
Non opioid used: NSAID BID	<input type="checkbox"/> YES <input type="checkbox"/> NO				
Non opioid: Tylenol 1000 TID	<input type="checkbox"/> YES <input type="checkbox"/> NO				
Elastomeric Infusor: less empty than previous day?	<input type="checkbox"/> YES <input type="checkbox"/> NO				
Decreased sensation/numbness in saphenous N distribution	<input type="checkbox"/> YES <input type="checkbox"/> NO				
Concerns at catheter site? (leaking, signs of infection, hematoma)	<input type="checkbox"/> YES <input type="checkbox"/> NO				
Home exercises performed?	<input type="checkbox"/> YES <input type="checkbox"/> NO				
Walking?	<input type="checkbox"/> YES <input type="checkbox"/> NO				
Falls/Motor weakness?	<input type="checkbox"/> YES <input type="checkbox"/> NO				
Signs of Local Anesthetic Toxicity? Ringing in ears, metallic taste in mouth, mouth or tongue feels numb	<input type="checkbox"/> YES <input type="checkbox"/> NO				
Patient satisfaction score (0-10)	_____	_____	_____	_____	_____
Additional Notes and Comments -chronic pain history and baseline meds -history of substance use/abuse -baseline motor function (knee buckling, gait aids, quads strength)					

**Figure 2.** Standardized Follow up Assessment Form. Assessment tool used with standardized questions for follow up phone calls. GA, general anesthetic; ACB, adductor canal block; ACC, adductor canal catheter, CACC, continuous adductor canal catheter; iPACK, infiltration between the popliteal artery and capsule of the posterior knee; VAS, visual analogue score; NSAID, non steroidal anti-inflammatory drug; BID, twice daily; TID, three times daily; Saphenous N distribution, saphenous nerve distribution. This figure is available in color online at [www.jopan.org](http://www.jopan.org).

**Impact Assessment**

Patients were asked a standard set of questions on a daily basis to monitor for adverse events and to assess efficacy of the CACC; questions addressed many issues including pain scores (NSR and/or VAS), pain location, sensation to the medial aspect of the operative leg below the knee, opioid consumption, use of non-opioid and non-pharmacological modalities, appearance of the catheter insertion site, appearance of the elastomeric infusion pump, ability to ambulate and perform physiotherapy exercises, and overall patient satisfaction (Figure 2). Assessments, either in person or via telephone, were charted as a free text note in the electronic medical record by the APS RN. Any concerns were reported directly to the responsible anesthesiologist. Surgical issues detected during phone calls were referred to the surgical team. Information collected regarding CACC efficacy (eg, pain location, medial lower leg sensation, and opioid consumption) and adverse events from the follow up phone calls was presented regularly to the CACC implementation team. From a quality improvement perspective, close attention was given to ensure this initiative was providing safe and superior analgesia compared to the previously used TKA analgesic protocol of spinal opioid and PAI +/- single shot ACB/iPACK blocks. Figure 3 represents an example of our reports to the implementation team highlighting the decrease in opioid consumption and increase in patient satisfaction associated with CACC when compared to patients who received a spinal plus a single shot ACB/iPACK. Of note, this figure represents early patient reports and the observed differences in patient satisfaction and opioid use continued to

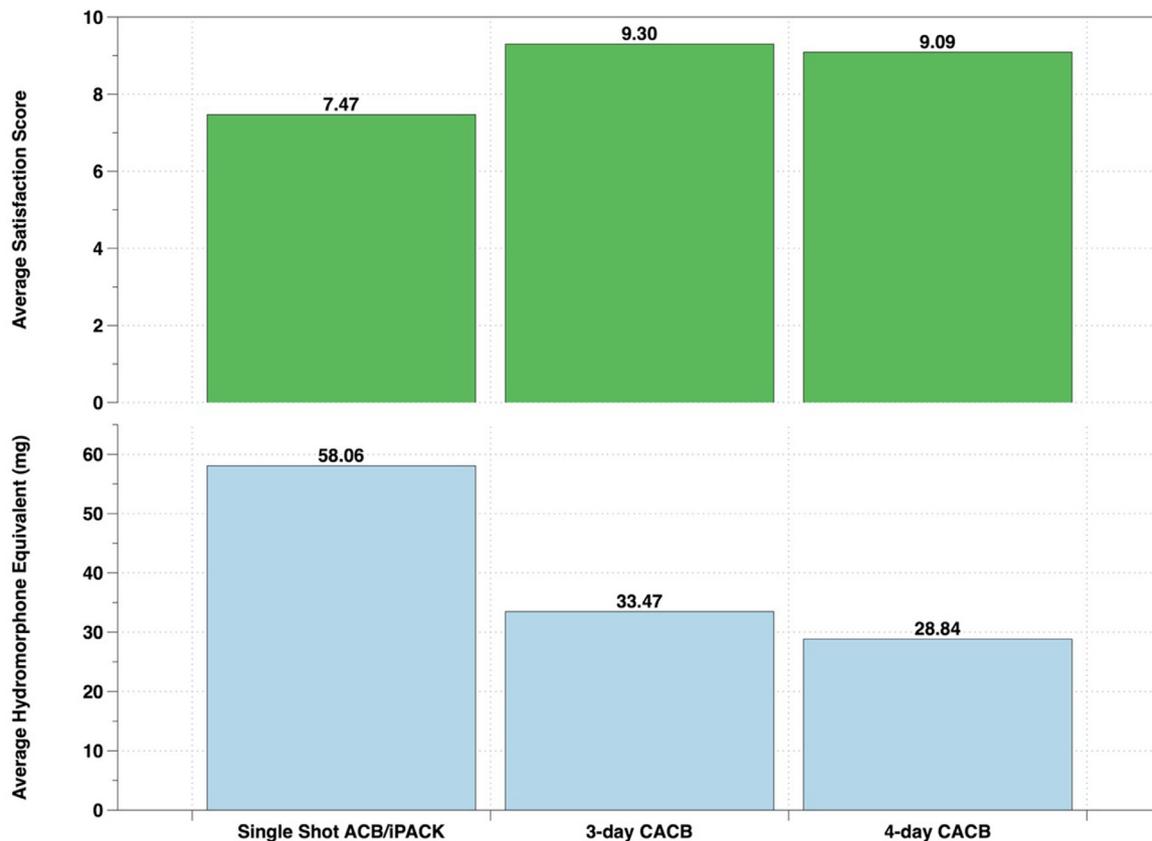
widen as our team gained more experience with the catheter insertion and fixation techniques. We also included all patients in our summary reports to the implementation team, including those with a history of chronic opioid use preoperatively and those whose CACC became dislodged or otherwise malfunctioned.

*Pain Scores*

Since the CACC provides sensory coverage only to the anterior and medial regions of the knee, patients still experienced some pain following their TKA, although average pain scores tended to be lower. One study found that patients recovering from a TKA with a CACC reported average pain scores 38% lower with a reduced opioid consumption of 51% (in morphine milligram equivalents) than those who received single shot spinal anesthetic and PAI only.<sup>18</sup> We observed that patients were able to report their pain scores more accurately and we were able to see more differences in pain scores after education with the NRS/VAS pain scales.

*Pain Location*

Although we did not find pain location reported in the literature as a marker of CACC function, we found that it is critically important to determine whether the CACC is functioning optimally. Patients reported pain in several specific locations following TKA, namely, the posterior knee, anterior/medial knee, distal thigh, proximal thigh, and calf.



**Figure 3.** Early data report: decreased opioid consumption and increased patient satisfaction. Example of early data reported to the perioperative implementation team highlighting the decrease in opioid consumption and increase in patient satisfaction seen in patients receiving a continuous adductor canal catheter (CACB) when compared to patients who received a single shot adductor canal block (ACB). Both groups also received a spinal and single shot iPACK block. This figure is available in color online at [www.jopan.org](http://www.jopan.org).

Patients with a well-working CACC most commonly reported pain in the distal thigh, upper thigh or posterior knee. Patients without a CACC, or one that wasn't functioning optimally, invariably reported their worst pain in the antero-medial knee. We also noted that when the CACC infusion was completed, the location of maximum pain often changed from an alternative location to the antero-medial knee. During follow up assessments, patients were reminded that the CACC does not alleviate all post-operative pain and reassured regarding the functionality of the CACC based on their reported location(s) of pain.

#### Lower Leg Sensation

Since the saphenous nerve supplies sensory innervation to the skin of the medial aspect of the lower leg, we asked patients to test the sensation of their medial lower leg to light touch and compare it with either the lateral lower leg or the medial lower leg of the non-operative limb. We found that with an effective CACC, patients generally reported some decrease in sensation to the medial side of the operative leg. While the loss of sensation was most pronounced immediately postoperatively after the initial bolus dose of local anesthetic, most patients continued to report a distinct difference in sensation between the operative and nonoperative medial lower leg for the duration of the infusion. This objective sensory loss proved useful in decreasing patients' anxiety when they questioned the efficacy of their CACC, and we encouraged patients to test medial lower leg sensation on their own if they were concerned.

#### Appearance of Catheter Insertion Site

Patients were asked to describe the condition of their CACC dressing, specifically if any fluid or blood was collecting underneath, or leaking

beyond the borders of the transparent dressing, and if there was any erythema or localized tenderness to palpation. Leaking of clear fluid at the CACC insertion site was not an infrequent complication (usually backtracking of local anesthetic along the catheter path), however it posed no threat to the patient provided they did not find it distressing and were still experiencing effective analgesia. If leaking was present, patients were instructed to reinforce the dressing with gauze to prevent clothing from becoming dampened. On rare occasions, if the leak was very large or the patient found it distressing, we removed the CACC before completion of the infusion. Vascular puncture leading to the formation of hematoma is uncommon after the placement of CACCs and occurs in greater than 5% of blocks.<sup>19</sup> Infection at the site is also infrequent, with a reported incidence of 0% to 5.2%, while abscess formation is rarely reported (<0.4%).<sup>20</sup> In cases of suspected hematoma or infection, discontinuing the ACC infusion and removing the catheter is recommended.<sup>19</sup> Accidental dislodgement of the CACC catheter is possible despite meticulous attention to the dressing technique and prevention of any tension on the catheter-infusor connection site. Daily reminders to patients to be aware of their infuser and to secure the pump before ambulation can help decrease the potential for dislodgement.<sup>19</sup>

#### Appearance of Elastomeric Infusor

There are a variety of commercially available elastomeric infusors with varying appearances and flow rates. Due to slow infusion rates and initial reservoir balloon size, it is very difficult to appreciate volume depletion over a short time frame, however there should be notable differences on a 24 hour basis that patients are able to recognize and describe over the phone. A very common concern on the first post-operative phone call (usually 16-18 hours after the infusor is connected) is that the infusor is not emptying. This is managed with

reassurance and further education. Catheter kinking or obstruction is a rare but possible occurrence which would result in the inability of local anesthetic to be infused. In our experience, this was usually noticed immediately postoperatively and dealt with before discharge by the attending anesthesiologist. However, if a discharged patient was displaying no analgesic effect combined with no visible volume changes to the infuser after 36 hours, the CACC would be discontinued.<sup>21</sup>

#### *Falls and Motor Weakness*

Before the implementation of the program, falls and motor weakness were one of the primary concerns of the CACC implementation team. Patients received a thorough physiotherapy assessment before discharge and were required to successfully navigate a previously determined ambulation distance and number of stairs. Once discharged, patients were asked daily about perceived weakness and whether there was any change in their ability to complete the assigned exercises. We found that motor weakness related to the catheter infusion itself was very rare, and far more likely to be related to breakthrough pain. There were no falls as a result of the CACC. The few cases (out of several hundred) where motor weakness developed during the catheter infusion were all in patients less than five feet tall receiving a fixed rate infusion of 8mls/hr. After noticing this pattern, we began using an infusion rate of 5 mLs/hr for all patients five feet tall or less.

#### *Signs of Local Anesthetic Systemic Toxicity*

A very rare complication of CACCs is local anesthetic systemic toxicity.<sup>22,23</sup> Due to the potential severity of this complication, patients were screened daily for signs and symptoms of local anesthetic toxicity. Additionally, special mention of this complication was referenced in the educational handouts with instructions to report to the nearest emergency department should any symptoms develop. Signs and symptoms of local anesthetic toxicity include agitation, dizziness, confusion, tinnitus, perioral numbness, metallic taste, dysrhythmia, seizures, and cardiac arrest.<sup>19</sup> When completing daily assessments, a practical consideration was to distinguish between new and pre-existing tinnitus. In our population we found that baseline tinnitus was not infrequent.

#### *Removal and Disposal of the ACB Catheter and Elastomeric Infusor*

We secured CACCs using a transparent dressing and skin glue at the point of insertion. Catheter tubing was then coiled and secured to the patients' skin using several pieces of tape. Patients were walked through the adductor canal catheter (ACC) removal process over the phone, beginning with a statement of encouragement and reassurance: "There is no wrong way to do this," and comparing the process to the removal of a simple bandage, as many patients voiced anxieties regarding the self-removal process, but subsequently found the process very easy. Patients were instructed to begin removing the tape proximally at the coiled catheter tubing, or wherever the dressing might have begun to lift, then work around the edges of the transparent dressing, gently pulling outwards and upwards in the direction of their hip. Most of the time the catheter adhered to the transparent dressing due to the skin glue and came out as the dressing was removed. However, if the catheter remained once the dressing was removed, patients were instructed to pull out the catheter with gentle tension in the direction of their hip. The actual catheter removal is painless; however, there is discomfort associated with removal of the transparent dressings. Patients were given the option of applying a bandage to the ACC insertion site following removal based on personal preference, but most found it unnecessary. Scant serosanguinous or clear fluid oozing was occasionally reported after removal of the ACC. Frank blood was very rare despite all patients receiving postoperative anticoagulation for DVT prophylaxis. To ensure the

removal of the entire catheter, patients were asked to confirm if the tip was intact as evidenced by a black dot on the distal end. All components of the catheter and elastomeric infusion pump were discarded in the garbage. Inpatients had their ACC removed by either the APS RN or an anesthesiologist following the same process described above.

#### **Lessons Learned**

1. Daily phone calls by an RN for the duration of the CACC infusion were paramount for both patient safety and patient satisfaction. With respect to patient education and safety, we were able to identify and correct many errors with respect to patients' postoperative pharmacologic regimens (eg, exceeding the daily recommended dose of acetaminophen, or not taking their anticoagulant) and their postoperative activity levels (eg, exceeding the recommended activity levels or ambulating without a gait aid). This was the case despite ample preoperative and pre-discharge education. With respect to patient satisfaction, patients rated the phone calls very highly and reported feeling very supported and satisfied, even in cases where the CACC did not work optimally. Further, the daily phone calls were frequently cited as the key element in patients' decision to consent to same day discharge.
2. The anticipated time spent talking with patients was vastly underestimated. Patients often had multiple questions and required frequent repetition of discharge instructions despite receiving written instructions and access to an electronic app with educational resources. In some cases, patients could be very tangential as well and it was imperative for the APS RN making the phone calls to be able to respectfully redirect conversations to stay focused on the CACC follow-up assessment.
3. Daily reinforcement of multimodal analgesia uses and nonpharmacological strategies were required despite preoperative preparation and the extensive discharge education provided. In many cases, this education was key to decreasing inappropriate and excessive opioid use and occasionally for patient safety as well (as mentioned in point 1).
4. An effective CACC vastly decreases the amount of pain patients experience postoperatively, particularly with activity. A frequent point of education that we had not anticipated was to discourage activity levels in excess of those recommended by physiotherapy as many patients were so comfortable, they felt they were capable of more than the prescribed activity. This caused concern for hemorrhage into the wound as well as excessive pain when the local anesthetic effect ended.
5. Despite verbal and written instructions to wait for a phone call to remove the ACC when the infusion was completed, some patients removed the catheter on their own. Phone calls earlier in the morning (0800-0930) from the APS RN proved to help reduce this occurrence. Patients that removed the catheter on their own were asked to retrieve the catheter to confirm that the catheter tip was present.
6. Patients were fearful of the pain after the ACC was discontinued (POD#3-4 depending on elastomeric pump). Since we found that most patients reported a very modest increase in pain scores when the infusion was complete (0-2/10 with NRS), we were able to offer reassurance and also took the opportunity to reinforce multimodal and nonpharmacological education, both of which proved effective in reducing patient anxiety.
7. An abundance of surgical related questions and concerns were asked by patients during the follow up phone calls suggesting a need for additional surgical education resources for patients.
8. Language barriers posed significant challenges. We strongly suggest that patients should not be discharged home from the hospital with a CACC if they will not be able to communicate

with the APS RN (or unless a friend/family member present at all times is able to communicate and translate on their behalf) for the follow up calls and the removal of the ACC. Having the ACC (and surgical) educational material printed in multiple languages could potentially offer some additional benefit.

9. By blocking the antero-medial knee pain with the CACC, the primary location of pain before the implementation of the catheters, alternative locations of pain emerged. Thigh pain secondary to intraoperative tourniquet use caused mild to severe discomfort for patients. NSAID's and cryotherapy were often able to offer relief, in addition to education and reassurance. After bringing this to the attention of the surgeons, the intraoperative tourniquet pressures were also decreased from a default of 300 mm Hg to 225 to 250 mm Hg (depending on the intraoperative systolic blood pressure) with appreciable effect on reported postoperative tourniquet pain.
10. Not all elastomeric infusers function equally. As this was a new program, we used several different infusers to elicit the best fit for our institution. We found differences in the consistency of the infusion between the different options, and this was a key factor in our final decision. We also found that having an option to adjust the flow rate did not change the overall effectiveness of the catheter. More importantly, we found that a flow rate of no less than 8 mL/hr was key in providing an effective sensory block for patients five feet tall or greater.
11. Quadriceps weakness from the CACC was very rare once a consistent insertion technique was established. There were no falls identified that were related to the ACC. Of the three patients who did fall postoperatively, all incidents were due to the fact that the patient attempted to ambulate without a gait aid.
12. Troubleshooting over the phone can be challenging, thus it is imperative that the APS RN making the phone calls has a sound understanding of the ACC, elastomeric infuser function, and all potential adverse events.
13. Patients rarely accessed the 24/7 anesthesia contact number, largely due to the consistency and trust in the daily phone calls as well as the daily education provided. Patients were comfortable addressing questions and concerns with the APS RN during daily phone calls, and received frequent instructions on what constituted an emergent versus non-emergent concern. Patients frequently volunteered that the daily phone call allowed them to avoid an emergency room visit as their questions and concerns were adequately addressed in a timely fashion.
14. The majority of patients expressed tremendous appreciation for the opportunity to recover at home, even those who were initially hesitant about early discharge. In patients who had delayed discharged on the first or second postoperative day for medical reasons, pain control and sleep invariably improved and opioid consumption tended to decrease once discharged.
15. Having a most responsible anesthesiologist available for nursing support to assist with troubleshooting of the CACC was a key component to the success of this initiative.

## Conclusion

CACCs via elastomeric pumps have been shown to offer significant advances to pain control following TKA, decrease opioid use, enable earlier discharge, and improve patient satisfaction.<sup>11,20,24,25</sup> During our development and implementation of a CACC program, we observed all these advantages unequivocally. A critical feature of these programs was the management of the catheters in the hospital and at home. APS

RNs have an important role to play in this regard. In our experience, implementation of daily telephone follow up by an APS RN for discharged TKA patients with a CACC was crucial for patient safety, and patient satisfaction, and reducing emergency phone calls and emergency room visits. We anticipate that the practical insights we describe in this paper will be a helpful resource for other APS and surgical nurses as more outpatient peripheral nerve catheter programs are developed.

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