



# Regional Catheters for Outpatient Surgery—a Comprehensive Review

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## Abstract

**Purpose of Review** This review summarizes and discusses the history of continuous catheter blockade (CCB), its current applications, clinical considerations, economic benefits, potential complications, patient education, and best practice techniques.

**Recent Findings** Regional catheters for outpatient surgery have greatly impacted acute post-operative pain management and recovery. Prior to development, options for acute pain management were limited to the use of opioid pain medications, NSAIDs, neuropathic agents, and the like as local anesthetic duration of action is limited to 4–8 h. Moreover, delivery of opioids post-operatively has been associated with respiratory and central nervous depression, development of opioid use disorder, and many other potential adverse effects. CCB allows for faster recovery time, decreased rates of opioid abuse, and better pain control in patients post-operatively.

**Summary** Outpatient surgical settings continue to focus on efficiency, quality, and safety, including strategies to prevent post-operative nausea, vomiting, and pain. Regional catheters are a valuable tool and help achieve all of the well-established endpoints of enhanced recovery after surgery (ERAS). CCB is growing in popularity with wide indications for a variety of surgeries, and has demonstrated improved patient satisfaction, outcomes, and reductions in many unwanted adverse effects in the outpatient setting.

**Keywords** Outpatient surgery · regional anesthesia · continuous catheter · Enhanced recovery after surgery · Local anesthetics

## Introduction

As advancements in anesthesiology and surgery continue to propel healthcare safety and quality forward, an increasing array of surgical procedures once performed in hospitals are

now being performed in an outpatient setting. Currently, the three prominent categories of outpatient surgical settings include ambulatory surgical centers (ASCs), day surgeries performed in hospital operating rooms, and office-based procedural suites. In 2010, 28.6 million ambulatory surgical visits

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occurred in day surgery at hospitals and ASCs [1]. This number is steadily rising as more ASCs become Medicare certified. The contemporary focus on efficiency, quality, and safety mandates the implementation of prophylactic measures to prevent the development of post-operative nausea, vomiting, and pain; accordingly, these measures receive particular emphasis in the outpatient surgical setting [2, 3]. Reliance on traditional general anesthetic technique and post-operative management incurs heightened risk of complication, thereby increasing unanticipated hospital admissions, length of stay, and discharge delays [4–6]. Recently, novel technological advancements have expanded the role of regional catheter anesthetic techniques, resulting in a significant paradigm shift in anesthesia and pain management for ambulatory surgery [7].

A wealth of economic, humanitarian, and societal benefits provide motivation for effective perioperative pain management [8•, 9–11], for which continuous catheter blockade (CCB) has become an essential facet in both ambulatory and inpatient populations. Improvements in early mobilization and functional recovery decrease the frequency of unanticipated hospital admissions and readmission [8•]. CCB improves the quality of pain management, increases sleep quality in the post-operative period, and reduces post-operative opioid requirements [8•]. Data from the Center for Disease Control and Prevention demonstrate that longer exposure to opioids ( $\geq 8$  days) in opioid naïve patients correlates with an increased likelihood of continued long-term use [9]. In response to the US' epidemic of opioid misuse and abuse, an overwhelming push to decrease patient exposure to opioids is underway; multimodal analgesia through techniques such as CCB remains crucial to these efforts [10].

The efficacy and benefit of CCB in the management of both upper and lower extremity post-operative pain has been well demonstrated in the literature. Interest is also beginning to develop in the application of CCB to procedures that are not related to extremities such as use of continuous paravertebral blockade for postmastectomy [11]. As the number of surgeries performed in the outpatient ambulatory setting continues to rise, improved perioperative pain management and advancements in CCB will increase safety for patients with appropriate indications and reduce healthcare-related costs as a result of improved efficiency. This review article will discuss the risks and benefits of CCB, as well as the importance of patient education in successful outpatient CCB.

## Benefits of Continuous Catheter Blockage

It is well established that optimal recovery following minimally invasive surgeries requires patients to be mobile and actively participating in rehabilitation if applicable, as soon as possible, which in turn requires adequate post-operative pain control. CCB has been shown to improve functional recovery

after total hip and total knee replacement by alleviating pain and minimizing traditional opioid-based therapies' side effects. Regional catheters allow continuous inhibition of pain transmission, permitting the patient to ambulate sooner and with a greater range of motion. CCB has made commonplace the discharge of patients within 24 h after joint replacement surgeries, imparting significant economic benefit to fast-tracking paradigms by facilitating a faster return to work, reducing the need for adjuvant medications such as opioids, shortening hospital stay, and reducing the number of unanticipated admissions. Opioid consumption can be decreased by 40–70% when using a continuous nerve block [12–14, 15•, 16, 17].

## Indications

Musculoskeletal procedures comprise a significant volume of overall continuous catheter usage. Indications for catheter placement in orthopedic surgeries span a broad range of procedures across the upper and lower extremity, and are especially useful in the management of the same day surgical patient. In addition, plastic, breast, thoracic, urological, abdominal, pelvic, and traumatic surgeries have all described the usage of CCB.

### Upper Extremity

Many operative and non-operative injuries of the shoulder joint utilize CCB. Continuous interscalene infusion provides anesthetic blockade for shoulder procedures including total and hemiarthroplasty of the shoulder, rotator cuff repairs, arthrodesis and debridement, manual frozen shoulder manipulation, and proximal humerus fractures. For the elbow joint, continuous infraclavicular block remains the current modality of choice. Indications are similar to that of the shoulder and include arthroplasty, arthrodesis, and fractures. Ultrasound-guided approaches to the supraclavicular or axillary nerves are also safe and effective for intra-operative upper extremity analgesia. For long-term use, infraclavicular techniques have demonstrated less patient discomfort and lower rates of catheter migration.

While severe traumatic injuries are less commonly encountered in an outpatient setting, it is possible to utilize regional catheters for the inpatient management of severe upper and lower extremity injury. Benefits for post-operative patients with upper extremity trauma may include improved rates of successful re-implantation secondary to sympathectomy driven improvements in revascularization, particularly in cases where the injury has compromised blood flow. Image guided placement of tunneled catheters in traumatic scenarios ensures placement and reduces the risk of infection.

Classically, regional anesthesia is contraindicated in trauma secondary to concern for compartment syndrome, a unique and catastrophic complication of trauma that may lead to irreversible nerve and tissue injury [18–22]. Related to this risk, infusion rates must be maintained at the absolute minimum level necessary to achieve adequate sensory blockade while avoiding complete motor block. For both upper and lower extremity trauma, a baseline neurological assessment should be conducted before providing analgesia, although pre-existing neurological injury is not necessarily an absolute contraindication to blockade [18–22].

### Lower Extremity

Currently, nearly one million total joint replacements are performed in the USA annually, and this number is expected to increase to nearly four million by 2030. Likely, CCB utilization will follow this trend [23]. Continuous lumbar plexus block has demonstrated greater efficacy than continuous femoral blocks and IV hydromorphone PCA for total hip replacement [23]. Similarly, lumbar plexus blocks can be used for total knee replacement, although femoral blocks and sciatic nerve blocks remain viable alternatives. Additionally, sciatic blockade demonstrates utility in total ankle replacement. Currently, post-operative and “take home” analgesia for lower extremity surgeries usually include a femoral or lumbar plexus perineural catheter, depending on the operative site.

Lower extremity trauma may present challenges for catheter-based analgesia. Acetabular or femoral neck fractures may only require a lumbar plexus block, whereas most complicated lower extremity injuries require both lumbar and sacral plexus placement. Thromboprophylaxis is recommended for these patients. Tibial plateau fracture, in particular, represents a unique and challenging scenario for regional blockade. Sensory but not motor blockade should be attempted by delivering only the minimum effective analgesic dose such that compartment syndromes remain detectable via evaluation of motor ability in the lower extremity. [24–29]

### Thoracic, Pelvic, Abdominal, and Urological Surgery

Continuous paravertebral block has demonstrated superiority for post-operative pain management in breast, thoracic, pelvic, abdominal, and urological surgery compared to single injection or epidural analgesia. Markers for improved pain include decreased pain at rest, decreased opioid consumption, superior pulmonary function, and fewer analgesic related side effects such as nausea and hypotension. The success of paravertebral catheters lies in selecting the appropriate level for placement. Thoracic and breast surgery requires placement at T4 while a nephrectomy, hepatic surgery or hysterectomy may require placement as low as T6–T10. Moderate-quality evidence shows that paravertebral blockade exhibits a more favorable

minor complication profile than neuraxial blockade, including less hypotension, nausea and vomiting, pruritis, and urinary retention [30–38]. Along with the improved side effect profile and outcomes, contraindications to the neuraxial techniques, such as anticoagulation status, do not impact paravertebral blockade to the same degree. This extends and applies to chest trauma, as epidural analgesia has been the historical therapy of choice for rib fractures but is often limited by thromboprophylaxis. Paravertebral blocks have emerged as an alternative, as they provide less hypotension with a lower risk of hematoma even when used with NOACs [30–38].

Open thoracic and abdominal procedures, historically reliant on neuraxial or paravertebral blockade as stated above, have benefited from the introduction of erector spinae plane (ESP) blocks in recent years [39, 40]. These blocks purport effective analgesia over the same distribution with a more favorable side effect profile and complication rate than epidurals. ESP block can be carried out at the thoracic or lumbar level via ultrasound probe and in-plane needling technique. Local anesthetic introduced between the erector spinae muscle and transverse processes effectively blocks the dorsal and ventral rami of the abdominal and thoracic nerves, thereby imparting surgical anesthesia to the desired dermatomes. Ultrasound guidance confirms the placement of the catheter in the erector spinae plane and successful anesthetic deposition prior to catheter tunneling and securement. Static numeric pain scores, dermatomal pain evaluation, and coughing scores allow evaluation of block fidelity following placement [39, 40].

### Technique

Ultrasound guidance revolutionized catheter placement. Neurostimulatory confirmation, long a mainstay of regional techniques, is now optional, although still sometimes beneficial in the placement of continuous catheters. Blind techniques are still used, although the use of ultrasound is fully advocated for and taught almost universally. Ultrasound guidance reduces the time necessary for placement, vascular punctures, need for opioids, and volume of anesthetic used in the catheter itself [41, 42].

Choice of medication remains contentious. Bupivacaine, ropivacaine, levobupivacaine, and lidocaine are some of the more commonly used agents, although lidocaine usage in orthopedics is limited due to differing agents’ superior profile of analgesic versus motor blockade [41].

While various rates of infusions, concentrations, and modes of administration have been tried, no definitive conclusion has emerged as the optimal formulation for any one technique. Most reported infusions contain ropivacaine 0.2% or bupivacaine 0.125 to 0.25% without adjuvant. Insufficient information exists in particular regarding the ideal medication or concentration for ambulatory procedures. Most sources

report that the dose, rather than the concentration or infusion rate, is the most important determinant of analgesic benefit. This dose will vary by patient, medication used, concentration, and length of hospital stay. Finally, additive medications such as clonidine and morphine are controversial and not yet established as safe and effective adjunctive measures [26, 41–47].

Sterile technique and catheter securing remain paramount to the placement of long-term catheters. A test dose of local anesthetic and epinephrine via the catheter is typically employed to investigate correct positioning. Inaccurate catheter placement can occur in up to 40% of cases; complication severity increases considerably if the patient is discharged following ambulatory surgery with a malpositioned catheter [47]. Clinicians need recall that surgical blockade is possible even with incorrectly positioned catheters; in this scenario, incorrect placement may not be detected until postdischarge. Side effects of the local anesthetic, often lidocaine, such as perioral paresthesias, metallic taste, and tinnitus indicate intravascular placement, in addition to the increase in heart rate with intravascular administration of epinephrine. Furthermore, cardiotoxic side effects of bupivacaine including heart block and arrest are possible, but preceding EKG changes such as QRS widening may herald impending collapse, thereby allowing the clinician to intervene appropriately. Neurostimulatory approaches may potentially improve catheter placement by providing subjective patient feedback, which guides a stimulating catheter to the intended target via correlation of reported sensation to desired nervous blockade. This method is especially useful when ultrasound guidance is unavailable [48].

## Patient Education

Proper patient education is crucial to postplacement success. Patients must be taught how to manage and remove their catheters in their own home with proper cleaning and sterile technique. Oral and written instructions, as well as healthcare provider contact numbers, should be provided. Topics reviewed should include infusion pump instructions, breakthrough pain treatment, catheter site care, limb protection, and the plan for catheter removal. Pain should be expected after removal of the catheter, and fluid leakage at the catheter site is common [48]. Warning signs of catheter complication which should prompt health care provider contact include nerve injury evidenced by prolonged blockade postremoval, pulmonary compromise, and site infection such as erythema or purulent secretion [49].

Catheter removal can be done via several methods. With instructions given by phone, up to 98% of patients felt comfortable removing their catheter alone [49], but some patients may still prefer return to clinic for provider-directed removal. One study reported that 4% of patients preferred to return to the healthcare provider to remove the catheter [49]. Nonsterile

gloves should be provided to patients to promote clean technique [19, 49–51].

## Complications and Risks

### Thromboprophylaxis and Antithrombotic Therapies

Although a decreased risk of hematoma exists with continuous catheter techniques in comparison to neuraxial blockade, ASRA guidelines recommend the same precautions for deep and plexus continuous catheter blockade as they do for neuraxial blocks in patients receiving antithrombotic or thrombolytic therapies. Hematoma has been reported even in the absence of anticoagulation, and vascular punctures frequently occur during the performance of blocks. Retroperitoneal hematoma has been described for lumbar plexus and psoas compartment blockade for hip surgery. Major bleeding has been described with subscapular, upper extremity, chest, femoral, pudendal, and lumbar plexus blockade [51–62].

A list of precautions for specific medications is provided in Table 1. Thromboprophylaxis may be beneficial for some patients undergoing CCB to counteract deep vein thrombosis and pulmonary embolism.

The following guidelines, established by Hantler et al., report considerable success, with zero major bleeding complication in 3588 patients undergoing joint replacement (50.2% knee arthroplasty and 49.8% hip arthroplasty) and 6935 blocks in patients receiving thromboprophylaxis [63•].

1. Blocks should be performed 12 h after the last dose of enoxaparin and 24 h after the last dose of fondaparinux in patients with INR < 2.0
2. Thromboprophylaxis can be initiated after the block is performed.
3. Removal of the perineural catheter is allowed regardless of the drug used for thromboprophylaxis, based on the analgesic requirement, without consideration for the INR or the type of thromboprophylaxis.

### Continuous Nerve Blockade and Falls

Patients with continuous nerve blockade do not experience a higher rate of falls than patients receiving alternative local anesthetic techniques. In contrast to anecdotal evidence and case reports describing fall events, data obtained from over 30,000 patients failed to demonstrate any increased fall risk with CCB. Rate of infusion should be minimized if fall risk is high, and neurological workup may also reveal patients at increased risk of such events [50, 64–66].

**Table 1** Medication precautions

Medication	ASIPP Guidance		ASRA Guidelines (85,494)	Nordic Guidelines (538)	European Guidelines (539)	Belgium Guidelines (541)
	Time to Wait After Last Dose of Medication Before High Risk Interventional Techniques Are Performed	Time to Wait After Last Dose of Medication Before Caudal or Paravertebral Interventional Techniques are Performed				
NSAIDS	Do not stop	Do not stop	Do not stop	12 h to 2 weeks	Do not stop	Do not stop
Aspirin	Do not stop	Do not stop	Do not stop	None to 12 h	Do not stop	Do not stop
Low dose aspirin	May stop for 7 days	May stop for 7 days	7 days	3 days	Do not stop	NA
High dose aspirin						
Antiplatelet agents						
Phosphodiesterase Inhibitors	Do not stop	Do not stop	Do not stop	Do not stop	NA	NA
Dipyridamole (Persantine)	Do not stop	Do not stop	NA	NA	42 h	NA
Cilostazol (Pletal)	Do not stop	Do not stop	NA	NA	NA	NA
Aggrenox (dipyridamole plus aspirin)	Do not stop	Do not stop	NA	NA	NA	NA
Platelet aggregation inhibitors						
Clopidogrel (Plavix)	May stop for 7 days	May stop for 7 days	5–10 days	5 days	7 days	7 days
Prasugrel (Effient)	May stop for 7 days	May stop for 7 days	7–10 days	5 days	7–10 days	7 days
Ticlopidine (Ticlid)	May stop for 14 days	May stop for 14 days	5–10 days	5 days	10 days	10 days
Vitamin K antagonists						
Warfarin	When INR is 1.4 or less, both warfarin	When INR is 2.0 or less, both warfarin	When INR is 1.4 or less,	When INR is below 1.4–2.2 stop	When INR is below 1.4 or	When INR is less than
	May be stopped for 1–5 days.	May be stopped for 1–5 days.	Stop for at least 5 days.	for 1–4 days	1.4. Stop for 4–10 days	
Thrombin inhibitors						
Dabigatran (Pradaxa)*	Normal renal function	Normal renal function	NA	NA	NA	NA
Anti-Xa Agents	Impaired renal function (creatinine clearance <50 mL/min) at least 5 days	Impaired renal function (creatinine clearance <50 mL/min) at least 5 days				
Rivaroxaban (Xarelto)	24 h	24 h	NA	NA	NA	NA
Heparins						
Heparin (treatment) - IV	6 h and a PTT within normal limits	6 h and a PTT within normal limits	10–12 h and a PTT within normal limits	4 h and a PTT within normal limits	4–6 h and a PTT within normal limits	6 h and a PTT within normal limits
Heparin (treatment) - SC	12 h and aPTT within normal limits	12 h and aPTT within normal limits	10–12 h and a PTT within normal limits	4 h and a PTT within normal limits	4–6 h and a PTT within normal limits	12 h and a PTT within normal limits
LMWH	12 h	12 h	10 h	10–24 h	12 h	12–24 h

## Infection

The risk of infection with continuous peripheral nerve blockade, a significant concern, is unconfirmed secondary to limited epidemiological data. Infection associated with epidural anesthesia compromises the bulk of the data, with recent studies reporting that between 23 and 57% of peripheral nerve catheters may become colonized, with 0–3% resulting in infection [66, 67]. Severe infectious complications such as abscess in the psoas, axilla, and resultant necrotizing fasciitis have been reported rarely in the literature [68, 69].

Duration of infusion and frequency of use remain significant risk factors for infection with perineural catheters. Most patients undergo a short, infrequent duration of therapy lasting only a few days, although prolonged utilization is growing as covered in this review. Additionally, antibiotic use is common and supported by the literature with CCB [70, 71]. Fortunately, local anesthetic solutions exhibit bacteriostatic action that limits overall rates of infection. Risk factors for infection include absence of prophylactic antibiotics, placement in the femoral or axillary regions, and infusion duration over 48 h. If infection is confirmed, the catheter should be removed and proper antibiotics regimens initiated [70–74].

## Nerve Injury

Ultrasound guidance reduces the frequency of nerve injury with continuous nerve block. Nerve injury is rare, and it is difficult to determine the cause of nerve injury in situations of trauma, tourniquet use, or operative measures [19, 67, 69, 75, 76]. Transient loss of neurological function has been reported with some blocks, and functionality usually returns. Long-acting local anesthetics are often blamed for this phenomenon. For example, continuous femoral block in 1416 patients demonstrated only a 0.21% neural lesion rate, with complete return of function in all three patients [74]. In a study of 400 popliteal sciatic nerve blocks, two neuropathies and one infection occurred with complete resolution at 6-month follow-up [69].

## Block Failure and Catheter Malfunction

Disconnection or damage to the catheter itself remain the most common complications, presenting as a loss of analgesic delivery and severe pain at the site of the catheter or in the region of the blockade. In order to diagnose a catheter-related failure, the clinician may increase the dose or manually provide a dose of anesthetic and await return of analgesia. Gentle, careful placement and handling of the catheter once in place may prevent this complication.

A potential catastrophic complication of catheter failure is release of all anesthetic in the pump at once, instead of at a

constant rate over time. This may result in anesthetic overdose and should be treated with the proper pharmacologic combatant, e.g., lipid emulsion for cardiovascular toxicity. Electronics in the pump may fail resulting in the cessation of drug delivery secondary to sporadic failure or low battery. If a patient requires an MRI, the pump status should be checked before and after to ensure the electronics are not damaged and flow can be resumed or stopped as programmed [12, 19, 49].

## Conclusion

Outpatient surgery continues to expand in volume and complexity. Continuous catheter delivery of local anesthetic is likewise growing as a safe and effective means of delivering analgesia to the ambulatory patient. Continuous catheter anesthetic is currently indicated for a variety of surgeries, and its platform is extending from elective peripheral limb procedures to abdominal surgeries and trauma. Due to its relatively improved side effect profile, decreased length of stay, and need for opioid medications, in addition to economic advantages, regional catheters should be considered as a peri- and post-operative analgesic measure.

## Compliance with Ethical Standards

**Conflict of Interest** Mark R. Jones, Julie A. Petro, Matthew B. Novitch, Adeel A. Faruki, Jeffrey B. Bice, Omar Viswanath, and Paragi H. rana declare no conflicts of interest. Dr. Kaye is a speaker for Depomed, Inc. and Merck, Inc.

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