Ambulatory Anesthesia and Regional Catheters: When and How

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KEYWORDS

- Peripheral catheters • Ambulatory anesthesia
- Continuous peripheral nerve block

Several clinical trials have demonstrated the superiority of continuous peripheral nerve block (CPNB) compared with traditional opioid-based analgesia.[1–7] In addition to providing improved analgesia, CPNB is associated with less sedation, nausea, and pruritis.[8] Although single injection nerve blocks (SINB) can also provide excellent analgesia, CPNB allows added flexibility in both duration and density of local anesthetic effect. Recently there has been increased use of CPNB in the ambulatory surgery setting for both adults[9–11] and pediatric patients.[11–13] The ability to provide safe and effective CPNB at home is an attractive alternative to opioid-based analgesia with its related side effects. In some cases, CPNB shortens the duration[14] or eliminates the need[15] for hospitalization in patients who otherwise would require inpatient treatment for pain control.

In this article, several practical issues related to the use of CPNB in the ambulatory setting are discussed. Techniques for catheter placement, infusion regimens, patient education, and complications are reviewed. Recognizing that there are many institutional-based preferences for CPNB placement and management, special emphasis is placed on separating evidence-based techniques from institutional preferences.

WHY CHOOSE CPNB OVER SINGLE INJECTION?

Perhaps the most compelling reason to use CPNB is the increased flexibility in duration and block density that is possible compared with SINB. After orthopedic surgery, significant increases in visual analog scale scores may persist for 2 to 3 days.[16–18] Although SINB can provide up to 24 hours of analgesia, blocks of this duration require

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concentrated local anesthetics that are associated with dense motor and sensory effect. By contrast, CPNB can be used to provide prolonged analgesia with low volumes of dilute local anesthetic.[1,2,5] Thus, flexibility in the duration and density of local anesthetic effect are provided while avoiding the need for initial injection of large volume, and potentially toxic doses, of local anesthetic.

Low-density nerve blocks are attractive for several reasons. Although most patients appreciate the excellent analgesia provided by nerve blocks, dense motor and sensory effect can be unpleasant and potentially dangerous. Patients may report decreased satisfaction when the extremity is "too numb" or "dead." Limb neglect caused by a dense motor and sensory block may also result in positioning injury and falls.[11,19] As more data emerge for infusions of dilute local anesthetic, improved patient satisfaction and safety are being documented. Already there are data showing that after shoulder surgery, lower concentration interscalene blocks (0.125% vs 0.25% bupivacaine) provide comparable analgesia but with improved diaphragm function and higher oxygen saturation.[20]

Finally, the cost savings from reduced need for hospitalization made possible with CPNB[14,15] have not been reported with SINB. Thus, the use of ambulatory catheters may represent an unprecedented example of improved patient care at a lower cost.

CPNB PLACEMENT TECHNIQUES

Techniques for CPNB placement have developed in large part from existing methods for SINB. Accurate needle placement has historically relied on eliciting a paresthesia or electrical stimulation (ES) of the nerve. Ultrasound (US) guidance has recently assumed a major, if not dominant, role in the performance of CPNB.

For several years, ES was the preferred technique for performing nerve blocks and enjoyed a "gold standard" status.[21] Although no data exist showing a consistent relationship between stimulating current and proximity to the nerve, this technique has remained popular due to the lack of a viable alternative.[22–24] Despite limitations, ES has been successfully used for many years with apparently few complications. Initial CPNB placement using ES techniques employed only stimulating needles. In the 1990s, ES catheters were introduced in hopes of improving the ease of placement and success rate for CPNB.[25] Unfortunately, when compared with conventional catheters, most studies have failed to show significant clinical benefit from these more costly catheters.[26–28]

The introduction of portable, high-resolution US has been an important development in regional anesthesia. Initially viewed as a novelty or a supplement to ES, US is now firmly recognized as a "stand-alone" technique.[29] In fact, a review of clinical trials comparing ES with US confirms that US-guided blocks are performed more quickly, with higher success rates, less procedure related pain, lower dose requirements, and fewer vascular punctures than those performed using ES.[21,30–34] In addition, the catheter tip position can be easily confirmed by injecting agitated local anesthetic or air through the catheter while imaging the nerve. These techniques, originally described anecdotally,[35,36] are now commonly reported as a method to verify catheter position.[33,34]

SKIN PREPARATION AND PATIENT DRAPING

Indwelling catheter placement requires strict adherence to sterile procedure. The American Society of Regional Anesthesia and Pain Medicine (ASRA) recommends sterile precautions, including antiseptic hand washing, sterile gloves, surgical hats and masks, and the use of alcohol-based chlorhexidine antiseptic solution.[37] These guidelines are extrapolations from data pertaining to neuraxial regional techniques and central venous access techniques. A sterile drape is applied to isolate the area of skin preparation. When using a US-guided technique, the transducer must either be covered with a sterile sleeve (**Fig. 1**) or be positioned outside of the sterile field (**Fig. 2**).

NEEDLE TYPE

The use of short beveled needles is a widely accepted practice in regional anesthesia. Many practitioners report an increased ability to recognize a "pop" or other tactile feedback when using a short beveled or Tuohy needle. The notion that nerve injury is less likely to occur with short beveled needles is controversial. A single animal study has suggested a relationship between bevel type and the incidence of nerve injury; however, this has never been validated clinically.[38] A subsequent study refuted the notion that short beveled needles are less prone to cause injury.[39] Recently there has been an increased interest in using US-guided techniques that do not require immediate proximity between the needle and the nerve. Since the transition to US-guided techniques, conventional thin-walled needles have also been used safely for CPNB placement.[11] If this trend continues, bevel type may play a less important role when choosing a needle. Nevertheless, the Tuohy needle remains a popular choice for many practitioners when transitioning from SINB to CPNB placement.

LOCAL ANESTHETIC INJECTION DURING CATHETER PLACEMENT

The timing, volume, and concentration of local anesthetic injected during the placement of CPNB may vary considerably between institutions. When using ES techniques, it is reported that local anesthetic injection through the stimulating needle may alter the threshold for nerve depolarization.[40] A theoretical disadvantage to injecting local anesthetic through the needle before catheter insertion is an inability to verify accurate placement by injection of local anesthetic through the catheter and

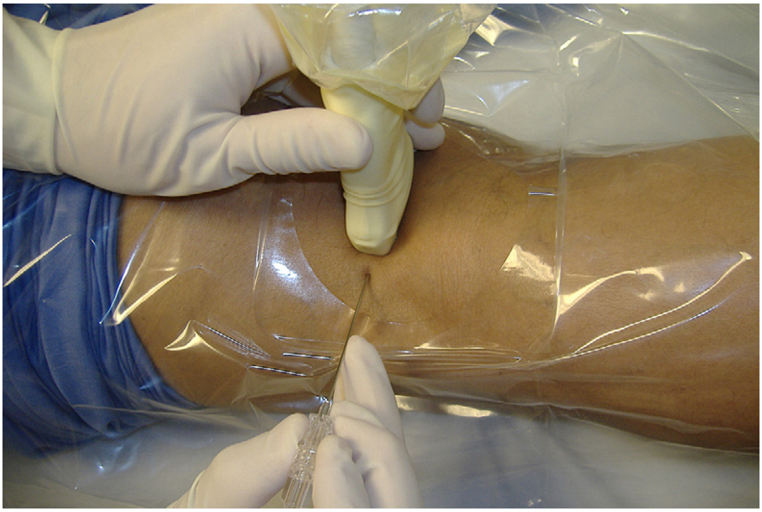

Fig. 1. An example in the left popliteal fossa of the US transducer covered with a sterile sleeve and positioned adjacent to the needle inside the sterile field.

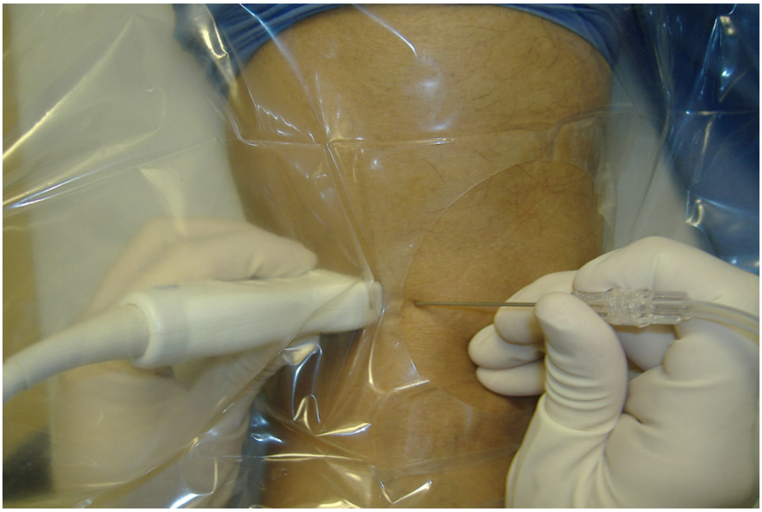

Fig. 2. An example in the left popliteal fossa of the US transducer positioned outside the sterile field. The needle is inserted through the skin within the sterile field and passes through the US beam, which is outside the field. A clear fenestrated drape with an adhesive border separates the needle and transducer.

observing subsequent sensory and motor effect.[41,42] The obvious concern for outpatients would be a scenario whereby initial bolus injection though the needle produced successful analgesia but subsequent infusion through the catheter failed. The ability to visualize catheter position relative to the nerve using US may eliminate this concern in the future.[36] **Figs. 3** and **4** demonstrate the appearance of agitated local anesthetic injected through existing interscalene and femoral catheters, respectively.

A significant advantage of CPNB placed for postoperative analgesia is that it does not require injection of a large, concentrated dose of local anesthetic. Interscalene catheters, for example, provide excellent analgesia after initial injection of only 20 mL of 0.125% bupivacaine.[20] This total dose of bupivacaine (25 mg) is considerably lower than doses typically used for SINB (100–150 mg).

SECURING THE CATHETER

As with many aspects of CPNB placement, there is variability among institutions regarding how to secure the catheter. Catheter dressing focuses on preventing leakage, dislodgment, and infection. Liquid adhesives are commonly applied to the skin before the dressing. Although they are very effective for securing tape and other coverings, a small percentage of patients may experience contact dermatitis from a common substance (styrax gum) found in both tincture of benzion and mastisol.[43] Sterile adhesive strips and other fixation devices can also be used at the catheter insertion site to prevent dislodgment.

Catheter tunneling is practiced at many institutions in hopes of minimizing infection and dislodgment. For CPNB, there are no prospective, randomized studies comparing infection rates for tunneled catheters versus catheters without tunneling. In fact, large infection-free series have been reported both with and without tunneling.[11,44] The risk of catheter dislodgment with and without tunneling has likewise not been assessed prospectively. Therefore, tunneling to prevent infection or dislodgment remains an

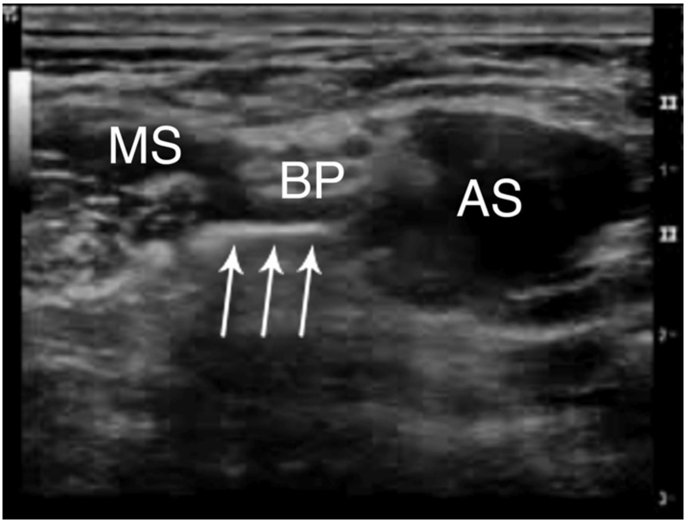

Fig. 3. Arrows highlight the position the catheter tip in the interscalene space (ISS). The injectate at the tip is hyperechoic due to local anesthetic containing microbubbles. The anterior scalene muscle (AS), middle scalene muscle (MS), and brachial plexus (BP) are displayed.

institutional preference rather than evidence-based practice. An important consideration for CPNB in the ambulatory setting is the ease with which the catheter can be withdrawn after the dressing has been removed. Patients should be instructed to seek consultation if any resistance is present during catheter removal. For this reason,

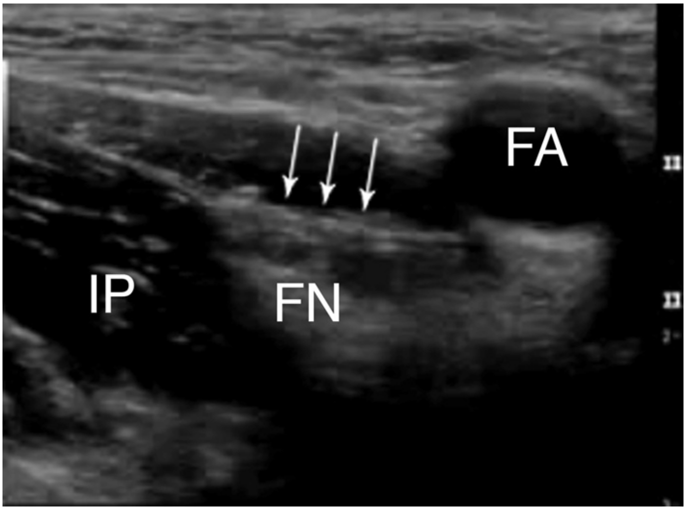

Fig. 4. Arrows highlight the position the catheter tip superficial to the femoral nerve (FN). The injectate at the tip is hyperechoic due to local anesthetic containing microbubbles. Also displayed are the femoral artery (FA) and the iliopsoas muscle (IP).

the ease with which a catheter can be withdrawn after removing the dressing is another consideration when deciding whether to tunnel the catheter.

PATIENT EDUCATION AND FOLLOW-UP

Successful ambulatory catheter programs provide focused education for patients and their caretakers. The goal of education should be to prepare patients to manage and remove their own catheters at home. With brief instruction, most questions and concerns about CPNB management can be answered for patients before discharge from the hospital. This education can be combined with written instructions and hospital contact information. Examples of these written instructions are included in Appendices 1 and 2.

At home, patients should have simple instructions to access hospital personnel. Although many anesthesiologists have concerns about the volume of patient calls, the actual need for intervention may be surprisingly low. In one large series, only 4% of patients required physician intervention after hospital discharge.[11] Only 1% of patients required intervention at night or on a weekend.[11] In this same series, only 1 of the 620 patients was unable to remove their catheter at home. Every effort should be made to simplify outpatient CPNB management. Patients may already be concerned with issues such as wound care and rehabilitation. Fixed-rate elastomeric pumps may be advantageous in this setting because they require little or no instruction for use, require no interaction by the patient, and can be discarded at home.

COST AND ECONOMIC EFFECT

The economic impact of CPNB on ambulatory surgery is increasingly evident. For selected orthopedic procedures, catheters may provide a significant reduction in hospital costs. In some cases, surgeries that have historically required hospitalization for pain control can be performed as outpatients.[15] Patients with obstructive sleep apnea represent another potential application for CPNB. Current guidelines recommend hospital admission and monitoring for some patients with obstructive sleep apnea who require postoperative treatment with opioid analgesics.[45] By using CPNB as the primary mode of analgesia, postoperative opioids may be minimized or avoided altogether. Thus, catheter use may provide improved safety as well as decreased cost of hospitalization for these patients.

Equipment costs are an important consideration when establishing a CPNB program. At present, ES and US are the 2 dominant modalities used to guide catheter placement. Although US is a viable stand-alone method, initial equipment costs can be considerable. Each institution must balance the initial investment in imaging equipment with the ongoing needle and catheter costs associated with ES methods.

Infusion pumps are probably the area of greatest cost disparity in CPNB practice. Prices for disposable pumps vary from $55 for fixed rate elastomeric pumps to more than $300 for bolus/basal capable pumps.[46] Although there is ample evidence demonstrating improved analgesia and decreased side effects with CPNB infused at a basal rate, the data supporting the addition of a bolus capability are less consistent.[16,17] Hence, the significant increase in cost and complexity for bolus/basal pumps should be balanced against any individual benefit.

LOCAL ANESTHETICS, INFUSION RATES, AND DELIVERY SYSTEMS

After CPNB placement, there are a variety of local anesthetics, dosing regimens, and delivery systems that have been successfully used. The number of existing techniques suggests there is still no established best practice. Usually a low concentration of long-acting local anesthetic is administered through the catheter. The delivery of short-acting local anesthetics such as lidocaine and mepivacaine seems reasonable, but studies on their use are limited.[47] The most commonly reported drugs, bupivacaine and ropivacaine, both seem to provide adequate analgesia without toxicity. However, innate property differences between the two may lead to differences in motor blockade. Ropivacaine has been described as being more ''motor sparing'' in comparison with bupivacaine.[48] Although ropivacaine is also reportedly less cardiotoxic than bupivacaine, this difference may only be clinically relevant when large doses are anticipated. Extensive experience with prolonged infusions of bupivacaine (up to 25 mg/h) has not revealed clinically detectable toxicity.[49] Instead, toxicity with both bupivacaine and ropivacaine is associated almost exclusively with a single large injection such as an SINB or catheter bolus. Although the addition of clonidine has been shown to increase the duration of analgesia associated with SINB,[50] its benefits as an adjuvant to CPNB remain unproven. In studies thus far, the addition of clonidine to ropivacaine for CPNB has not resulted in improved analgesia or decreased local anesthetic use.[51,52]

The optimal combination of local anesthetic concentration and volume to be infused through a perineural catheter also remains to be determined. One trend that seems to be consistent is that analgesia can be achieved at most locations using low concentrations of long-acting local anesthetics (ropivacaine 0.2%, bupivacaine 0.125%) infused at rates from 5 to 12 mL per hour.[11,16–18]

Catheter infusion regimens (ie, basal, basal-bolus, bolus only) have also been the subject of many studies. An important finding of these reports is the significant pain relief and reduction in opioid requirements provided by a simple basal infusion.[1,3,11,13] Bolus-only regimens may be associated with higher pain scores, oral analgesic use, and number of sleep disturbances compared with techniques with a basal infusion.[16,17] In comparing basal-bolus and basal-only techniques, however, pain scores and patient satisfaction are mixed.[16–18]

Many types of pumps exist for the outpatient setting,[46] including reusable and disposable, electronic and nonelectronic, basal-only and basal-bolus capable. Nonelectronic disposable infusion pumps include elastomeric, positive-pressure (spring-powered and gas-pressure–powered), and negative-pressure (vacuum) pumps.[53] In choosing an appropriate model, several factors should be considered including cost, ease of use, flow-rate accuracy, programmability, and bolus capability. Electronic pumps offer more accuracy in hourly volume delivery than the elastomeric pumps.[54] Such pumps also allow infusion rates and bolus doses to be readily programmed and changed depending on the individual patient's needs. However, they are associated with more technical problems and are considerably more expensive than more simple devices.[55] In clinical trials comparing electronic-programmable pumps with the simple elastomeric variety, elastomeric pumps provided similar postoperative analgesia, fewer technical problems, and decreased cost.[55] Furthermore, the lack of programming ability eliminates any risk of programming error by the practitioner or the patient. Reusable electronic pumps may be cost effective over time but require a mechanism for their return by patients, making them less convenient. In summary, if cost is a major consideration, elastomeric pumps offer adequate functionality at a price significantly less than their electronic counterparts. Though they are less accurate, the variability in dose delivery has not been shown to be clinically significant, nor reported to be the cause of adverse events.[56] By contrast, if programmability and the ability to deliver patient-controlled boluses are important, then consideration should be given to electronic infusion pumps.

In summary, no particular combination of drug, rate, regimen, or pump has been established as best practice. In most CPNB studies, accurately positioned catheters at reasonable range of basal infusions (5–10 mL/h) will provide analgesia that is superior to opioid-based techniques. When considering the cost of outpatient catheter programs, the measurable differences between various pumps and local anesthetics should be carefully considered.

COMPLICATIONS

Complications associated with the outpatient use of CPNB are largely similar to those associated with their use in the hospital setting.[57] In recent years, a large body of literature has been assembled to identify the most notable adverse events associated with continuous catheter techniques. A working knowledge of these complications is important when discussing these treatment options with patients. Such complications include infection, neurologic complications, and local anesthetic toxicity.

Infection

Most studies reporting infection associated with CPNB are from hospitalized patients; however, data for large outpatient series are accumulating as well. For inpatients, incidence of catheter infection ranges from 0% to 3.2%,[44,57,58] while outpatient rates are less than 1%.[11,59] The American Society of Regional Anesthesia and Pain Medicine (ASRA) recommends sterile precautions, including antiseptic hand washing, sterile gloves, surgical hats and masks, and the use of alcohol-based chlorhexidine antiseptic solution. These guidelines are extrapolations from data pertaining to neuraxial and central venous access techniques. Added to these recommendations should be a provision for sterile precautions while filling infusion pumps. At least one report of severe, deep cellulitis has been attributed to contaminated infusate from a pump that was not filled under sterile conditions.[60]

Several specific risk factors associated with infection have been identified. Those applicable to the outpatient setting include duration of catheter use longer than 48 hours, lack of antibiotic prophylaxis, and axillary or femoral location.[59] Although tunneling has been recommended to reduce of bacterial colonization, this practice has never been confirmed as a factor in reducing infection.

Neurologic Complications

Although neurologic injury associated with CPNB is usually transient and ranges from 0.3% to 2.0%,[11,57] it remains one of the anesthesiologist's primary concerns. Injury may occur during performance of the block as well as during the postoperative period. Because placement techniques are similar between hospitalized and ambulatory patients, this discussion focuses on unique aspects of patients treated at home with catheters.

There are few reports of nerve injury in patients who go home with CPNB; however, pressure injury has been implicated as a likely cause.[11] For patients with an extremity in which there is little or no sensation, special precautions must be taken during application of casts, splints, and other dressings. Likewise, the patient must position the extremity carefully at all times. When determining the rate and concentration of local anesthetic infusions, the desire to achieve complete analgesia with the nerve block should be balanced against the risks of "limb neglect." Multimodal approaches to analgesia have recently been explored, which may prove beneficial in preserving more motor function and proprioception while providing excellent analgesia.[61]

A somewhat more novel neurologic concern associated with outpatient CPNB is the risk of falls. In a recent report, 4 of 233 patients (1.7%) treated with continuous femoral nerve block after knee surgery fell as outpatients.[19] These falls occurred despite patients receiving instruction not to bear weight on the affected extremity. This complication, although uncommon, is another example of the potential benefit in providing low-concentration blocks that preserve more motor function and proprioception.

Local Anesthetic Toxicity

As previously mentioned, one advantage of CPNB over SINB is the ability to provide prolonged analgesia without initial large-volume injections of concentrated local anesthetics. Indeed, recent data suggest that US-guided interscalene injection of bupivacaine, 25 mg (20 mL, 0.125%) provides excellent postoperative analgesia after shoulder surgery.[20] Most investigators report subsequent basal hourly infusion rates of 5 to 10 mL per hour using dilute solutions of either ropivacaine or bupivicaine.[11,16–18] With these low rates of infusion, it is not surprising that local anesthetic toxicity is not listed as a complication in any large published series of CPNB to date. However, even with these favorable results, it should be noted that although continuous infusion is unlikely to result in sudden onset of toxicity, patients with a pump allowing bolus capability could theoretically be at risk if intravascular migration should occur.

SUMMARY

The use of CPNB provides improved analgesia with fewer side effects than traditional opioid-based techniques. These benefits are increasingly relevant in the ambulatory surgery setting where more complex procedures are being performed as outpatients. Safe and effective use of these catheters at home has been demonstrated in large trials whose patients manage and remove their own catheters. Although variations exist between institutions with respect to placement and management strategies, several trends are becoming apparent. First, US is rapidly emerging as a dominant technique for placing CPNB. Second, patients are able to successfully manage and remove catheters at home with minimal supervision and low complication rates. Finally, by containing catheter-related expenses and reducing the need for hospitalization, the elusive goal of improved care at lower cost could be achieved.

APPENDIX 1
INTERSCALENE CATHETER: PATIENT INSTRUCTIONS (EXAMPLE)

You have received a nerve catheter to help control pain control after surgery. We have provided the information below to answer questions you may have.

1. In addition to the catheter, you may take pain medication prescribed by your surgeon as needed.
2. Keep the dressing clean and dry until it is time to remove the catheter. A small amount of blood and/or clear fluid under the dressing is normal.
3. If you detect any increased pain, swelling, or redness at the site of the catheter, notify the Doctor named below immediately.
4. The pump attached to this catheter will work in any position and is not affected by gravity. You may attach it anywhere that is convenient for you. The "balloon" inside empties very slowly and may not appear to be changing in size.
5. Some normal side effects that may be present with this catheter include:
   Drooping eyelid
   Slight redness in the eye

A smaller pupil
Hoarseness of the voice
Slight shortness of breath (diaphragm weakness).

6. Be aware that without normal sensation in your arm and hand, you must keep it well-padded and protected from injury.
7. Your catheter should be removed on________, when the bottle is empty. Simply remove the tape and adhesive and pull the catheter out. The catheter should come out very easily.
8. For any questions or concerns you may reach Dr________ directly at phone # ________.

APPENDIX 2
FEMORAL NERVE CATHETER: PATIENT INSTRUCTIONS (EXAMPLE)

You have received a nerve catheter to help control pain control after surgery. We have provided the information below to answer questions you may have.

1. In addition to the catheter, you may take pain medication prescribed by your surgeon as needed.
2. Keep the dressing clean and dry until it is time to remove the catheter. A small amount of blood and/or clear fluid under the dressing is normal.
3. If you detect any increased pain, swelling, or redness at the site of the catheter, notify the Doctor named below immediately.
4. You should not bear weight or walk without assistance or crutches until the sensation has completely returned to your leg.
5. The pump attached to this catheter will work in any position and is not affected by gravity. You may attach it anywhere that is convenient for you. The "balloon" inside empties very slowly and may not appear to be changing in size.
6. Be aware that without normal sensation in your leg, you must keep it well-padded and protected from injury.
7. Your catheter should be removed on________, when the bottle is empty. Simply remove the tape and adhesive and pull the catheter out. The catheter should come out very easily.
8. For any questions or concerns you may reach Dr________ directly at phone #________.

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