Introduction to Perineural Catheters

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Published 15 October 2019

KEY POINTS

- The siting of perineural catheters is an advanced skill and should be attempted only after a single-shot technique has been mastered.
- Strict aseptic precautions must be used.
- Proper training in the management of nerve catheters is essential for ward staff and the acute pain team. A printed protocol for troubleshooting should be made available.
- Perineural catheters must be used in combination with a multimodal analgesic regimen.

INTRODUCTION

The siting of perineural catheters is an advanced skill and should not be attempted unless the single-shot technique has been mastered. It involves the percutaneous insertion of an indwelling catheter in close proximity to the target nerves (eg, interscalene, supraclavicular, infraclavicular, axillary, psoas compartment, femoral, sciatic, and popliteal) or into a fascial plane (eg, rectus sheath, transverse abdominis plane, or fascia iliaca). Initially, perineural catheter placement techniques used stimulating or nonstimulating catheters inserted via an insulated needle.[1] Here, the space for the catheter is created by injecting glucose solution if using a nerve-stimulating catheter or injecting saline or local anaesthetic if using a nonstimulating catheter. Subsequent to the widespread use of ultrasound guidance, the focus has shifted to use ultrasound to guide catheter insertion and final placement.[2] Local anaesthetic is then infused via the catheter, providing prolonged analgesia.

The use of a perineural catheter to provide continuous peripheral nerve block (CPNB) offers several advantages and improves patient care.[3] Perineural catheters provide better quality analgesia and reduce the incidence of postoperative nausea and vomiting when compared with intravenous opiates. There is also some evidence to show improved functional recovery after joint replacement surgery.[4] The use of CPNB can facilitate same-day discharge after many types of extremity surgery, which would previously have required at least an overnight admission for pain control.[5]

CONTRAINDICATIONS TO PERINEURAL CATHETERS

Absolute contraindications:

- Patient refusal
- Skin infection at or near the puncture site
- Local anaesthetic allergy

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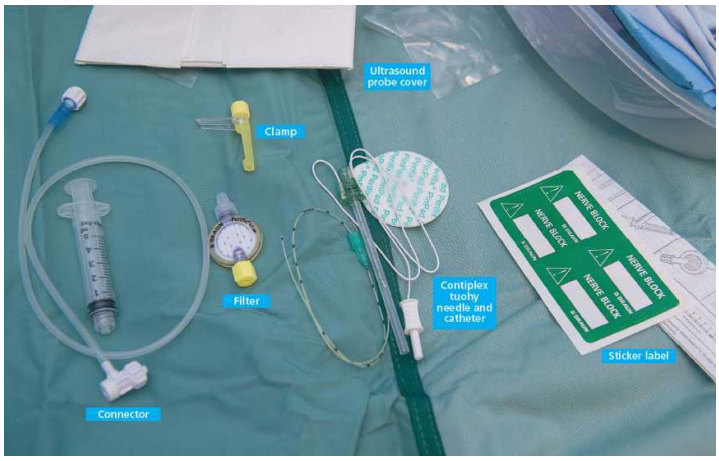

Figure 1. Perineural catheter kit for a catheter through the needle.

Relative contraindications:

- Systemic infection
- Pyrexia
- Risk of compartment syndrome
- Bleeding diathesis or anticoagulation

Recently, the Association and Anaesthetists of Great Britain and Ireland (AAGBI) published consensus guidelines for performing regional anaesthesia in the presence of abnormal coagulation.[6] Deep plexus blocks are considered to be higher risk procedures compared with more superficial peripheral nerve blocks. The risk-benefit profile for each patient and block should be carefully considered.

EQUIPMENT

- Monitoring: pulse oximetry, electrocardiography, and noninvasive blood pressure as per AAGBI guidelines[7]
- Intravenous access
- Consider antibiotic prophylaxis[8,9]
- Ultrasound machine
- Local anaesthetic: Initial test dose, bolus dose, and catheter infusion. The local anaesthetic infusion dose should ideally be a prepacked solution prepared under strict aseptic precautions and preferably by pharmacy. This reduces the risk of infection at the catheter site.
- Equipment to secure catheter (eg, dressings and surgical glue)
- Peripheral nerve catheter set
- Pump device for delivery of local anaesthetic solution. Both electronic and disposable elastomeric pumps are commonly used. Electrical pumps should be specific and labelled for perineural block use only. For safety reasons, epidural infusion pumps should not be used for delivery of local anaesthetic for the purposes of continuous peripheral nerve blockade. Previous disposable pumps provided less reliable infusion rates, but the newer disposable pumps are now very accurate. A disposable pump can usually be carried by the patient, which encourages mobility and potential discharge home with the pump in situ.
- Intralipid and local anaesthetic toxicity management guideline

Peripheral Nerve Catheter Set

There is a vast choice of peripheral nerve catheter kits available. It is beyond the scope of this article to discuss them in detail. It is worth familiarising yourself with them before attempting to insert a peripheral nerve catheter. There are 2 main choices to make:

- Catheter through needle (Figure 1) is more commonly used. The catheter is easier to feed after a small volume (5 mL) of local anaesthetic has been injected to distend the potential space. However, the needles are 18 to 19 gauge (large-bore needles), which makes the placement of the catheter slightly more uncomfortable in the awake patient, but the needle is much easier to visualise on ultrasound.
- Catheter over needle (similar to an intravenous cannula). The catheter over needle system should be quicker to place and generally involves a smaller-gauge needle. In the past, catheters were more difficult to feed, but more recently with the

Figure 2. Strict aseptic precautions including gown, cap, mask, and drape.

advent of ultrasound, the needle can be placed in the correct position and simply withdrawn to leave the catheter in the correct position. The smaller-gauge needle in these sets may be too flexible, and it can be difficult to redirect the needle once it is through the skin.

Stimulating Versus Nonstimulating Catheter

A stimulating catheter can cause electrical stimulation of the nerve at the tip of the catheter and can be used to verify that the catheter has not dislodged from the original position in the postoperative period. When a nonstimulating catheter is used, the set normally comes with an insulated needle through which you can stimulate; the catheter is then fed through the needle into the correct position. The availability of high-quality ultrasound machines and increasing expertise in ultrasound techniques have reduced the time for insertion and failure rates. Currently, most clinicians use nonstimulating catheters, stimulating through the needle with ultrasound guidance (dual guidance). The use of pressure injection monitors in combination with nerve stimulation and ultrasound (triple guidance) may not be useful when using large-gauge needles for nerve catheter insertion. Conversely, some ultrasound experts no longer use nerve stimulation and use only ultrasound for insertion and checking the final position of the catheter. An ultrasound machine can subsequently also be used to verify the position of the catheter, if catheter dislodgement or movement is suspected. A further advantage of this technique is that the spread of injected local anaesthetic can also be visualised in real time.

TECHNIQUE FOR INSERTION

Prior to performing any nerve block, the anaesthetist should obtain patient consent and ensure there are no contraindications to the procedure. Standard noninvasive haemodynamic monitoring must be attached and oxygen immediately available. Ensure there is good intravenous access. The insertion of a perineural catheter should be done with adherence to strict aseptic precautions. The operator should wear a gown, hat, mask, and sterile gloves (Figure 2). A sterile field should be prepared at the insertion site using 0.5% chlorhexidine in alcohol for skin antisepsis and sterile drapes. Administration of intravenous antibiotic prophylaxis prior to the procedure may be considered when placing nerve catheters with an increased risk of infection such as axillary and femoral nerve catheters.[8] It is advisable to perform perineural catheter insertion while the patient is awake if possible, as any pain or paraesthesia on insertion may be associated with nerve damage. In the event that the patient experiences these symptoms, the needle should be repositioned. There is no evidence to suggest that the risk of nerve damage is increased with the use of nerve catheters compared with single-shot blocks. Intravenous sedation or anxiolysis may be administered if required.

Different Methods of Nerve Location

- Ultrasound: in-plane approach or out-of-plane approach[10]
- Nerve stimulator: traditional approach with single-shot block[11]

Advantages of using an out-of-plane approach include a shorter needle path through the tissue with potentially less pain on insertion. For certain blocks such as interscalene block, using the out-of-plane technique also allows the catheter to be inserted along the axis of the nerve. Because the out-of-plane technique has a short needle path through the skin, the catheter generally requires tunnelling to avoid displacement. Advantages of using an in-plane ultrasound approach include easy visualisation of the catheter tip and easier placement of the catheter, as the tissue is already tunnelled by way of the needle path. Some anatomical sites are more suited for in-plane catheter insertion, for example, the femoral or popliteal regions.

The length of the catheter beyond the needle tip must not exceed 3 cm for perineural catheters, especially if the catheter is parallel to the nerves, but for fascial plane blocks, the catheter length is usually inserted for a longer distance beyond the tip (3-7 cm). There is conflicting evidence to suggest that the use of multiorifice catheters is more effective than single-orifice catheters for perineural placement.[12,13] Expert opinion suggests that for in-plane catheter techniques in which the catheter is placed across the axis of the nerves, a multiorifice catheter might result in a higher success rate. In contrast, a multiorifice catheter might be advantageous for placement in a fascial plane.

Ultrasound has proven to be extremely helpful in guiding the correct positioning of the catheter tip and evaluating the spread of local anaesthetic through the catheter, before tunnelling or securing the catheter position.

Ultrasound-Guided Placement of a Nonstimulating Perineural Catheter

We use an 18G insulated Tuohy tip needle (a component of the nerve stimulator kit) with a nonstimulating catheter as part of the ‘catheter through the needle’ technique. This technique can be modified according to the block being performed and local protocols.

Because of the larger diameter of the needles used for catheter insertion, it is useful to make a small incision in the skin with a scalpel blade to aid the passage of the needle through the skin. Local anaesthetic should be infiltrated into the skin prior to needle insertion. The relatively bigger size of the needle (compared with a 22G Stimuplex needle) also makes it more visible on ultrasound.

- Advance the needle until the desired twitches are obtained or the needle tip is seen on ultrasound in the desired position (perineural or in the correct fascial plane).
- After aspirating to exclude intravascular placement, we inject 5 to 10 mL of a short-acting local anaesthetic (1% prilocaine/or 1% lignocaine) with adrenaline 1:200 000 via the needle to distend the space and facilitate catheter insertion.
- A short-acting local anaesthetic solution with adrenaline may also be injected down the catheter to exclude inadvertent intravenous placement. Observe the electrocardiogram; an increase in heart rate may be suggestive of intravascular placement.
- Note the distance from the skin to the needle tip and then feed the catheter in until there is 2 to 3 cm beyond the needle tip. The position of the catheter tip can be confirmed on the ultrasound by injecting 0.5- to 1-mL aliquots of local anaesthetic. Some clinicians use air, but this can distort the ultrasound image.
- If resistance to advancing the catheter beyond the needle tip is encountered, 1 or more of the following techniques may be helpful.
  - Advance the catheter 0.5 cm while withdrawing the needle at the same time.
  - Rotate the needle by about 45°.
  - Withdraw the needle half a centimetre and try again.
  - Expand the perineural space with local anaesthetic, saline, or 5% dextrose.
  - If ultrasound is being used, the needle tip should still be visible and can be repositioned near the nerves before placing the catheter. It is easier to withdraw the catheter under ultrasound guidance into the correct position, so most clinicians would preferentially insert it further than required initially.
- Once the placement of the catheter is confirmed, secure it using surgical skin glue and/or tunnelling away from the surgical field (Figure 3). Tunnelling will help prevent catheter dislodgement and has also been shown to reduce the incidence of infection.[14] The use of surgical glue at the catheter puncture site also reduces leakage of infused local anaesthetics.

The local anaesthetic infusion may be started intraoperatively or postoperatively in recovery, where the patient is monitored using pulse oximetry, electrocardiography, and noninvasive blood pressure as per the Association of Anaesthetists’ guidelines.[7] Monitoring should continue until the patient is transferred from the recovery area. Catheter infusions must not be started or given a top-up bolus without monitoring. Vitals should be monitored at regular intervals on the ward as per local practice policy.

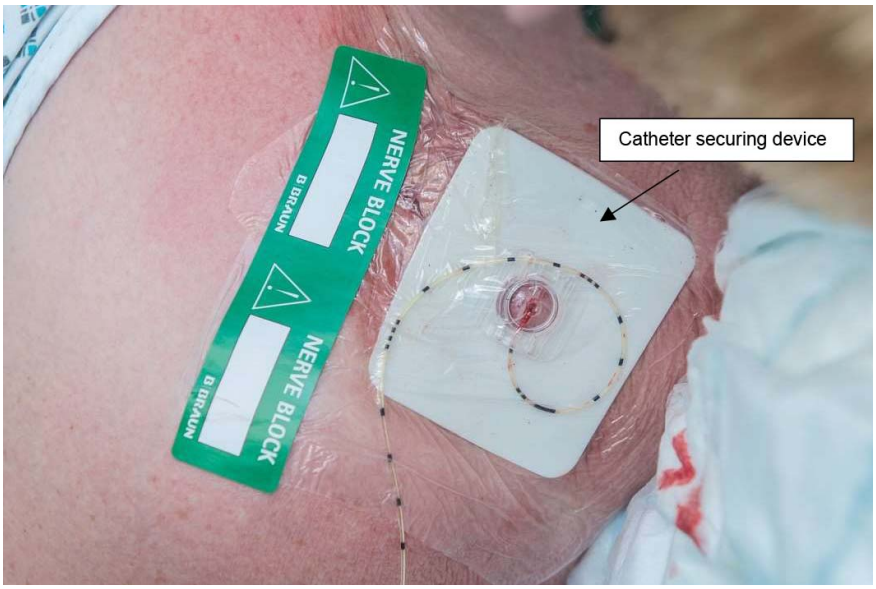

Figure 3. Tunneled catheter secured with a clear dressing.

Neurovascular monitoring including capillary refill time, sensation, and movement of the surgical limb at regular (10- to 15-minute) intervals is also advisable in recovery and on the ward. This practice allows assessment of the nerve block. It also aids diagnosis and management of potential vascular injury, which sometimes occurs during orthopaedic surgical procedures and that may be masked by the effects of regional anaesthesia.

With nerve-stimulator techniques, the initial administration of a short-acting local anaesthetic (eg, 1% lignocaine) through the needle can help to confirm the correct position for catheter placement. A subsequent bolus of a longer-acting local anaesthetic (eg, 0.5% bupivacaine) via the catheter could then be administered. If a longer-acting local anaesthetic is used to initially expand the potential space, this could result in anaesthetising the nerves due to correct needle placement but could mask the fact that the catheter was never placed in the correct position (primary catheter failure). The use of ultrasound has the advantage of direct visualisation of local anaesthetic spread both via the needle and following catheter placement and therefore facilitates the initial use of either a long- or short-acting local anaesthetic.

Local Anaesthetic Infusions

Ensure safe local anaesthetic dose limits are not exceeded when taking into consideration the local anaesthetic already given to the patient prior to commencing the local anaesthetic infusion (see Table 1).

- A local anaesthetic bolus may be given postoperatively prior to commencing the infusion, unless a bolus was given preoperatively (at the time of catheter insertion).
- The catheter is then connected to the pump device.
- The choice of local anaesthetic for the continuous infusion includes bupivacaine, levobupivacaine, or ropivacaine. These agents can be used in concentrations ranging from 0.1% to 0.25% according to the anaesthetist's preference. The safety profile of ropivacaine 0.2% makes this solution the most popular for continuous infusions. (Note that even very low concentrations [0.06%] of local anaesthetic infusion can result in a significant motor block.)
- The initial infusion rate is set between 5 and 10 mL/h. The use of ultrasound to verify correct catheter placement and local anaesthetic spread has resulted in lower required infusion rates.
- An optional patient-controlled bolus of 3 to 5 mL every 30 minutes may also be used on certain infusion pumps, but this function does increase the cost of the device.
- There is no additional advantage of adding adjuvants to prolong the block.

POSTOPERATIVE MANAGEMENT

Postoperative Monitoring: What and for How Long?

It is vital that perineural infusions are used as part of a multimodal analgesic regimen. Regular simple analgesia such as paracetamol and nonsteroidal anti-inflammatory drugs (if not contraindicated) should be given. It is common practice to

Local Anaesthetic	Single Dose	24 Hours
Bupivacaine	2 mg/kg (150 mg)	5.5 mg/kg (400 mg)
Levobupivacaine	2 mg/kg (150 mg)	5.5 mg/kg (400 mg)
Ropivacaine	3 mg/kg (225 mg)	11 mg/kg (800 mg)

Table 1. Recommended Doses[a] of Local Anaesthetics[15]

prescribe an oral opioid on an as-needed basis for breakthrough pain. However, before doing so, catheter malfunction or displacement should be excluded.

- The peripheral nerve catheter should be clearly marked using labels or stickers. (These are often included in the nerve catheter packs).
- Members of the acute pain team and recovery and ward nurses responsible for the postoperative care of the patient with a nerve catheter should be trained and competent in the use of the infusion equipment. They should be aware of the potential complications of the technique, including the signs and symptoms of local anaesthetic toxicity. Guidelines for the management of suspected local anaesthetic toxicity should be familiarised and easily accessible.
- Patients should be aware of the potential complications of the technique, including the signs and symptoms of local anaesthetic toxicity and what to do if they experience any of these (eg, call for help in hospital or potentially know how to stop the infusion, especially if they are at home).
- An infusion/pump troubleshooting protocol should be readily available in the recovery area and on the ward.
- The perineural catheter is commonly not left in situ for longer than 2 to 3 days unless the benefits of pain control outweigh the risk of infection from the indwelling catheter.

Discharging Patients Home With a Perineural Catheter In Situ

In some instances, it may be feasible to allow the patient to be discharged home with a perineural catheter in situ. This setup might be particularly beneficial for those patients expected to have moderate or severe postoperative pain for more than 24 hours. Appropriate patient selection is essential for the safe use of perineural catheters at home because of the extra responsibility that accompanies the catheter and pump system—something not all patients want or are capable of taking on. All suitable and consenting patients must receive clear verbal and written instructions regarding the use of perineural catheters in addition to the identification of possible complications, such as muscle weakness and reduced feeling for hot or sharp objects (insensate), and troubleshooting in the event of catheter displacement or local anaesthetic pump failure. Patients should be given details of whom to contact if they have any queries or concerns. A plan for subsequent follow-up and catheter removal should also be in place.

COMPLICATIONS

Block failure is the most common complication. The use of ultrasound for location of the nerves and stimulating catheters has reduced the failure rates to less than 5%.[16]

Inadvertent catheter migration or removal can be minimised by securing the catheter properly as described (secondary catheter failure).

Catheter knotting, looping, and kinking are rare and can be prevented by leaving an appropriate length of catheter in place (ie, not more than 3 cm beyond the tip of the needle).

Although bacterial colonisation of the perineural catheters has been reported as high, the incidence of abscess formation and sepsis is rare. Factors that increase infection risk are the use of axillary and groin sites, immunocompromised patients, critical care admission, frequent dressing change, and leaving the catheter in situ for more than 48 hours. The incidence of infection can be kept low by adherence to strict aseptic precautions during insertion.

Risk of peripheral nerve injury is no greater than with single-shot techniques.

To prevent local anaesthetic toxicity, the total dose of the local anaesthetic used should not exceed the maximum safe recommended doses (see Table 1).

SUMMARY

- Perineural catheter techniques involve the percutaneous insertion of a catheter adjacent to a peripheral nerve(s). Site-specific analgesia is provided by infusing local anaesthetic via the catheter.
- Perineural catheters are most commonly used for patients following surgical procedures expected to cause significant pain and lasting for more than 24 hours. They may be used in an ambulatory setting where patients are discharged home with a catheter in situ.

- Use of perineural catheters is associated with reduced opioid consumption and decreased opioid-related side effects such as respiratory depression, postoperative nausea and vomiting, and sedation.
- Associated complications of perineural catheters include failure of adequate nerve blockade, catheter migration or displacement, infection, and injury to the nerve.
- Staff should be adequately trained to identify and manage common catheter-related complications including awareness and familiarity with guidelines to identify and treat local anaesthetic toxicity.

FURTHER READING

Dr Brian Ilfeld's group has published a lot of work on this topic. We would highly recommend that you read the following articles:

Ilfield BM. Continuous peripheral nerve blocks: an update of the published evidence and comparison with novel alternative analgesic modalities. *Anesth Analg*. 2017;124(1):308-335.
Ilfeld BM. Continuous peripheral nerve blocks: a review of the published evidence. *Anesth Analg*. 2011;113(4):904-925.

REFERENCES

1. Gandhi K, Lindenmuth DM, Hadzic A, et al. The effect of stimulating versus conventional perineural catheters on post-operative analgesia following ultrasound-guided femoral nerve localization. *J Clin Anesth*. 2011, 23:626-631.
2. Tran DQ, Munoz L, Russo G, et al. Ultrasonography and stimulating perineural catheters for nerve blocks: a review of the evidence. *Can J Anaesth*. 2008,55:447-457.
3. Liu SS, Salinas FV. Continuous plexus and peripheral nerve blocks for post-operative analgesia. *Anesth Analg*. 2003;96:263-272.
4. Capdevilla X, Barthelet Y, Biboulet P, et al. Effects of perioperative analgesic technique on the surgical outcome and duration of rehabilitation after major knee surgery. *Anesthesiology*. 1999;91:8-15.
5. Russon K, Sardesai AM, Ridgway S, et al. Postoperative shoulder surgery initiative (POSSI): an interim report of major shoulder surgery as a day case procedure. *Br J Anesth*. 2006;97(6):869-873.
6. Association of Anaesthetists of Great Britain and Ireland, Obstetric Anaesthetists' Association, and Regional Anaesthesia UK. Regional anaesthesia and patients with abnormalities of coagulation. *Anaesthesia*. 2013;68:966-972.
7. Association of Anaesthetists of Great Britain and Ireland. Recommendations for standards of monitoring during anaesthesia and recovery 2015. *Anaesthesia*. 2016;71:85-93.
8. Bomberg H, Krotten D, Kubulus C, et al. Single-dose antibiotic prophylaxis in regional anesthesia: a retrospective registry analysis. *Anesthesiology*. 2016;125:505-515.
9. Nicolotti D, Lotti E, Compagnone C. Perineural catheter infection: a systematic review of the literature. *J Clin Anesth*. 2016;35:123-128.
10. MacGregor M, Kelliher L, Kirk-Bayley J. The physics of ultrasound—part II. *Anaesthesia Tutorial of the Week 218. ATOTW Weekly*, 21 March 2011.
11. Sardesai AM, Iyer U. Nerve stimulation for peripheral nerve blockade. *Anaesthesia Tutorial of the Week 149. ATOTW Weekly*, 31 August 2009.
12. Fredrickson MJ, Ball CM, Dalgleish AJ. Catheter orifice configuration influences the effectiveness of continuous peripheral nerve blockade. *Reg Anesth Pain Med*. 2011;36:470-475.
13. Fredrickson MJ. Randomised comparison of an end-hole, triple hole and a novel six hole catheter for continuous interscalene analgesia. *Anaesth Intensive Care*. 2014;42:37-42.
14. Vincent C, Legrand JF, Guitard PG, et al. Bacterial colonization after tunneling in 402 perineural catheters: a prospective study. *Anesth Analg*. 2009:108(4):1326-1330.
15. Cox B, Duriex ME, Marcus MAE. Toxicity of local anaesthetics. *Best Pract Res Clin Anaesthesiol*. 2003;17(1):111-136.
16. Jeng CL, Torrillo TM, Rosenblatt MA. Complications of peripheral nerve blocks. *Br J Anaesth*. 2010;105(S1):i97-i107.