The Pain Procedure Handbook

A Milestones Approach

Trent Emerick
Scott Brancolini
Michael E. Farrell II
Ajay Wasan
Editors

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Editors
Trent Emerick
Department of Anesthesiology and Perioperative Medicine, Secondary Appointment in Bioengineering
University of Pittsburgh Medical Center and University of Pittsburgh School of Medicine
Pittsburgh, PA, USA

Michael E. Farrell II
ECMC Center for Interventional Spine & Pain
Buffalo, NY, USA

Scott Brancolini
Department of Anesthesiology and Perioperative Medicine
University of Pittsburgh Medical Center and University of Pittsburgh School of Medicine
Pittsburgh, PA, USA

Ajay Wasan
Department of Anesthesiology and Perioperative Medicine
University of Pittsburgh Medical Center and University of Pittsburgh School of Medicine
Pittsburgh, PA, USA

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Preface

This manual was designed with the physician trainee (medical students, residents, fellows, and others) in mind as they work to achieve their educational and technical competencies. As such, you will see that each chapter has specific areas of text that are subdivided into what a trainee at various levels of competency should be able to understand and perform. Green boxes represent beginner level competencies, yellow boxes represent intermediate level competencies, and red boxes represent advanced level competencies that should be skillfully mastered as a physician enters independent practice.

Pittsburgh, PA, USA — Trent Emerick
Pittsburgh, PA, USA — Scott Brancolini
Buffalo, NY, USA — Michael E. Farrell II
Pittsburgh, PA, USA — Ajay Wasan

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The editors would also like to thank Amy Early, radiation technician extraordinaire, for her help with our fluoroscopy images, teaching, and excellence in patient care.

Contents

Editors and Contributors

Associate Editors

Hayden Hundley Flowers Hospital, Dothan, AL, USA

Ankur Patel Wellspan Health Interventional Pain Medicine Gettysburg Hospital, Hanover, PA, USA

Marissa Pavlinich South Hills Pain and Rehabilitation, Jefferson Hills, PA, USA

Neeraj Sriram Palmetto Pain Management, Columbia, SC, USA

Brandon Staub Chronic Pain Division, University of Pittsburgh Medical Center, Pittsburgh, PA, USA

Alexander (Sasha) Varzari University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA

Other Content and Imaging Contributors

William (Billy) Lane Texas Pain Consultants Associates, Houston, TX, USA

Patrick Polsunas Allied Pain and Spine Institute, San Jose, CA, USA

Cathy Zhang Louisiana Pain Institute, Covington, LA, USA

Contributors

Leath Abdullah University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA

Chronic Pain Division, University of Pittsburgh Medical Cente, Pittsburgh, PA, USA

Richa Lamba Dudek Spine & Pain Associates/St. Luke's University Health Network, Lehighton, PA, USA

Michael E. Farrell II, MD ECMC Center for Interventional Spine & Pain, Buffalo, NY, USA

Michael Glicksman University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA

Hayden Hundley Flowers Hospital, Dothan, AL, USA

Isaiah Levy University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA

Tetyana Marshall University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA

Sean McDermott University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA

Merna Naji University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA

Ankur Patel Wellspan Health Interventional Pain Medicine Gettysburg Hospital, Hanover, PA, USA

Marissa Pavlinich South Hills Pain and Rehabilitation, Jefferson Hills, PA, USA

Patrick Polsunas Allied Pain and Spine Institute, San Jose, CA, USA

Anne Pribonic University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA

Connor Richardson University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA

Neeraj Sriram Palmetto Pain Management, Columbia, SC, USA

Alexander Stanton University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA

Joseph P. Staszel Upper Allegheny Health System, Olean General Hospital, Olean, NY, USA

Upper Allegheny Health System, Bradford Regional Medical Center, Bradford, PA, USA

Brandon Staub Chronic Pain Division, University of Pittsburgh Medical Center, Pittsburgh, PA, USA

Alexander Varzari University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA

Ron Vidri University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA

John Yin University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA

Part I

Cervicothoracic Procedures

Cervical Epidural Steroid Injection

1

Michael E. Farrell II, Hayden Hundley, and Alexander Varzari

Abstract

Cervical epidural steroid injections are most commonly used to treat cervical radiculopathy refractory to conservative treatment. Cervical radiculopathy is a chronic pain condition characterized by neck pain, paresthesia, or muscle weakness that can radiate to the shoulders, arms, and hands and is often caused by compression or inflammation of the cervical spinal cord nerve roots. The injection of corticosteroids via a transforaminal or interlaminar approach can improve this inflammation and reduce the pressure on the nerve roots.

Cervical epidural steroid injections are indicated for cervical herniated discs, degenerative disc disease, cervical spondylosis, or cervical spinal stenosis, with up to 50% of patients having significant relief after the procedure (Conger et al., Pain Med, 21(1):41–54, 2020). Contraindications include active infection, uncontrolled coagulopathy or bleedings disorders, and in many cases oral anticoagulants. Additionally, this procedure is contraindicated in patients with actively progressing neurological conditions and emergencies.

M. E. Farrell II (✉)
ECMC Center for Interventional Spine & Pain, Buffalo, NY, USA
e-mail: mfarrell2@ecmc.edu

H. Hundley
Flowers Hospital, Dothan, AL, USA

A. Varzari
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: varzaria@upmc.edu

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Keys to Procedure

- Understand the relevant cervical spine anatomy on AP and contralateral oblique (CLO).
- Understand proper patient positioning to optimize epidural space.
- Be able to perform the hanging drop or loss of resistance technique.
- Understand the complications and corrective steps if encountered.

Anatomy Pearls

See Images 1.1, 1.2, 1.3, and 1.4.

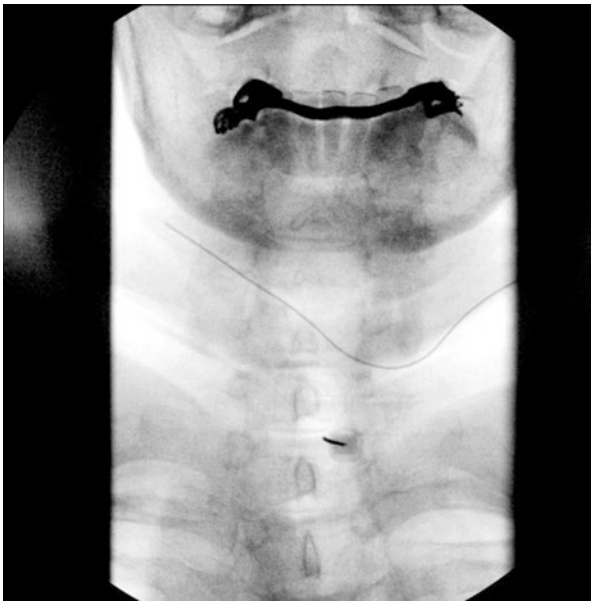

Image 1.1 AP view with needle at C7-T1 interlaminar space

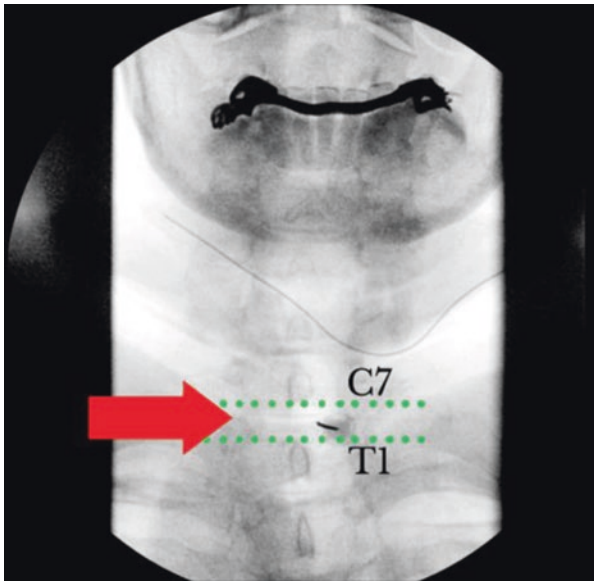

Image 1.2 Labeled AP image delineating the C7-T1 interlaminar space

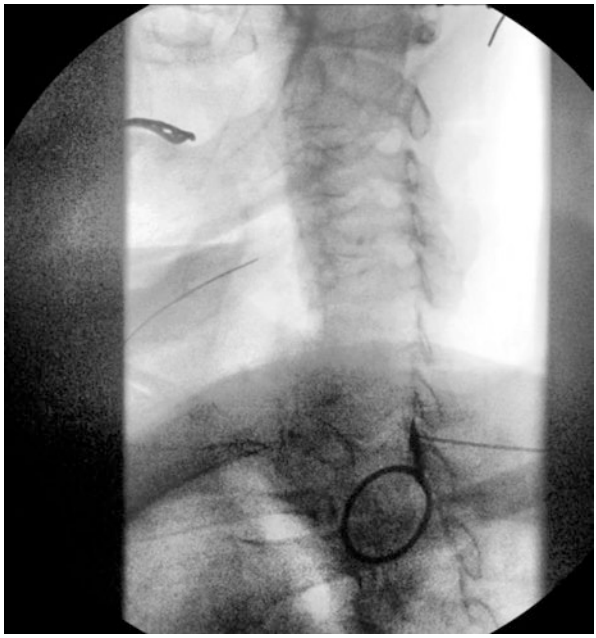

Image 1.3 CLO View of CESI

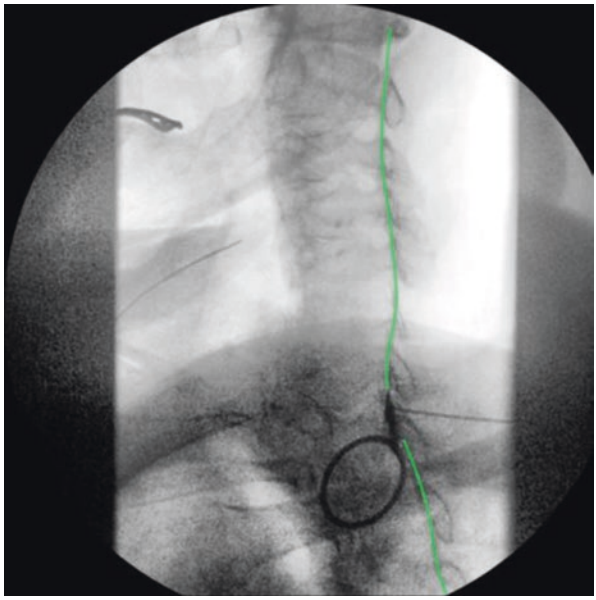

Image 1.4 CLO View with outline of ventral interlaminar line (green)

Supplies and Setup

- Sterile drape
- Chlorhexidine-based soap
- 20G Tuohy needle
- LOR syringe
- Lidocaine 1% for skin—5 mL
- Dexamethasone 10 mg—1 mL
- Isovue 300—3 mL (if no allergy)
- 25G 1.5″ needle for skin local
- 18G 1.5″ needle to draw up medications
- Extension tubing (3″) for contrast
- 3 mL syringe with 25G 1.5″ needle for skin local
- 5 mL syringe with extension tubing for contrast
- 3 mL syringe for injectate (Dexamethasone 10 mg)
- 3 mL slip-tip syringe for saline (if hanging drop technique).

Patient Positioning

– Prone using a small headrest under the forehead to allow airflow between table and patient and arms placed down at sides.

Pitt Pain Pearl
Increasing neck flexion can widen the interlaminar space in order to increase the size of the needle landing zone and plan trajectory

How to Perform the Procedure

1. Sterilely prep posterior neck and drape with sterile drape.
2. Locate the anatomic landmarks for an approach to the C7-T1 interspace in AP view.
3. Square off superior endplate of T1 and inferior endplate of C7 using caudal or cephalad tilt to optimize the C7-T1 interlaminar space.
4. Place the needle directly in midline or just ipsilateral to midline on the painful side in the interlaminar space (Images 1.1 and 1.2).
5. Anesthetize the skin at target entry site with Lidocaine 1% and insert Tuohy coaxial to the fluoroscopic beam.
6. Initial Tuohy placement should be shallow "to achieve purchase in the posterior muscles of the neck."

7. Rotate the C-arm to the lateral or contralateral oblique (CLO) views (approximately 50° contralateral for CLO in cervical region) for further Tuohy advancement.
8. Advance Tuohy with 15–20° of cranial angulation from the axial plane parallel to the spinous processes while visualizing the needle tip depth as it approaches the ventral interlaminar line (VILL) in the CLO view or the spinolaminar line in the lateral view (Image 1.3 and 1.4).

9. Engage ligamentum flavum and perform hanging drop or LOR technique while advancing in 1–2 mm increments with intermittent CLO views as needed until epidural space is accessed
   - If LOR or hanging drop response are equivocal, consider checking placement with contrast.
10. The final Tuohy position should be just ventral to VILL in CLO view (preferred) or just sublaminar in lateral view.
11. Confirm appropriate Tuohy placement in cervical epidural space with 1 mL contrast and verify appropriate spread of contrast in AP and CLO (or lateral) views (Image 1.2).
12. Administer 1.0 mL of dexamethasone 10 mg slowly.
13. Withdraw Tuohy, clean area, apply adhesive dressing.

Checkpoints to Mastery

Beginner

- Make proper adjustments on AP x ray with C7-T1 endplates "squared off."
- Locate the C7-T1 interspace and be able to point it out on fluoroscopic image.
- Insert Tuohy and obtain coaxial needle view within the C7-T1 interlaminar space.

Intermediate

- Make proper adjustments to C-arm and obtain CLO view.
- Identify the ventral interlaminar line (VILL).
- Direct needle parallel to spinous process until approaching VILL.

Advanced

- Engage the ligamentum flavum and appreciate resistance changed at the VILL on CLO.
- Perform hanging drop or loss of resistance technique.
- Confirm correct needle placement with contrast.

Pitt Pain Pearls and Pitfalls

- Review cervical MRI prior to the procedure to examine posterior epidural space dimensions.
- C7-T1 level is typically targeted since it has the largest posterior to anterior distance between the ligamentum flavum and dura/spinal cord.
- If the posterior epidural space is minimal to nonexistent at C7-T1, consider choosing the T1-T2 segment or C6-C7 and consider optimal patient positioning if targeting above C7-T1.
- CLO less than 45° from AP can mislead one to think the needle is deeper (more ventral) than it actually is.
- Conversely more oblique than 50° can make the needle seem more shallow (dorsal) than it actually is.
- Crossing midline can compromise CLO view.
- Take into account patient claustrophobia while placing sterile towels or drapes around head and history of vasovagal reactions.
- Be cognizant of location of ephedrine or other treatments for bradycardia/hypotension in clinic if required acutely during the procedure.
- Patients may require IV placement prior to first cervical epidural.

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Cervical Medial Branch Blocks (TON, C3, C4, C5)

2

John Yin, Hayden Hundley, and Alexander Varzari

Abstract

Cervical facet (zygapophyseal) joints are the only synovial joints in the spine and create the posterolateral articulation between vertebra. Facet joints are formed by the articulation of the inferior articular process of cervical vertebra with the superior articular process of the below vertebra. Each joint is innervated by articular branches derived from medial branches of the cervical dorsal rami. The medial branches run in a groove between the superior articular and transverse processes of each vertebra and innervate the interspinous muscle/ligaments, periosteum, and the multifidus muscle (Bogduk, Spine (Phila Pa 1976) 8(3):286–293, 1983). Of note, each facet joint below C2-C3 is dually innervated from the medial branch above and below. Additionally, a deep medial branch supplies the C3-C4 facet joint and a superficial medial branch of C3 known as the third occipital nerve (TON) supplies the C2-C3 facet joint.

Cervical medial branch blocks are indicated for axial neck pain that is refractory to conservative treatment with evidence suggesting facet joint involvement. Typically, two diagnostic blocks are performed on different days to ensure correct diagnosis of facet joint pain (Sehgal et al., Pain Physician 8(2):211–224, 2005). The patient can then be treated with radiofrequency ablation. TON neurectomy is an effective treatment for headache that has been identified to originate from the C2-C3 facet joint (Hamer and Purath, Headache 54(3):500–510, 2014).

J. Yin (✉) · A. Varzari
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: yinz3@upmc.edu; varzaria@upmc.edu

H. Hundley
Flowers Hospital, Dothan, AL, USA

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Keys to Procedure

- Understand the cervical spine anatomy on lateral view.
- Understand cervical MBB anatomy including C3 dorsal ramus branches.
- Identify and target the centroid of cervical articular pillars on lateral, supine, prone positioning.

Anatomy Pearls

See Images 2.1 and 2.2.

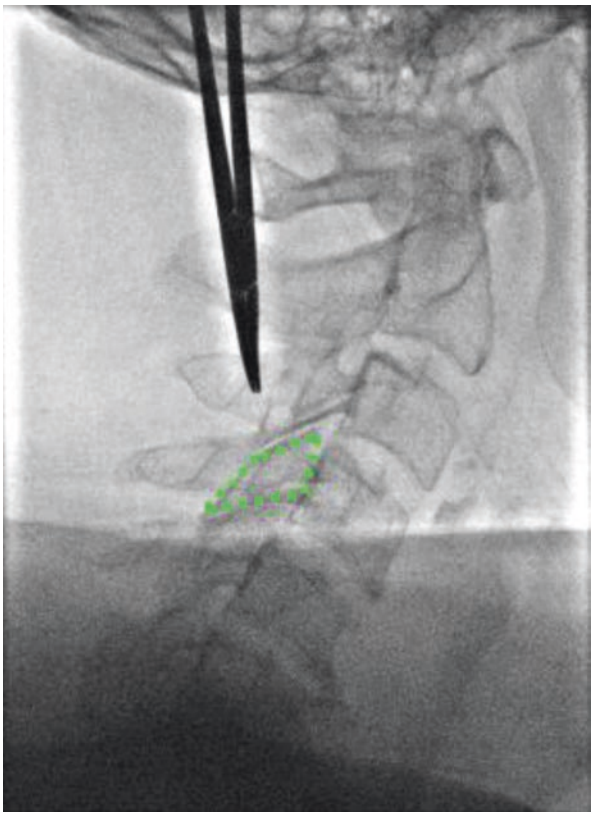

Image 2.1 Lateral view of cervical spine with articular pillar highlighted in green

Image 2.2 Spinal needle tip at centroid of C4 articular pillar

What You Will Need

- Sterile towels
- Chlorhexidine-based soap
- 25G 2″ or 3.5″ spinal needles ×3
- Bupivacaine 0.5%—3 mL
- 18G 1.5″ needle to draw up medications
- 3 mL syringe for injectate (3 mL Bupivacaine).

Patient Positioning

- Procedure can be performed in lateral, supine, or prone positions.
- Lateral approach is typically for diagnostic procedure only:
  - Patient is placed in the lateral decubitus position procedural side up with a pillow under the head.
  - Pillow should keep the cervical spine in alignment without lateral flexion to either side.
  - C-arm is placed directly over the patient's neck in the axial plane without angulation.
- Supine approach:
  - Patient is placed in supine position with head in neutral position and a true lateral view is obtained to locate the anatomic landmarks for a lateral approach to the lateral masses of the facets.

- Posterior approach is typically for cervical medial branch block (MBB) and radiofrequency ablation
  - Patient is placed prone with a small headrest under the forehead to allow for airflow between the table and the patient's nose and mouth.
  - C-arm may need to be angled 25–35° caudally from the axial plane.

How to Perform the Procedure

Lateral Positioning

1. Place patient in lateral decubitus position with neck supported with pillow, in neutral position, with the symptomatic side up.
2. Verify and mark laterality.
3. Sterilely prep the neck over the targeted lateral aspect of the neck and drape with sterile towels.

4. Obtain a true lateral view for the initial target cervical articular pillar (e.g., left C3) (Image 2.1).
   - The true lateral view at this level should have the silhouettes of the articular pillars from both sides superimposed (e.g., left C3 and right C3 articular pillars).

5. The target point is the centroid (intersection of the diagonals of the quadrilateral) of the articular pillar with same segmental number as the target nerve.
6. Anesthetize the skin as the respective level and insert 25G spinal needle.
7. Advance needle under the tip is at the centroid of the lateral mass on a true lateral view (Image 2.2).
8. After negative aspiration, administer 0.5 mL of Bupivacaine 0.5%.
9. Obtain true lateral views of the subsequent target levels (e.g., left C4, left C5) and repeat steps 4–8.

Supine Position

1. Place patient in supine position with arms at the side.
2. Verify and mark laterality.
3. Sterile prep the neck over the targeted lateral aspect of the neck and drape with sterile towels avoiding the face if possible.

4. The procedure is performed in the same manner as above with true lateral views obtained for the respective cervical levels and administration of bupivacaine at the centroid of the articular pillars at each level.

Prone Position

See Chap. 3 procedure template.

Third Occipital Nerve (TON)

- The C3 dorsal ramus forms two medial branches:
  - Deep Medial Branch—crosses the C3 articular pillar to innervate C3-C4 facet joint along with C4 medial branch
  - Superficial Medial Branch, also known as Third Occipital Nerve (TON), which innervates C2-3 facet joint.
- TON also innervates the semispinalis and suboccipital skin and can be included during cervical MBB in patients with unilateral cervicogenic headaches.
- The procedure requires an additional needle to be placed near the superior aspect of the C3 articular pillar overlying the C2-3 facet joint.

Beginner

- Identify key anatomic landmarks on lateral X-ray including centroid of articular pillar.
- Describe the innervation of the C2-3 and C3-4 facet joint and C3 dorsal ramus.

Intermediate

- Properly position patient in the lateral, supine, or prone position and obtain the true AP/lateral corresponding X-ray.
- Identify all bony landmarks on AP and lateral imaging.

Advanced

- Advance the needle to the exact destination on the articular pillar in supine, lateral, and prone positions.
- Discuss utility of using various injectates (lidocaine, bupivacaine, and different concentrations of each) and how this will affect clinical results.

Pitt Pain Pearls and Pitfalls

- In lateral decubitus position, patient can hug pillow if needed and consider surgical cap if patient has long hair that covers target area.
- When performing using a lateral approach, note that the dependent shoulder (shoulder resting on the table on the non-procedural side) extends cephalad and is often projected in the image overlying cervical spine.

- Failure to obtain true lateral risks aiming needle towards contralateral side of the neck.
- During advancement of needle in lateral approach, always keep the needle tip over the bony target.
- Confirm laterality since mistakes on determining symptomatic sides can occur when changing positions from supine to prone.
- If patients have unilateral occipital headaches associated with facet mediated neck pain, consider including TON in block.
- Procedure may be technically easier in the lateral position, but more time may be spent obtaining true lateral views.
- Avoid placing the needle through superficial vessels of the neck. Placing the needle through SCM can also be painful.
- Absolute contraindication to cervical MBB/RFA is an implanted cardiac defibrillator per SIS.

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Cervical Medial Branch Radiofrequency Ablation (TON, C3, C4, C5)

3

John Yin, Hayden Hundley, and Alexander Varzari

Abstract

Cervical facet (zygapophyseal) joints are the only synovial joints in the spine and create the posterolateral articulation between vertebra. Facet joints are formed by the articulation of the inferior articular process of cervical vertebra with the superior articular process of the below vertebra. Each joint is innervated by articular branches derived from medial branches of the cervical dorsal rami. The medial branches run in a groove between the superior articular and transverse processes of each vertebra and innervate the interspinous muscle/ligaments, periosteum, and the multifidus muscle (Bogduk, Spine (Phila Pa 1976) 8(3):286–293, 1983). Of note, each facet joint below C2-C3 is dually innervated from the medial branch above and below. Additionally, a deep medial branch supplies the C3-C4 facet joint and a superficial medial branch of C3 known as the third occipital nerve (TON) supplies the C2-C3 facet joint.

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J. Yin (✉) · A. Varzari
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: yinz3@upmc.edu; varzaria@upmc.edu

H. Hundley
Flowers Hospital, Dothan, AL, USA

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Keys to Procedure

- Understand positioning to optimize "opening" of facet joints.
- Be able to target the lateral groove or "waist" of the articular pillar.
- Ensure needle and lesions are parallel to the length of the medial branch.
- Be able to reposition the needle if complications arise.

See Images 3.1 and 3.2.

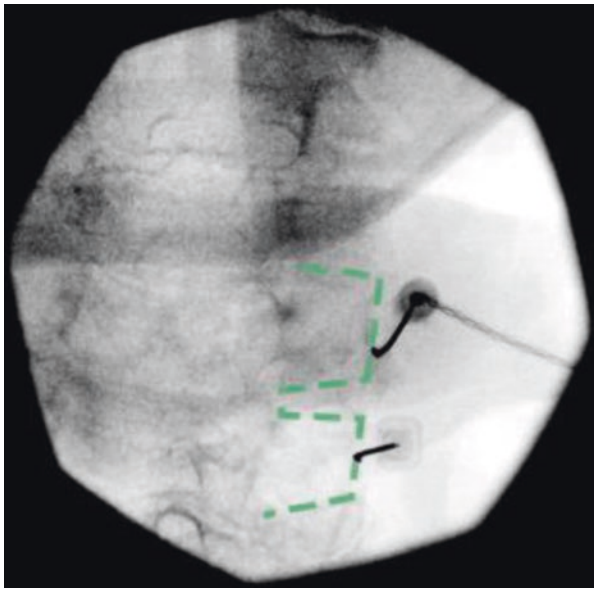

Image 3.1 AP view of final RFA needle positions. Highlighted shows the C4 articular pillar with needles adjacent

Image 3.2 Lateral view of the final RFA needle positions at C3, C4, and C5

What You Will Need

- Sterile towels
- Half-sheet drape
- Chlorhexidine-based soap
- RFA Generator that displays impedance, voltage, amperage, and temperature
- Electrode grounding pad (connected to RFA Generator)
- RFA cannula with stylet ×3
- Lidocaine 1% for skin—5 mL
- Lidocaine 2%—3 mL
- 25G 1.5″ needle for skin local
- 18G 1.5″ needle to draw up medications
- 5 mL syringe with 25G 1.5″ needle for skin local
- 3 mL syringe for Lidocaine 2%
- Consider injecting Bupivacaine 0.25% (1 mL) + dexamethasone 10 mg split between three levels after RFA with 3 mL syringe.

Patient Positioning

- Procedure typically performed in supine or prone positions, generally not lateral.
- Supine approach:

  - Patient is placed in supine with the head in a neutral position and a true lateral view is obtained to locate the anatomic landmarks for a lateral approach to the lateral masses of the facets.
- Posterior approach:
  - Typically preferred for cervical medial branch blocks and radiofrequency ablations.
  - Patient is placed prone with a small headrest under the forehead to allow for airflow between the table and the patient's nose and mouth.

How to Perform the Procedure

Prone Position

1. Place the patient in prone position and confirm laterality and procedure.
2. Sterilely prep and drape the target area.
3. Tilt the C-arm image intensifier caudally until the facet joints "open" for the targeted segment; typically, 25–35° caudally from the axial plane.

4. Oblique the C-arm image intensifier up to 30° towards the symptomatic side (e.g., left C3 lateral mass).
5. The target of the electrode-tip is the lateral groove or "waist" of the articular pillar.
6. After identifying the initial target, anesthetize the skin with lidocaine 1%.

7. Insert the RFA cannula coaxial to the C-arm beam in a lateral to medial fashion.
   - Use AP and lateral views while advancing needle to ensure needle placement is not too ventral or dorsal.
8. After contacting bone at the appropriate aspect of the "waist," adjust needle to ensure electrode positioning parallel to the target medial branch nerve and be able to cover the maximal accessible portion of the medial branch nerve at that level.
9. Steps 6–10 are repeated at the "waist" of subsequent articular pillars for needle placement at their respective levels.
10. After appropriate needle placement at the respective levels, remove the stylet and insert the thermal unit into the RFA cannula (Images 3.1 and 3.2).
11. Assess impedance and perform sensory stimulation.
    - Patient should feel paresthesia in their neck with 0.3–0.7 V at 50 Hz.

12. Perform motor stimulation ensuring there is no upper extremity muscle contractions elicited with 1.5–2 V at 2 Hz.
13. Repeat sensory and motor stimulation for each subsequent level.
14. Administer Lidocaine 2% to anesthetize medial branch nerve prior to ablation.
15. Commence thermal ablation at 80 °C for 90 s at each level.
16. Remove needles, clean site, and place adhesive dressing at the end of the procedure.

Pitt Pain Pearls and Pitfalls:

- For radiofrequency lesioning, the needle is placed parallel to the nerves (rather than perpendicular in the diagnostic block).
- The goal is to make lesions parallel to the entire accessible length of the medial branch as it winds its way around the curved articular pillar compared to diagnostic MBB injection where the injectate is placed at the center of articular pillar.
- Prior to ablation, ensure no needle movement with needle manipulation for local anesthetic administration.
- Impedance levels will typically decrease following administration of local anesthetic (goal less than 400–500 Ω).
- During thermal ablation, the initial 10–20 s are typically most painful as probe heats up. If pain is not tolerable, pause ablation and verify location of probes.

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Further Reading

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Thoracic Epidural Steroid Injection

4

Ron Vidri, Hayden Hundley, and Alexander Varzari

Abstract

Epidural spinal injections (ESI) are one of the most common treatments for chronic back pain. Injections are performed with local anesthetics with or without corticosteroids and can reduce inflammation providing pain relief, restoring function, and improving participation in a physical therapy program. They are most commonly performed at the lumbosacral level to treat lumbosacral radicular pain caused by lumbosacral disc herniation. Though thoracic back pain is less common than cervical or lumbosacral back pain it can still cause significant limitations for patients who suffer from it. Thoracic epidural steroid injections are an effective treatment for several thoracic chronic pain conditions to include disc herniation, spinal stenosis, and post thoracic surgery and thoracotomy pain (Benyamin et al., Pain Physician 15(4):E497–E514, 2012; Manchikanti et al., Pain Physician 17(3):E327–E338, 2014; Manchikanti et al., Pain Physician 24(S1):S27–S208, 2021).

Lumbar epidural steroid injections can be performed via a transforaminal, interlaminar, or caudal approach with mixed data regarding the superiority of any one approach (Ghai et al., Pain Physician 17(4):277–290, 2014; Manchikanti et al., Clin Orthop Relat Res 473(6):1940–1956, 2015; Parr et al., Pain Physician 12(1):163–188, 2009). Many physicians choose the transforaminal approach due to the ability to better target the ventral epidural space (Lee et al., Spine J 18(12):2343–2353, 2018). Risks of the transformational approach include including paraplegia and pain, with caudal ESIs being considered a safer though less targeted approach. The caudal approach carries a lower risk of thecal sac puncture and can be done fluoroscopically, with ultrasound guidance, or with a

R. Vidri (✉) · A. Varzari
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: vidrirm@upmc.edu; varzaria@upmc.edu

H. Hundley
Flowers Hospital, Dothan, AL, USA

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combination of both—mainly with fluoroscopy being used to check contrast spread in patients with prior low back surgery.

When isolated lumbar nerve root irritation is suspected, selective nerve root blocks can be performed for diagnosis and to better target the affected nerve root. Causes of nerve root irritation can include disc herniation, ligamentum flavum hypertrophy, facet hypertrophy, and osteophytes leading to nerve root irritation (Stafford et al., Br J Anaesth 99(4):461–473, 2007).

Lumbar epidural steroid injection and selective nerve root blocks are considered temporizing treatments and recurrence of low back pain is expected. They do not alter prognosis for patients with certain condition in whom surgery is indicated.

Keys to Procedure

- Understand the relevant thoracic spine anatomy on AP and CLO.
- Understand proper patient positioning to optimize epidural space.
- Be able to perform the hanging drop or loss of resistance technique.
- Understand the complications and corrective steps if encountered.

Anatomy Pearls

Patient Positioning

See Image 4.1.

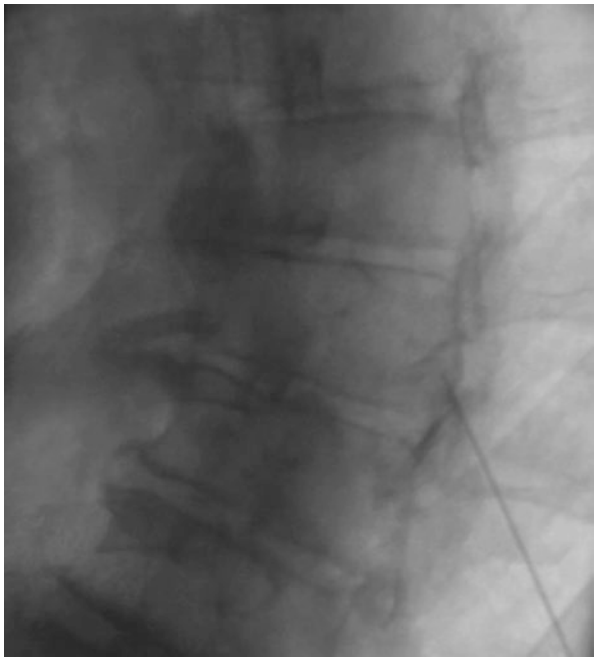

Image 4.1 CLO View of T9-10

What You Will Need

- Sterile drape
- Chlorhexidine-based soap
- 20G Tuohy needle
- Loss of Resistance syringe
- Lidocaine 1% for skin—5 mL
- Dexamethasone 10 mg—1 mL
- Preservative-free normal saline—2 mL
- Isovue 300—3 mL (if no allergy)
- 25G 1.5″ needle for skin local:
- 18G 1.5″ needle to draw up medications
- Extension tubing (3″) for contrast
- 3 mL syringe with 25G 1.5″ needle for skin local
- 5 mL syringe with extension tubing for contrast
- 3 mL syringe for injectate (0–2 mL preservative free normal saline + Dexamethasone 10 mg).

Pitt Pain Pearls

- Steeper angle required compared to other intra-laminar procedures.
- T1-T2 typically performed as alternative if anatomy precludes C7-T1 injection.

How to Perform the Procedure

1. Sterilely prep over target thoracic area and drape with sterile drape in prone position
2. Locate the anatomic landmarks to the specific thoracic interspace initially with C-arm angled with 40–50° caudal tilt from AP.
3. Square off superior endplate of vertebral body below and inferior endplate of vertebral body above targeted interlaminar space using caudad or cephalad tilt
4. Anesthetize the skin at target entry site with Lidocaine 1%.
5. Insert the Tuohy using a paramedian approach (1 cm below interspace, 1 cm lateral to spinous process on the painful side.
6. Advance Tuohy 10–15° toward midline (if paramedian) with 50–60° of cranial angulation from the axial plane toward interlaminar space.
7. Rotate the C-arm to the lateral or contralateral oblique (CLO—Image 4.1) views for further Tuohy advancement.
8. Advance Tuohy while visualizing the needle tip depth as it approaches the ventral interlaminar line (VILL) in the CLO view or the spinolaminar line in the lateral view.
9. Use a loss of resistance technique while advancing in 1–2 mm increments with intermittent CLO views as needed until epidural space reached.

10. The final needle position should be just ventral to VILL in CLO view (preferred) or just sublaminar in lateral view.
11. Confirm appropriate Tuohy placement in thoracic epidural space with 1 mL contrast and verify appropriate spread of contrast in AP and CLO (or lateral) views.
12. Administer injectate (2 mL PF normal saline + 1 mL Dexamethasone 10 mg) slowly.
13. Withdraw Touhy, clean area, apply adhesive dressing.

Checkpoints in Master

1. Sterilely prep over target thoracic area and drape with sterile drape.
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11. Confirm appropriate Tuohy placement in thoracic epidural space with 1 mL contrast and verify appropriate spread of contrast in AP and CLO (or lateral) views.
12. Administer injectate (2 mL PF normal saline + 1 mL Dexamethasone 10 mg) slowly.
13. Withdraw Touhy, clean area, apply adhesive dressing.

Checkpoints to Mastery

Beginner

- Make proper adjustments on AP X-ray with cephalad and caudal vertebral endplates "squared off."
- Locate the desired thoracic interspace and be able to point it out on fluoroscopic image.
- Insert Tuohy and obtain coaxial needle view within the targeted thoracic interlaminar space.

Intermediate

- Make proper adjustments to C-arm and obtain CLO view (Alternate—Lateral).
- Identify the ventral interlaminar line (VILL), (Alternate—Spinolaminar line).
- Direct needle parallel to spinous process until approaching VILL or Spinolaminar.

Advanced

- Engage the ligamentum flavum and appreciate resistance changed at the VILL on CLO.
- Perform hanging drop or loss of resistance technique.
- Confirm correct needle placement with contrast.

Pitt Pain Pearls and Pitfalls

- Review thoracic MRI prior to the procedure to examine posterior epidural space dimensions.
- CLO less than 45° from AP can mislead one to think the needle is deeper (more ventral) than it actually is.
- Conversely more oblique than 45° can make the needle seem more shallow (dorsal) than it actually is.
- Crossing midline can compromise CLO view.
- Take into account patient claustrophobia while placing sterile towels or drapes around head.
- Be cognizant of location of ephedrine or other treatments for bradycardia/hypotension in clinic if required acutely during the procedure.
- Patients may require IV placement prior to first thoracic epidural.

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Further Reading

Atlas of image-guided intervention in regional anesthesia and pain medicine. 2nd ed. Rathmell.
Atlas of image-guided spinal procedures. 2nd ed. Furman.

Part II

Lumbosacral Procedures

Lumbar Epidural Steroid Injection

5

Sean McDermott, Hayden Hundley, and Alexander Varzari

Abstract

Epidural spinal injections (ESI) are one of the most common treatments for chronic back pain. Injections are performed with corticosteroids with or without local anesthetics and can reduce inflammation providing pain relief, restoring function, and improving participation in a physical therapy program. They are most commonly performed at the lumbosacral level to treat lumbosacral radicular pain caused by lumbosacral disc herniation. Though thoracic back pain is less common than cervical or lumbosacral back pain it can still cause significant limitations for patients who suffer from it. Thoracic epidural steroid injections are an effective treatment for several thoracic chronic pain conditions to include disc herniation, spinal stenosis, and post thoracic surgery and thoracotomy pain (Benyamin et al., Pain Physician 15(4):E497–E514, 2012; Manchikanti et al., Pain Physician 17(3):E327–E338, 2014; Manchikanti et al., Pain Physician 24(S1):S27–S208, 2021).

Lumbar epidural steroid injections can be performed via a transforaminal, interlaminar, or caudal approach with mixed data regarding the superiority of any one approach (Ghai et al., Pain Physician 17(4):277–290, 2014; Manchikanti et al., Clin Orthop Relat Res 473(6):1940–1956, 2015; Parr et al., Pain Physician 12(1):163–188, 2009). Many physicians choose the transforaminal approach due to the ability to better target the ventral epidural space (Lee et al., Spine J 18(12):2343–2353, 2018). Risks of the transformational approach include including paraplegia and pain, with caudal ESIs being considered a safer though less targeted approach. The caudal approach carries a lower risk of thecal sac puncture and can be done fluoroscopically, with ultrasound guidance, or with a

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University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: mcdermotts3@upmc.edu; varzaria@upmc.edu

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combination of both—mainly with fluoroscopy being used to check contrast spread in patients with prior low back surgery.

When isolated lumbar nerve root irritation is suspected, selective nerve root blocks can be performed for diagnosis and to better target the affected nerve root. Causes of nerve root irritation can include disc herniation, ligamentum flavum hypertrophy, facet hypertrophy, and osteophytes leading to nerve root irritation (Stafford et al., Br J Anaesth 99(4):461–473, 2007).

Lumbar epidural steroid injection and selective nerve root blocks are considered temporizing treatments and recurrence of low back pain is expected. They do not alter prognosis for patients with certain condition in whom surgery is indicated.

Keys to Procedure

- Recognize and optimize Anterior Posterior (AP) and Contralateral Oblique views (CLO) of the lumbar spine.
- Choose an appropriate needle entry point and optimize trajectory with fluoroscopic guidance.
- Appreciate typical tactile differences of the needle and the loss of resistance syringe during the procedure.

Anatomy Pearls

See Images 5.1, 5.2, and 5.3.

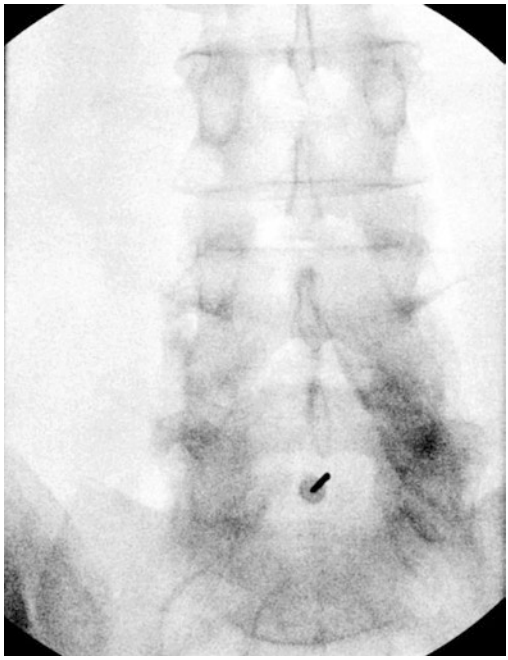

Image 5.1 AP view at L5-S1 for needle placement

Image 5.2 CLO view showing contrast spread in the epidural space

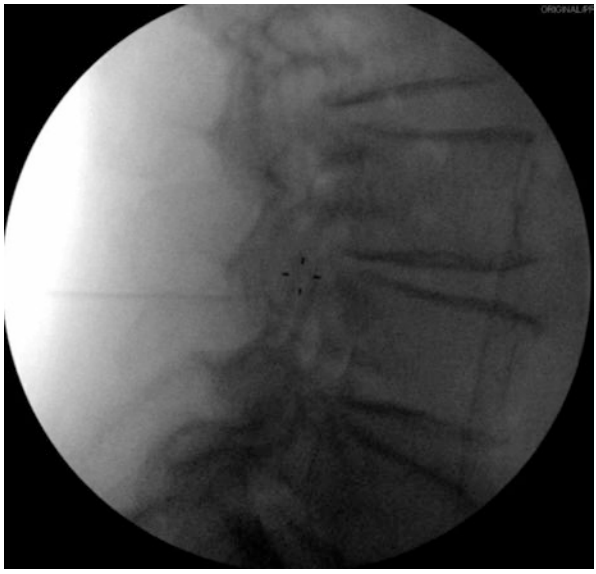

Image 5.3 Lateral needle view

Supplies and Setup

- Sterile drape
- Chlorhexidine-based soap ×3
- 20G Tuohy needle—3.5 in. or larger depending on body habitus
- Loss of resistance syringe
- Lidocaine 1% for skin—5 mL
- Preservative-free Methylprednisolone 80 mg—1 mL (consider 40 mg in patients with diabetes), or dexamethasone 10 mg
- Preservative-free normal saline—2–4 mL
- 25G 1.5″ needle for skin local
- 18G 1.5″ needle to draw up medications
- 3 mL syringe with 25G 1.5″ needle for skin local
- 5 mL syringe for injectate (2–4 mL PF normal saline + steroid)
- Optional:
  - Isovue 300—3 mL (if no allergy)
  - Separate 18G 1.5″ needle to draw contrast
  - Extension tubing (3″) for contrast
  - 3 mL syringe for contrast.

Patient Positioning

– Prone with pillow under abdomen to flex thoracolumbar spine and minimize lumbar lordosis.

How to Perform the Procedure

1. Sterilely prep over lumbar spine and drape with sterile drape.
2. Obtain a true AP view of the lumbar spine.
3. Consider small adjustments to cranial/caudal tilt to help “open” and optimize approach to interlaminar space.
4. Identify optimal entry point based on individualized patient pathology—including interspace level (commonly L5-S1 interspace) and laterality
   (a) Select based on symptom laterality and dermatomes, largest open space on fluoroscopy, and pre-procedure MRI findings
5. Anesthetize the skin at target entry site with Lidocaine 1% and insert Tuohy coaxial to the fluoroscopic beam (Image 5.1).

6. After needle is inserted 2–3 cm, switch to contralateral oblique (CLO), which is 45° oblique on the contralateral side of midline relative to the needle. Advance needle while visualizing the needle tip depth as it approaches the ventral interlaminar line (VILL). After switching to CLO view, if the needle is more than a few centimeters from the VILL, switch back and forth between an AP view and CLO view as the needle is advanced.

7. Engage the needle in the ligamentum flavum at the VILL. Confirm location of needle with fluoroscopy in the CLO view and/or the spinolaminar line in the lateral view (Image 5.2 and 5.3).
8. Use the loss of resistance technique to obtain access to the epidural space.
9. Optional: confirm location in the epidural space with contrast.
10. Tuohy should be just ventral to the VILL in CLO view or just sublaminar in the lateral view.
11. Administer injectate slowly—2–4 mL PF normal saline + steroid.
12. Withdraw Tuohy, clean area, apply adhesive dressing.

Checkpoints to Mastery

Beginner

- Adjust fluoroscopy to obtain true AP view of lumbar spine.
- Optimize fluoroscopy to "open" target space.
- Insert Tuohy and adjust to obtain coaxial view in target space.

Intermediate

- Appreciate tactile feel of tissue planes and ligaments as needle is advanced.
- Make appropriate adjustments to C-arm to obtain CLO view (Alternate—Lateral view).
- Identify ventral interlaminar line (VILL) in CLO view.

Advanced

- Transition from AP to CLO (or lateral view) when needle is close to epidural space without inadvertently entering thecal sac.
- Appreciate loss of resistance in needle and syringe when entering the epidural space.
- Confirm needle placement with contrast spread, and needle position on lateral or CLO view.

Pitt Pain Pearls and pitfalls

- Use the contralateral oblique (or lateral view) and/or contrast to confirm depth prior to injecting steroid solution as false loss of resistance is common.
- If a dural puncture ("wet tap") occurs, the most conservative approach is to cancel the procedure. Other approaches could include re-attempting at another interspace, or withdrawing the needle and approaching the same space again, confirming lack of CSF flow with aspiration prior to injection.
- Small-appearing interspaces can often be optimized by caudal/cranial tilts of the C-Arm; oblique tilts may be used to optimize paramedian approach.
- Transitioning from AP to lateral or CLO view too early may add additional procedural challenges as medial/lateral guidance is lost and cranial/caudal guidance limited.
- Loss of resistance to air can cause pneumocephalus and severe headache, minimize risk by using saline or limit amount of air injected.

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Further Reading

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Caudal Epidural Steroid Injection with Fluoroscopy

6

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Abstract

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S. McDermott (✉) · A. Varzari
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When isolated lumbar nerve root irritation is suspected, selective nerve root blocks can be performed for diagnosis and to better target the affected nerve root. Causes of nerve root irritation can include disc herniation, ligamentum flavum hypertrophy, facet hypertrophy, and osteophytes leading to nerve root irritation (Stafford et al., Br J Anaesth 99(4):461–473, 2007).

Lumbar epidural steroid injection and selective nerve root blocks are considered temporizing treatments and recurrence of low back pain is expected. They do not alter prognosis for patients with certain condition in whom surgery is indicated.

Keys to Procedure

- Recognize and optimize lateral fluoroscopic view of sacrum and target structures.
- Select appropriate entry point and needle angle—midline, appropriate cranial/caudal position, and shallow angle towards sacral hiatus.
- Appreciate tactile feel of needle entry through sacrococcygeal ligaments into epidural space.

Anatomy Pearls

See Images 6.1 and 6.2.

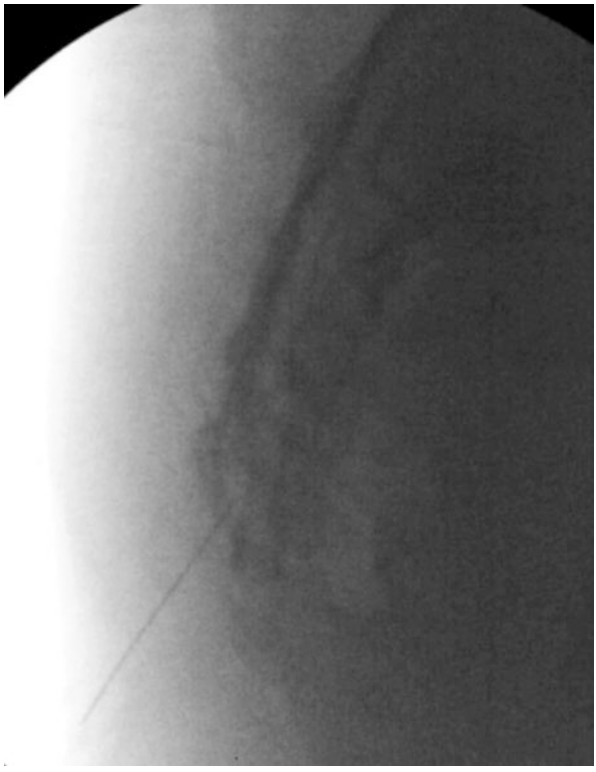

Image 6.1 Lateral view of needle entering caudal epidural space

Image 6.2 Lateral view of contrast spread into caudal epidural space

Supplies and Setup

- Sterile drape
- Topical Antiseptic (i.e. chlorhexidine/alcohol, betadine)
- 22G 3.5″ spinal or Tuohy needle
- Lidocaine 1% for skin—5 mL
- Preservative-free (PF) Methylprednisolone 80 mg—1 mL (consider 40 mg in patients with diabetes), or dexamethasone 10 mg
- PF normal saline—3–4 mL
- Bupivacaine 0.25%—2 mL (consider risks/benefits of adding local anesthetic to epidural)
- Isovue 300—3 mL (if no allergy)
- 25G 1.5″ needle for skin local
- 18G 1.5″ needle to draw medications
- 18G 1.5″ needle to draw contrast
- Extension tubing (3″) for contrast
- 3 mL syringe with 25G 1.5″ needle for skin local
- 5 mL syringe with extension tubing for contrast
- 10 mL syringe for injectate—4 mL PF normal saline +2 mL 0.25% Bupivacaine (if desired) + steroid
- Optional: pediatric epidural catheter

Patient Positioning

– Prone with pillow under pelvis to help with anatomic visualization.

How to Perform the Procedure

1. Sterilely prep over the lower lumbar spine, sacral hiatus, and coccyx and drape with sterile drape.
2. Palpate the sacral hiatus between the sacral cornua, or alternatively, use lateral fluoroscopic view to identify sacral hiatus.

3. Anesthetize the skin midline overlying the sacral hiatus with Lidocaine 1%.
4. Introduce a 22G 3.5″ Tuohy or spinal needle at less than 45° angle, in the midline, overlying the sacral hiatus.
5. Use lateral fluoroscopic view to visualize the needle angle relative to the sacral hiatus and sacrococcygeal periosteum to avoid advancing too far ventrally into the viscera or too shallow dorsally (Image 6.1). Collimation in the lateral view can help better define the image.
6. A distinct change in resistance is often felt as the needle tip passes through the sacrococcygeal ligament.
7. The angle of the needle can then be increased (to 75° or more from the axial plane) to lie closer to the plane of the sacrum, and the needle tip can be advanced an additional 1–2 cm into the caudal epidural space.

8. Optional: obtain AP view to confirm needle is midline (or directed towards symptomatic side) and below S3.
9. Optional: advance catheter through epidural needle to desired level or until resistance is met.
10. Administer 1 mL of contrast through needle or catheter (if used) to ensure appropriate spread outlining epidural space in lateral view (Image 6.2) and/or AP view.
11. Administer injectate slowly—(4 mL PF normal saline +2 mL 0.25% Bupivacaine (if desired) + steroid.
12. Withdraw needle, clean area, apply adhesive dressing.

Checkpoints to Mastery

Beginner

- Identify the sacral hiatus and cornua with palpation.
- Identify the target structures on a lateral and AP fluoroscopic view.

Intermediate

- Adjust fluoroscope to obtain optimal lateral view.
- Appreciate tactile feel of the sacrococcygeal ligaments and entry into caudal space.

Advanced

- Confirm needle placement with contrast spread pattern.
- Insert an epidural catheter through Tuohy and advance to target position.

Pitt Pain Pearls and Pitfalls

- The 25G 1.5″ needle for skin can also be used to access epidural space in patient with low BMIs and no plans for use of pediatric epidural catheter. Removing the 1% Lidocaine syringe prior to advancing the skin needle into canal avoids inadvertent injection of additional lidocaine. Some also prefer to use a 22–25 g spinal needle rather than epidural needle.
- Avoid advancing the needle too far within the caudal space to avoid a wet tap, the thecal sac typically ends around S2–S3 in adults.
- During injection, palpation with a finger above the sacral hiatus can sometimes identify a subcutaneous injection if tissue expansion is felt.
- A hemostat may be used to tent skin and identify optimal needle entry point and trajectory prior to local infiltration.

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Further Reading

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Caudal Epidural Steroid Injection with Ultrasound

7

Merna Naji, Hayden Hundley, and Alexander Varzari

Abstract

Epidural spinal injections (ESI) are one of the most common treatments for chronic back pain. Injections are performed with local anesthetics with or without corticosteroids and can reduce inflammation providing pain relief, restoring function, and improving participation in a physical therapy program. They are most commonly performed at the lumbosacral level to treat lumbosacral radicular pain caused by lumbosacral disc herniation. Though thoracic back pain is less common than cervical or lumbosacral back pain, it can still cause significant limitations for patients who suffer from it. Thoracic epidural steroid injections are an effective treatment for several thoracic chronic pain conditions to include disc herniation, spinal stenosis, and post thoracic surgery and thoracotomy pain (Benyamin et al., Pain Physician 15(4):E497–E514, 2012; Manchikanti et al., Pain Physician 17(3):E327–E338, 2014; Manchikanti et al., Pain Physician 24(S1):S27–S208, 2021).

Lumbar epidural steroid injections can be performed via a transforaminal, interlaminar, or caudal approach with mixed data regarding the superiority of any one approach (Ghai et al., Pain Physician 17(4):277–290, 2014; Manchikanti et al., Clin Orthop Relat Res 473(6):1940–1956, 2015; Parr et al., Pain Physician 12(1):163–188, 2009). Many physicians choose the transforaminal approach due to the ability to better target the ventral epidural space (Lee et al., Spine J 18(12):2343–2353, 2018). Risks of the transformational approach include paraplegia and pain, with caudal ESIs being considered a safer though less targeted

M. Naji (✉) · A. Varzari
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: najimr@upmc.edu; varzaria@upmc.edu

H. Hundley
Flowers Hospital, Dothan, AL, USA

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approach. The caudal approach carries a lower risk of thecal sac puncture and can be done fluoroscopically, with ultrasound guidance, or with a combination of both—mainly with fluoroscopy being used to check contrast spread in patients with prior low back surgery.

When isolated lumbar nerve root irritation is suspected, selective nerve root blocks can be performed for diagnosis and to better target the affected nerve root. Causes of nerve root irritation can include disc herniation, ligamentum flavum hypertrophy, facet hypertrophy, and osteophytes leading to nerve root irritation (Stafford et al., Br J Anaesth 99(4):461–473, 2007).

Lumbar epidural steroid injection and selective nerve root blocks are considered temporizing treatments and recurrence of low back pain is expected. They do not alter prognosis for patients with certain condition in whom surgery is indicated.

Keys to Procedure

- Understand the relevant caudal anatomy.
- Optimize ultrasound images for best caudal epidural access.
- Understand the complications and corrective steps if encountered.

Anatomy Pearls

See Images 7.1 and 7.2.

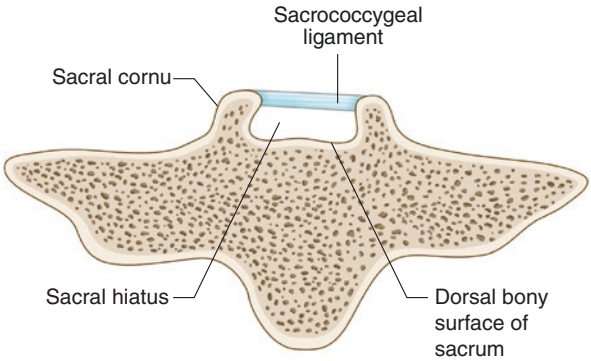


Image 7.1 Transverse ultrasound view of the sacral cornu and sacral hiatus

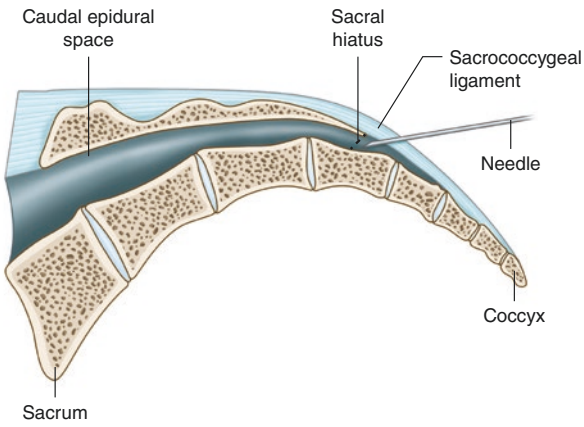


Image 7.2 Sagittal ultrasound view of the sacral hiatus

What You Will Need

- Sterile towels.
- Chlorhexidine/alcohol solution/betadine.
- Ultrasound with linear-array transducer.
- Sterile probe cover.
- Sterile ultrasound gel.
- 22G 3.5″ spinal needle.
- 18G 1.5″ needle to draw up medications.
- Lidocaine 1% for skin—5 mL.
- 25G 1.5″ needle for skin local.
- 3 mL syringe with the above 25G 1.5″ needle for skin local.
- Methylprednisolone 80 mg—1 mL (consider 40 mg in diabetic patients); or consider dexamethasone 10 mg.
- Preservative-free normal saline—4 mL.
- Bupivacaine 0.25%—2 mL (weigh risks/benefits of local anesthetic in epidural).
- 10 mL syringe for injectate (4 mL PF normal saline +/− 2 mL Bupivacaine +1 cc of steroid).

Patient Positioning

- Prone with a pillow under the pelvis to help with anatomic visualization.

How to Perform the Procedure

1. Sterilely prep the lower back, sacral hiatus, and coccyx, and drape with a sterile drape.
2. Palpate the sacral hiatus between the sacral cornua and place the transducer transversely at the midline to identify a transverse view of the sacral hiatus (Images 7.1 and 7.3).
3. Rotate the probe 90° to obtain a longitudinal view of the sacral hiatus (Images 7.2 and 7.4).

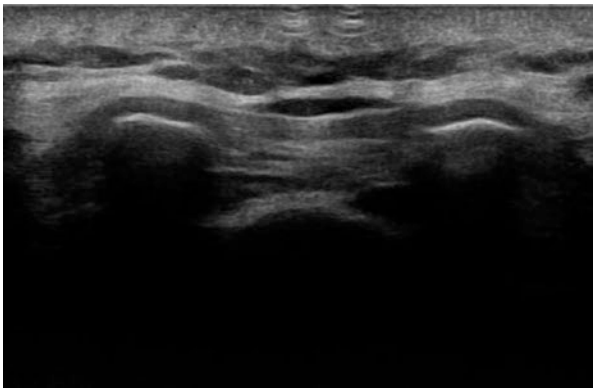
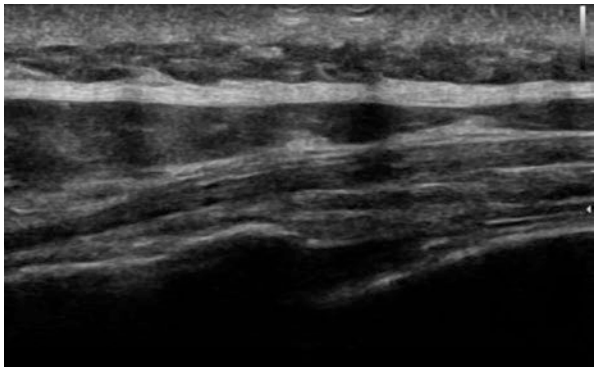


Image 7.3 Out-of-plane view of the needle in the caudal epidural space. The two hyperechoic reversed U-shaped structures are the two bony prominences of sacral cornua. Between the two cornua, there are two hyperechoic band-like structures. The one on top is the sacrococcygeal ligament and the one on the bottom is the dorsal bony surface of the sacrum. The sacral hiatus is the hypoechoic region observed between the two hyperechoic band-like structures

Image 7.4 In-plane view of entry site into sacral hiatus



4. Keeping ultrasound probe stationary, anesthetize the skin midline overlying the sacral hiatus with Lidocaine 1%.
5. Insert the 22G 3.5″ spinal needle and advance between the two cornua to the sacral hiatus and into the caudal epidural space. A distinct "pop" is felt as the needle tip passes through the sacrococcygeal ligament via the sacral hiatus into the epidural space.

6. Rotate the ultrasound transducer back to the transverse view to make sure the spinal needle is inserted correctly into the caudal epidural space.
7. Administer the injectate (4 mL PF normal saline +2 mL Bupivacaine +1 mL steroid) slowly. Place finger above sacral hiatus to ensure injectate is not being administered subcutaneously.
8. Withdraw the needle, clean the area, and apply an adhesive dressing.

Checkpoints to Mastery

Beginner

- Understand appropriate positioning and sterile ultrasound preparation.
- Obtain correct transverse and longitudinal images of the sacral hiatus.

Intermediate

- Anesthetize skin with local anesthetic.
- Insert spinal needle and appreciate the tactile sensation change as it passes through the sacrococcygeal ligament.

Advanced

- Ensure appropriate administration of medication under ultrasound confirmation.
- Manage any complications.

Pitt Pain Pearls and Pitfalls

- Contrast dye and protective lead are not required.
- You may need an assistant to assist with adjusting ultrasound settings during the procedure.

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Lumbar Transforaminal Epidural Steroid Injection/Selective Nerve Root Block

8

Isaiah Levy, Ankur Patel, and Alexander Varzari

Abstract

Epidural spinal injections (ESI) are one of the most common treatments for chronic back pain. Injections are performed with local anesthetics with or without corticosteroids and can reduce inflammation providing pain relief, restoring function, and improving participation in a physical therapy program. They are most commonly performed at the lumbosacral level to treat lumbosacral radicular pain caused by lumbosacral disc herniation. Though thoracic back pain is less common than cervical or lumbosacral back pain it can still cause significant limitations for patients who suffer from it. Thoracic epidural steroid injections are an effective treatment for several thoracic chronic pain conditions to include disc herniation, spinal stenosis, and post thoracic surgery and thoracotomy pain (Benyamin et al., Pain Physician 15(4):E497–E514, 2012; Manchikanti et al., Pain Physician 17(3):E327–E338, 2014; Manchikanti et al., Pain Physician 24(S1):S27–S208, 2021).

Lumbar epidural steroid injections can be performed via a transforaminal, interlaminar, or caudal approach with mixed data regarding the superiority of any one approach (Ghai et al., Pain Physician 17(4):277–290, 2014; Manchikanti et al., Clin Orthop Relat Res 473(6):1940–1956, 2015; Parr et al., Pain Physician 12(1):163–188, 2009). Many physicians choose the transforaminal approach due to the ability to better target the ventral epidural space (Lee et al., Spine J 18(12):2343–2353, 2018). Risks of the transformational approach include including paraplegia and pain, with caudal ESIs being considered a safer though less targeted approach. The caudal approach carries a lower risk of thecal sac puncture and can be done fluoroscopically, with ultrasound guidance, or with a

I. Levy (✉) · A. Varzari
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: levyir2@upmc.edu; varzaria@upmc.edu

A. Patel
Wellspan Health Interventional Pain Medicine Gettysburg Hospital, Hanover, PA, USA

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combination of both—mainly with fluoroscopy being used to check contrast spread in patients with prior low back surgery.

When isolated lumbar nerve root irritation is suspected, selective nerve root blocks can be performed for diagnosis and to better target the affected nerve root. Causes of nerve root irritation can include disc herniation, ligamentum flavum hypertrophy, facet hypertrophy, and osteophytes leading to nerve root irritation (Stafford et al., Br J Anaesth 99(4):461–473, 2007).

Lumbar epidural steroid injection and selective nerve root blocks are considered temporizing treatments and recurrence of low back pain is expected. They do not alter prognosis for patients with certain condition in whom surgery is indicated.

Keys to Procedure

- Understand the relevant lumbar spine anatomy on AP and ipsilateral oblique view.
- Understand key safety anatomic landmarks as visualized under fluoroscopy.
- Understand the complications and corrective steps if encountered.

Anatomy Pearls

- Scotty Dog.
  - "Nose" = Transverse process.
  - "Eye" = Pedicle.
  - "Ear" = SAP.
  - "Feet" = IAP.

See Images 8.1 and 8.2.

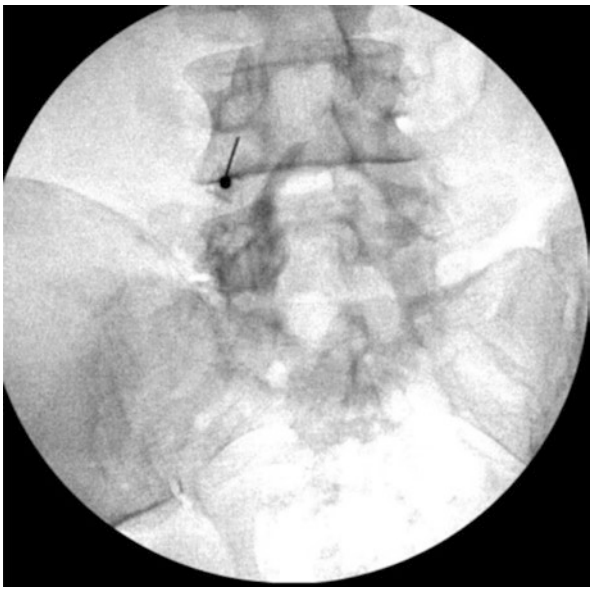

Image 8.1 Oblique view with needle tip under pedicle

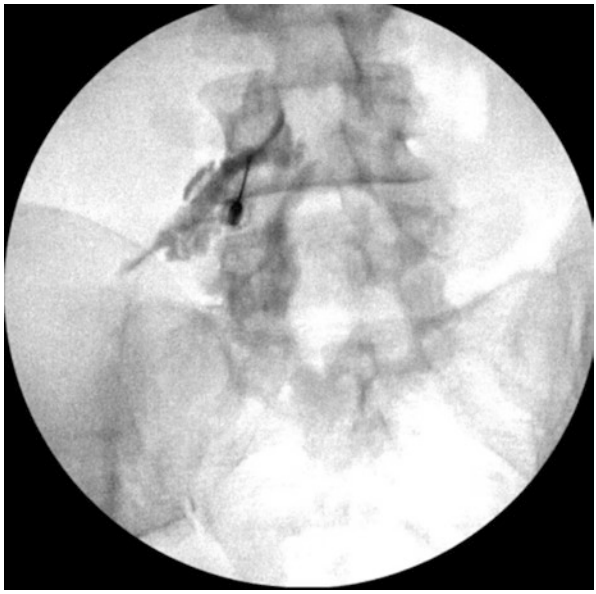

Image 8.2 Needle position in AP view after injection of contrast

What You Will Need

- Sterile towels.
- Chlorhexidine-based soap.
- 22G 3.5″ or 25G 3.5 or 5″ spinal needle.
- Lidocaine 1% for skin–5 mL (if using 22G spinal needles).
- Isovue 300–3 mL.
- Bupivacaine 0.25%–1 mL.
- Dexamethasone 10 mg–1 mL (consider nonparticulate steroids to minimize risks of intravascular uptake/infarct).
- 25G 1.5″ needle for skin local.
- 18G 1.5″ needle to draw up medications.
- Extension tubing (3″) for contrast.
- 5 mL syringe with 25G 1.5″ needle for skin local (if using 22G spinal needles).
- 3 mL syringe with tubing for contrast.
- 3 mL syringe for injectate (1 mL Bupivacaine+ Dexamethasone 10 mg).

Patient Positioning

- Prone with pillow under abdomen to flex thoracolumbar spine and minimize lumbar lordosis.

How to Perform the Procedure

1. Sterilely prep over lumbar spine and drape with sterile towels.
2. Obtain a true AP view of the lumbar spine and confirm the spinal level and side to be targeted.
3. Square off superior endplate corresponding to the vertebra at which the injection is being performed using caudad or cephalad tilt.
4. Oblique the C-arm image intensifier 15–30° ipsilateral to the targeted side of the nerve root until there is no periosteum (SAP, TP, lamina) to allow for proper visualization of the target point. The target entry point is typically just below the "chin" of the "scotty dog" (inferior to the pedicle).
   (a) If entering at a more oblique trajectory, final needle position likely more medial and less ventral final needle position. If less oblique trajectory, then final needle position less likely medial and more likely ventral.
   (b) Aim for the "safe triangle" - the target area formed by the inferior margin of the pedicle, the exiting nerve root, and an inferior line from the anterior margin of the pedicle. On the AP view, the needle should remain lateral to the midpedicular line.
5. Anesthetize the skin at target entry site with Lidocaine 1%and insert 22G 3.5 or 5″ spinal needle coaxial to the fluoroscopic beam. Typically, no skin local is needed if using 25G spinal needle.
6. Advance needle under fluoroscopic guidance so needle tip under the pedicle (Image 8.1).
7. Obtain a lateral view of the targeted intervertebral foramen and advance needle tip until approximately halfway into the foramen.
   (a) Keep needle along the superior aspect of the foramen to avoid contacting the spinal nerve and vascular structures in the ventral neural foramen.
8. Obtain an AP view to visualize the needle tip under the pedicle. Needle tip should not be beyond the midpedicular line (6 o'clock position of the inferior aspect of the pedicle) to avoid dural puncture.

9. Administer 1 mL of contrast to ensure contrast flow outlining the spinal nerve, nerve root sheath, and into the epidural space medial to the pedicle (Image 8.2).
   (a) Avoid any contrast flow pattern that does not outline the targeted structures including washout of contrast suggesting intravascular spread.
   (b) If available, use digital subtraction on fluoroscopy to confirm appropriate flow pattern and lack of intravascular uptake.
10. Administer injectate (1 mL Bupivacaine 0.25% + Dexamethasone 10 mg) slowly.
11. Withdraw needle, clean area, apply adhesive dressing.

Checkpoints to Mastery

Beginner

- Make proper adjustments on AP X-ray in order to "square off" SEP.
- Oblique fluoroscope ipsilaterally and identify anatomic landmarks of "Scotty Dog" view.
- Insert Tuohy, with needle aiming just under the "chin" of the "Scotty Dog" (inferior to the pedicle).

Intermediate

- Aim needle for the "safe triangle." On AP view, the needle should not be advanced beyond the midpedicular line (6 o'clock position of the inferior aspect of the pedicle) with the spinal nerve lying more medially. On lateral view, the needle should be kept superiorly in the intervertebral foramen to avoid annular tear.

Advanced

- Utilize contrast with live fluoroscopic imaging to ensure no intravascular uptake.
- Visualize outline of spinal nerve upon utilizing contrast.

Pitt Pain Pearls and Pitfalls

- Selective Nerve Root block is similar (needle tip is adjacent to the spinal nerve, but outside the intervertebral foramen) and can be used for surgical planning.
- Direct injection of a particulate steroid into a spinal segmental artery supplying the spinal cord may lead to infarction, so nonparticulate steroid is frequently used.

- Care when performing on the left T12–L3 due to the artery of Adamkiewicz lying in between these levels.
- Subarachnoid injection is also avoided by not advancing the spinal needle too medially past the pedicle.
- Supraneural approach can prevent direct trauma to the exiting nerve root or spinal cord itself.
- Positioning the needle more medially in the neural foramen increases the risk for dural puncture. If the needle is positioned too laterally, a selective nerve root block may be performed, and retrograde epidural flow may not be achieved. After epidural contrast material is administered, it should outline the nerve root sheath and retrograde or medial epidural flow.

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Further Reading

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Diagnostic Lumbar Medial Branch Block

9

Michael Glicksman, Ankur Patel, and Alexander Varzari

Abstract

The lumbar vertebrae are connected by the zygapophyseal or facet joints posteriorly. As each nerve root exits the vertebral foramen it divides into ventral and dorsal rami. The dorsal ramus is further divided into the lateral, intermediate, and medial branches. From L1 to L4, each medial branch travels between the superior articular process and transverse process of the vertebral level below. For example, the L1 medial branch crosses between the L2 superior articular process and transverse process. The L5 medial branch is variable and so the L5 dorsal ramus is targeted.

Each medial branch innervates two facet joints, so a single nerve block affects two facet joints. Additionally, each facet joint is dually innervated by the medial branch at its level and the medial branch of the above vertebra, so to fully block one facet joint it is necessary to block the medial branch above and below that joint (Bogduk, Spine (Phila Pa 1976) 8(3):286–293, 1983; Berkwits et al., 265–272, 2018). For example, blocking the L4/5 facet joint requires blocking the L3 and L4 medial branches.

Treating low back pain caused by the lumbar medial branch nerves usually requires two positive diagnostic nerve blocks prior to pursuing more definitive lumbar medial branch radiofrequency ablation due to potential for false positive diagnostic blocks (Manchukonda et al., J Spinal Disord Tech 20(7):539–545, 2007).

M. Glicksman (✉) · A. Varzari
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: glicksmanm@upmc.edu; varzaria@upmc.edu

A. Patel
Wellspan Health Interventional Pain Medicine Gettysburg Hospital, Hanover, PA, USA

T. Emerick et al. (eds.), *The Pain Procedure Handbook*,
https://doi.org/10.1007/978-3-031-40206-7_9

Keys to Procedure

- Understand the relevant lumbar spine anatomy on AP, oblique, and lateral views.
- Recognize the difference in performing L1–L4 vs. L5 medial branch blocks (MBB).
- Understand the complications and corrective steps if encountered.

Anatomy Pearls

- From L1 to L4, each medial branch nerve differs from the bone/vertebrae that it crosses, with each medial branch crossing the junction of the superior articular process (SAP) and transverse process (TP) one level below from where it originates [1].
  - The L1 medial branch crosses between the L2 SAP and TP and so forth until the L4 medial branch crosses between the L5 SAP and TP.
- The anatomy at L5 differs, with the L5 dorsal ramus itself running along the junction of the sacral ala and SAP of the sacrum before ultimately giving off a medial branch at the L5/S1 facet joint [2].
- Each medial branch innervates two facet joints, so a single medial branch block will affect two facet joints. However, to completely block one facet joint, it is necessary to block both the medial branch above and below that joint [2].
  - Blocking the L4/L5 facet joint requires blocking both the L3 and L4 medial branches.
  - Blocking the L5/S1 facet joint requires blocking both the L4 medial branch and L5 dorsal ramus.
- Target needle location:
  - L1–L4 medial branches: at the junction of the SAP and TP, represented by the inflexion point where the two processes form the head of the "Scotty dog."
  - L5 dorsal ramus: at the middle of the base of the SAP of the sacrum and slightly below the sacral ala, prior to its division into the L5 medial branch [2].

See Images 9.1, 9.2 and 9.3.

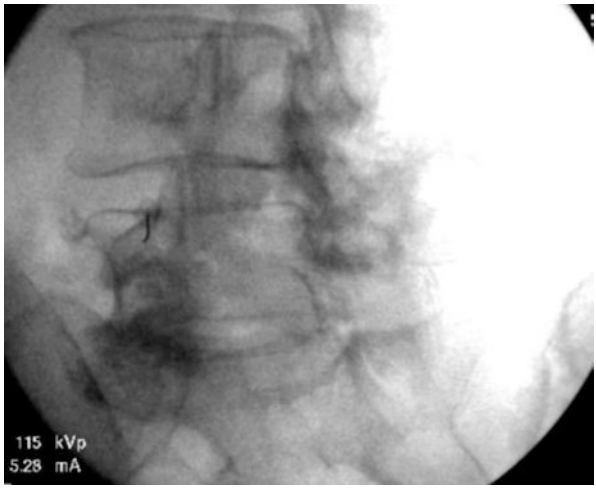

Image 9.1 Identify "Scotty dog" with the needle just superior to the eye of the "Scotty dog"

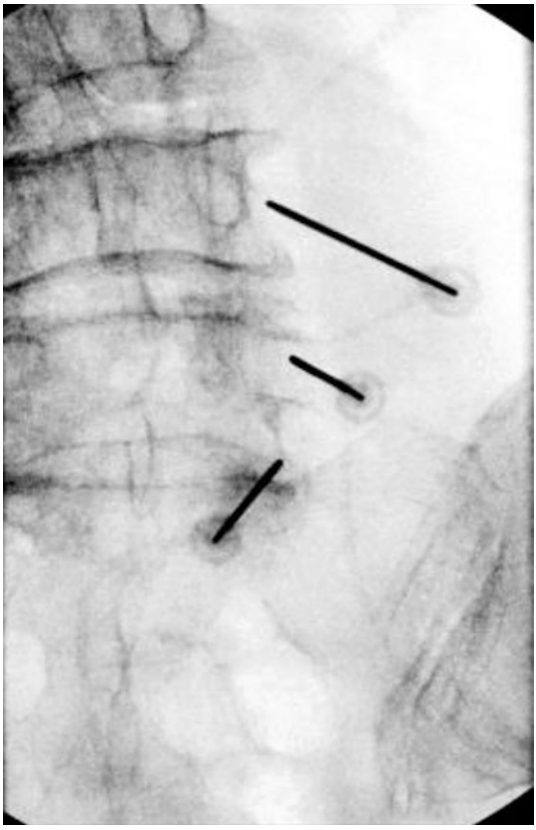

Image 9.2 Note correct needle placement at the junctions of the SAP and TAP at L4 and L5 to target the L3 and L4 medial branches, and at the junction of the SAP of the sacrum and sacral ala to target the L5 dorsal ramus

Image 9.3 Lateral view with needles in place at the bases of the TAP and SAP and SAP of sacrum and sacral ala to target the L3 and L4 medial branches as well as the L5 dorsal ramus

What You Will Need

- Sterile drape
- Chlorhexidine-based soap × 3
- 25G 1.5″ needle for superficial skin localization
  - 22G or 25G 3.5″ spinal needle (or longer depending on body habitus) × 3
- Bupivacaine 0.5%—3 mL
- 18G 1.5″ needle to draw up medications
- 3 mL syringe for injectate (can draw up approximately 3 mL Bupivacaine)

Patient Positioning

- Prone with pillow under abdomen to flex the thoracolumbar spine and minimize lumbar lordosis.

How to Perform the Procedure

1. Sterilely prep over lumbar spine and drape with sterile towels.
2. Obtain a true AP view of the lumbar spine and confirm the vertebral levels and side to be targeted.
3. Square off superior endplate corresponding to the vertebra at which the injection is being performed using caudad or cephalad tilt.
4. Oblique the C-arm image using intensifier 15–30° ipsilateral to the targeted side to form the "Scotty dog" appearance to allow for proper visualization of the target point (Image 9.1).
   (a) L1–L4 medial branches: The target for the needle is the pedicle, or just superior to the eye of the "Scotty dog."
   (b) L5 dorsal ramus: The target for the needle is the sacral ala.

5. Anesthetize only the superficial skin with Lidocaine 1% (this step can be skipped) and insert the spinal needle coaxial to the fluoroscopic beam.
6. Advance the needle until bone is encountered and the needle can no longer be advanced further.
7. Repeat steps 3–6 for the subsequent lumbar medial branch nerves.

8. Obtain a lateral fluoroscopic view to verify needle tips are not too anterior into the neural foramen (Image 9.3).
9. Administer 0.5 mL of Bupivacaine 0.5% at each level (or 0.75 mL at sacral ala).
10. Withdraw needles, clean site, and place adhesive dressing.

Checkpoints to Mastery

Beginner

- Understand the anatomy of the lumbar medial branch nerves.
- Make proper adjustments on AP view with lumbar endplates "squared off."
- Locate the "Scotty dog" on oblique view and be able to identify the location of appropriate needle placement to perform L1–L5 MBB on fluoroscopic images.

Intermediate

- Successfully identify the insertion site above the junction of the TAP and SAP (or SAP and sacral ala) and insert needle to obtain coaxial needle view.
- Advance needle until bone is encountered.

Advanced

- Confirm needle placement on lateral view and ensure not within the neural foramen.
- Confirm correct needle placement with contrast, ensuring that there is no epidural or vascular flow.
  - L1–L4: contrast should outline medial border.
  - L5: contrast should outline SAP of sacrum.

Pitt Pain Pearls and Pitfalls

- During an L5 medial branch block, the iliac crest may obstruct the needle view at the L5 dorsal ramus. If this happens, oblique the fluoroscope 5–10° back toward AP [2].
- Medial branch blocks require as accurate placement as possible since the injectate does not reliably spread in all directions surrounding the medial branch nerve.
- Some society guidelines recommend using contrast dye to confirm position given the precise placement of the needle to obtain a true medial branch block and to decrease the chance of a sham block [3].
- Be cognizant of the mamillo-accessory ligament which crosses perpendicularly over the medial branch and runs from the SAP to the TAP [1].

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Further Reading

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Atlas of image-guided intervention in regional anesthesia and pain medicine. 2nd ed. Rathmell.
SIS practice guidelines for spinal diagnostic and treatment procedures. 2nd ed. Bogduk.

Lumbar Medial Branch Radiofrequency Ablation (RFA)

10

Richa Lamba Dudek, Ankur Patel, and Alexander Varzari

Abstract

The lumbar vertebrae are connected by the zygapophysial or facet joints posteriorly. As each nerve root exits the vertebral foramen it divides into ventral and dorsal rami. The dorsal ramus is further divided in the lateral, intermediate, and medial branches. From L1 to L4, each medial branch travels between the superior articular process and transverse process of the level below. For example, the L1 medial branch crosses the L2 superior articular process. The L5 medial branch is variable and so the L5 dorsal ramus is targeted.

Each medial branch innervates two facet joints, so a single nerve block affects two facet joints. Additionally, each facet joint is dually innervated by the medial branch at its level and the medial branch of the above vertebra, so to fully block one facet joint it is necessary to block the medial branch above and below that joint (Bogduk, Spine (Phila Pa 1976) 8(3):286–293, 1983). For example, blocking the L4/5 facet joint requires blocking the L3 and L4 medial branches.

Treating low back pain caused by lumbar medial branch nerve usually requires two positive diagnostic nerve blocks prior to pursuing more definitive by lumbar medial branch radiofrequency ablation due to potential for false positive diagnostic blocks (Manchukonda et al., J Spinal Disord Tech 20(7):539–545, 2007).

R. L. Dudek (✉)
Spine & Pain Associates/St. Luke's University Health Network, Lehighton, PA, USA

A. Patel
Wellspan Health Interventional Pain Medicine Gettysburg Hospital, Hanover, PA, USA

A. Varzari
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: varzaria@upmc.edu

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https://doi.org/10.1007/978-3-031-40206-7_10

Keys to Procedure

- Understand relevant lumbar spine anatomy and zygapophyseal joint innervation.
- Understand basics of radiofrequency lesioning.

Anatomy Pearls

See Images 10.1 and 10.2.

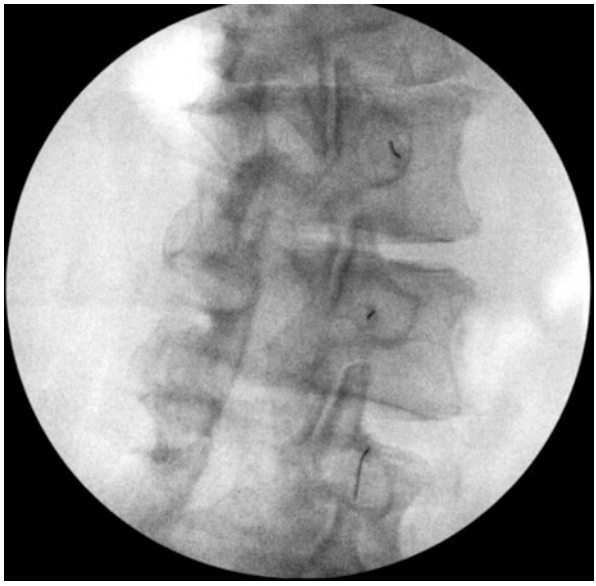

Image 10.1 Oblique view: "Scotty Dog" with needles in position

Image 10.2 Lateral view with RF needle cannulas in position

What You Will Need

- Sterile towels.
- Half sheet drape.
- Chlorhexidine-based soap.
- RFA Generator that displays impedance, voltage, amperage, and temperature.
- Electrode grounding pad (connected to RFA Generator).
- RFA cannula with stylet × 3.
- Lidocaine 1% for skin—5–10 mL.
- Lidocaine 2%—2–3 mL.
- 25G 1.5″ needle for skin local.
- 18G 1.5″ needle to draw up medications.
- 5 mL syringe with 25G 1.5″ needle for skin local.
- 3 mL syringe for lidocaine 2%.
- Consider injecting bupivacaine 0.25% (1 mL) + methylprednisolone (40 mg) or dexamethasone (10 mg) split between three levels after RFA.
  - Will need 3 mL syringe.

Patient Positioning

Prone with pillow under abdomen to flex thoracolumbar spine and minimize lumbar lordosis.

How to Perform the Procedure

1. Sterilely prep over lumbar spine and drape with sterile towels and half sheet.
2. Obtain a true AP view of the lumbar spine and confirm the vertebral levels and side to be targeted.
3. Square off superior endplate corresponding to the vertebra at which the injection is being performed using caudad or cephalad tilt.
4. Oblique the C-arm intensifier 15–30° ipsilateral to the targeted side to form the "scotty dog" (Image 10.1) appearance to allow for proper visualization of the target point for L1–L4 medial branch nerves. For the L5 dorsal ramus keep the C-arm in AP position.

   If using conventional RF:
5. Introduce caudal tilt 20–25° (this is to assist with parallel placement of the RFA cannula to the medial branches).
   (a) Target for needle is the junction of the SAP and transverse process for L1–L4 medial branch nerves and sacral ala for the L5 medial branch nerve [1].

   If using RF with cooled lesioning:
6. Target for needle is the eye of the "scotty dog" (the pedicle) for L1–4 medial branch nerves and sacral ala for the L5 medial branch nerve.
7. Anesthetize the skin with Lidocaine 1%.
8. Insert the RFA cannula with stylet coaxial to the fluoroscopic beam and advance until bone/os is felt. Larger gauge RFA needles will produce a larger lesion size [2].
9. Repeat steps 3–6 for the subsequent lumbar medial branch nerves.
10. Obtain a lateral and AP fluoroscopic view to verify needle tips are in appropriate position.

    For Conventional RF:
    (a) AP view: The electrode tip should lay against the lateral surface of the SAP.
    (b) Lateral view: The electrode should cross the neck of the SAP and its active tip should be centered the middle two-quarters of the neck (Image 10.2).

    For Cooled RF:
    (a) *See chapter on lumbar medial branch block, the RF electrode position will be similar to the needle position used for lumbar MBB in AP and lateral views.*
11. After appropriate needle placement at the respective levels, remove the stylet and insert the thermal unit into the RFA cannula.

12. Assess impedance and perform sensory stimulation.
    (a) Patient should feel paresthesia only in their low back with 0.3–0.7 V at 50 Hz [3].
13. Perform motor stimulation.
    (a) Ensure no lower extremity muscle contractions elicited with 1.5–2 V at 2 Hz [3].
14. A multifidus muscle twitch can be expected as motor stimulation may stimulate the external motor branch of the lumbar medial branch nerve. Repeat sensory and motor stimulation for each subsequent level.
15. Administer 0.5 cc lidocaine 2% to anesthetize medial branch nerve prior to ablation.
    (a) Ensure no needle movement with needle manipulation for local anesthetic administration prior to proceeding with ablation.
    (b) Impedance levels will typically decrease following administration of local anesthetic (goal: less than 400–500 ohms) [3].

    If using Conventional RF:
16. Commence thermal ablation at 80 °C for 90 s at each level [1].

    If using Cooled RF:
17. Set following recommended parameters: Temperature: 60 °C and Time: 2 min and 30 s [2].
    (a) Initial 10–20 s typically most painful as probe heats up.
    (b) Pause ablation if pain not tolerable or radiating down leg and verify location of probes.
18. Remove needles, clean site, and place adhesive bandage.

Pitt Pain Pearls and Pitfalls

- The safest option is to provide local analgesia for procedure or mild sedation to allow for patient feedback during sensory and motor testing to ensure no injury to a spinal nerve or ventral ramus occurs.

Check Points to Mastery

Beginner

- Ability to obtain appropriate view for probe placement.
  - Square off endplates of target level.
  - Sufficient ipsilateral oblique tilt to obtain “scotty dog” view.
  - For conventional RF: (Obtain sufficient caudal tilt for parallel placement of probes to lumbar medial branch nerves).
- Identifying target for RF probe prior to placement (L1—L4: Conventional RF: the junction of the SAP and transverse process. Cooled RF: the eye of the “scotty dog” (the pedicle), L5: sacral ala).
- Ability to advance probe in a coaxial trajectory to the X-ray beam.

Intermediate

- Determining which medial branches need to be targeted to denervate a specific zygapophyseal joint and identifying their anatomical location. For example, L3–L4 zygapophyseal joint is innervated by the L2 medial branch nerve (runs between the junction of the L3 SAP and TP) and L3 medial branch nerve (runs between the junction of the L4 SAP and TP) [4].
- Understanding the mamillo accessory ligament overlies a portion of the lumbar medial branches at the SAP and TP junction and may interfere with proper probe placement. Probe placement in an ipsilateral oblique view ("scotty dog" view) is thought to circumvent the ligament [1].

Advanced

- Understanding RF lesion characteristics and how it is affected by parameters such as time, temperature, probe length [2].

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Sacroiliac Intra Articular Joint Injection

11

Isaiah Levy, Ankur Patel, and Alexander Varzari

Abstract

The sacroiliac joints (SIJs) are large bilateral synovial-fibrous joints located between the articular surfaces of the sacrum and ilium. The role of the SIJ is to provide stability to and absorb forces from the spine and lower extremities. SI dysfunction is often seen with conditions that asymmetrically load the hip such as limb length discrepancy and arthritis, with pregnancy, or simply with age related degeneration. Pain presents as low back pain that can radiate to the buttock and thigh.

The SIJ capsule is supported by the interosseous sacroiliac ligament as well as several muscles including the gluteus maximus, gluteus medius, erector spinae, biceps femoris, piriformis, transversus abdominus, and thoracolumbar fascia making it a highly stable but poorly mobile joint. The SI joint is thought be primarily innervated by some combination of L4–S3 and the superior gluteal nerve (Cox and Fortin, Pain Physician 17(5):459–464, 2014; Roberts et al., Reg Anesth Pain Med 39(6):456–464, 2014).

SI joint injections are indicated to diagnose pain originating from the SI joint as well as treat SI joint pain refractory to conservative treatment with oral anti-inflammatories or physical therapy. Typically, a diagnostic injection is performed if three or more provocative tests such as FABER, pelvic compression, or Gaenslen's test are positive (Newman and Soto, Am Fam Physician 105(3):239–245, 2022).

I. Levy (✉) · A. Varzari
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: levyir2@upmc.edu; varzaria@upmc.edu

A. Patel
Wellspan Health Interventional Pain Medicine Gettysburg Hospital, Hanover, PA, USA

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After positive diagnosis of SI joint pain, a SI joint radiofrequency ablation (RFA) can provide long-lasting pain relief. This minimally invasive procedure interrupts nociceptive pain signals from the L5 dorsal ramus and the lateral branches of the S1, S2, and S3 nerve roots (Pastrak et al., Curr Pain Headache Rep 26(11):855–862, 2022). Techniques include conventional RFA, cooled RFA, bipolar RFA, pulsed radiofrequency denervation, and intra-articular pulsed radiofrequency.

Keys to Procedure

- Understand the relevant SI joint anatomy on AP and oblique view.
- Understand how to safely advance needle in order to enter SI joint space.
- Understand the complications and corrective steps if encountered.

Anatomy Pearls

See Images 11.1 and 11.2.

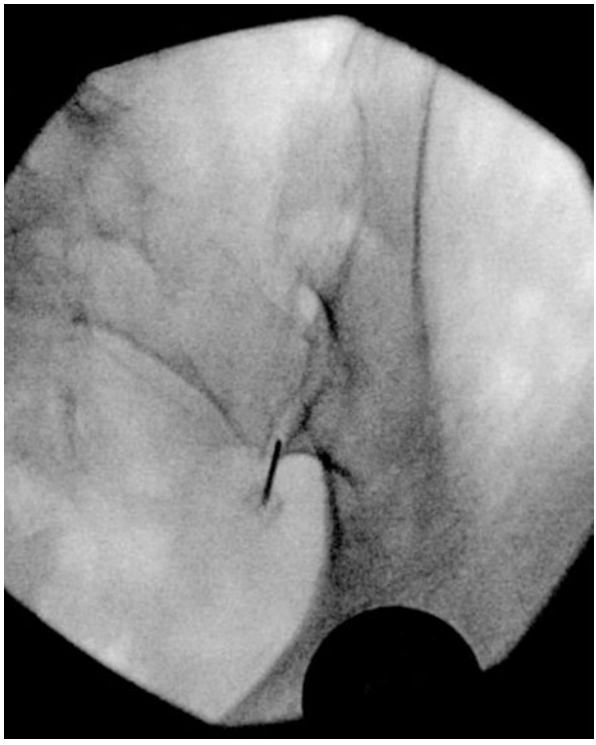

Image 11.1 Needle entry into infero-posterior SI joint

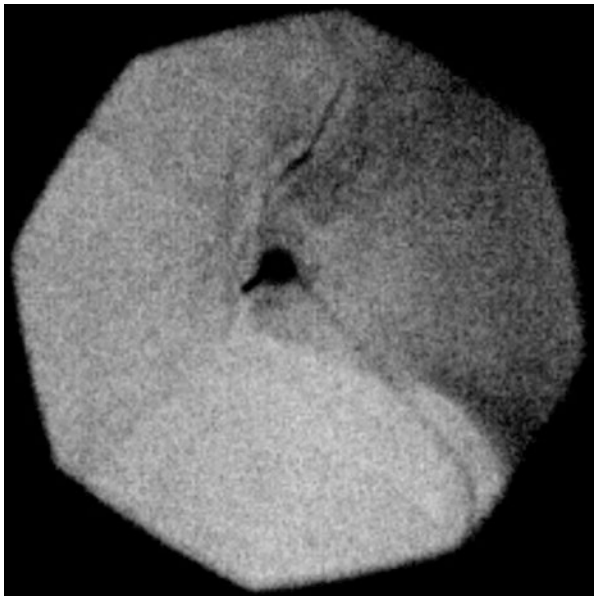

Image 11.2 AP view of contrast outlining SI joint

What You Will Need

- Sterile towels.
- Chlorhexidine-based soap.
- 22G 3.5″ or 25G 3.5″ spinal needle.
- Lidocaine 1% for skin–5 mL (if using 22G spinal needles).
- Isovue 300–3 mL.
- Bupivacaine 0.25%–2 mL.
- Dexamethasone 10 mg–1 mL.
- 25G 1.5″ needle for skin local.
- 18G 1.5″ needle to draw up medications.
- Extension tubing (3″) for contrast.
- 5 mL syringe with 25G 1.5″ needle for skin local (if using 22G spinal needles).
- 3 mL syringe with tubing for contrast.
- 3 mL syringe for injectate (2 mL Bupivacaine + 1 mL dexamethasone 10 mg).
- If bilateral SI joint injection—2 mL Bupivacaine 0.25% and dexamethasone 10 mg for each side.

Patient Positioning

– Prone with pillow under pelvis to help with anatomic visualization.

How to Perform the Procedure

1. Sterilely prep and drape with sterile towels.
2. Obtain a true AP view of the pelvis to visualize the targeted SI joint.

3. To obtain the best image of the posterior SI joint, tilt the C-arm 10–15° cephalad to elongate the posterior plane of the joint and oblique the C-arm 10–20° contralateral to optimize the inferior region of the joint. Target for needle is along the inferior, posterior aspect of the joint, approximately 1–2 mm cephalad of the joints most inferior end (Image 11.1).
4. Anesthetize the skin with Lidocaine 1% (if using a 22G spinal needle) and insert the spinal needle coaxial to the fluoroscopic beam.
5. Advance needle until the needle is felt to enter the joint (similar to the feeling of a needle in an eraser).
6. Obtain a fluoroscopic view to verify the needle tip in the joint between the ilium and sacrum on fluoroscopy.

7. Administer 0.5–1 mL of contrast to ensure the contrast outlines the joint space (Image 11.2).
8. Administer injectate (2 mL Bupivacaine + 1 mL dexamethasone 10 mg) slowly.
9. Remove needle, clean site, and place adhesive dressing.

Checkpoints to Mastery

Beginner

- Oblique fluoroscope ipsilaterally to open inferior portion of the SI joint.
- Visualize the anterior and posterior aspects of the SI joint.

Intermediate

- Aim and advance needle towards inferior aspect of the medial joint space, corresponding to the posterior SI joint.
- Advance until needle felt to be firmly within the joint.

Advanced

- Visualize both the anterior and posterior aspects of the SI Joint upon injection of contrast.

Pitt Pain Pearls and Pitfalls

- Some physicians may not use contrast to confirm placement, but it does provide verification of accuracy of injection.
- If the needle tip touches periosteum near the joint space, the best method is to walk off the side of the sacrum or ilium, which should guide the spinal needle into the joint space.
- If resistance is felt while injecting, slowly rotate the needle bevel while maintaining gentle pressure to improve flow. If there is still resistance, the needle may still be in ligament and can be slowly advanced 1–2 mm.

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Further Reading

Sacroiliac Intraarticular Joint Injection, Atlas of Image-Guided Spinal Procedures, 2nd Edition, Furman.

Sacroiliac Joint Bipolar Radiofrequency Ablation (RFA)

12

Merna Naji, Ankur Patel, and Alexander Varzari

Abstract

The sacroiliac (SI) joints are large bilateral synovial-fibrous joints located between the articular surfaces of the sacrum and ilium. The role of the SI joint is to provide stability to and absorb forces from the spine and lower extremities. SI joint dysfunction is often seen with conditions that asymmetrically load the hip such as limb length discrepancy and arthritis, with pregnancy, or simply with age related degeneration. Pain presents as low back pain that can radiate to the buttock and thigh.

The SI joint capsule is supported by the interosseous sacroiliac ligament as well as several muscles including the gluteus maximus, gluteus medius, erector spinae, biceps femoris, piriformis, transversus abdominus, and thoracolumbar fascia, making it a highly stable but poorly mobile joint. The SI joint is thought to be primarily innervated by some combination of L4–S3 and the superior gluteal nerve (Cox and Fortin, Pain Physician 17(5):459–464, 2014; Roberts et al., Reg Anesth Pain Med 39(6):456–464, 2014).

SI joint injections are indicated to diagnose pain originating from the SI joint as well as treat SI joint pain refractory to conservative treatment with oral anti-inflammatories or physical therapy. Typically, a diagnostic injection is performed if three or more provocative tests (such as FABER, pelvic compression, or Gaenslen's tests) are positive (Newman and Soto, Am Fam Physician 105(3):239–245, 2022).

M. Naji (✉) · A. Varzari
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: najimr@upmc.edu; varzaria@upmc.edu

A. Patel
Wellspan Health Interventional Pain Medicine Gettysburg Hospital, Hanover, PA, USA

T. Emerick et al. (eds.), *The Pain Procedure Handbook*,
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After a positive diagnosis of SI joint pain, a SI joint radiofrequency ablation (RFA) can provide long-lasting pain relief. This minimally invasive procedure interrupts nociceptive pain signals from the L5 dorsal ramus and the lateral branches of the S1, S2, and S3 nerve roots (Pastrak et al., Curr Pain Headache Rep 26(11):855–862, 2022). Techniques include conventional RFA, cooled RFA, bipolar RFA, pulsed radiofrequency denervation, and intra-articular pulsed radiofrequency.

Keys to Procedure

- Recognizing appropriate patient selection for procedure.
- Correctly identifying anatomical structures under fluoroscopy.
- Safely administering radiofrequency ablation technique after appropriate testing.

Anatomy Pearls

See Image 12.1.

- This procedure is also known as an ablation of the L5 dorsal rami and lateral branches of S1, S2, and S3 nerve roots.
- At the joint space connecting the sacrum to the iliacus is the sacroiliac joint that contains an interosseous sacroiliac ligament.
- Just medial to the joint are the L5 dorsal rami and S1, S2, and S3 lateral branches exiting from the lumbosacral foramen and traveling to the joint space laterally. The goal will be to ablate the small lateral branches of the nerve roots as they travel over the ligament.
- For this procedure, you will place four RFA probes along a path that separates the sacral foramen (where the nerves exit) and the sacroiliac joint in order to ablate the lateral nerve roots responsible for eliciting sacroiliac joint pain.

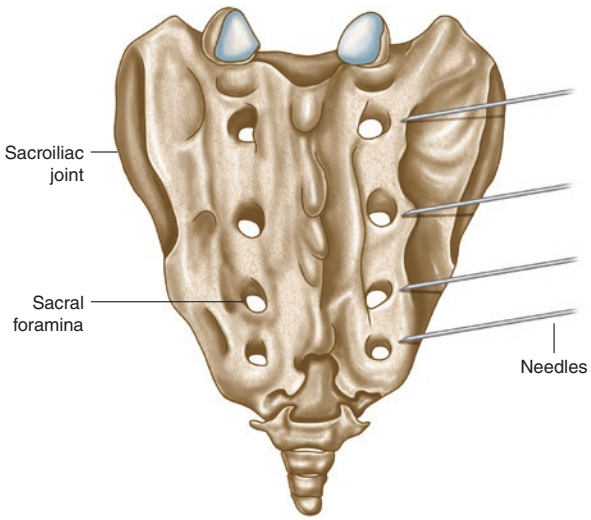

Image 12.1 Schematic of approximate target RFA cannula positions in relationship to foramen

What You Will Need

- Sterile towels.
- Half sheet drape.
- Chlorhexidine-based soap.
- RFA Generator that displays impedance, voltage, amperage, and temperature.
- Electrode grounding pad (connected to RFA Generator).
- RFA cannula with stylet × 4.
- Lidocaine 1% for skin—5 mL.
- Lidocaine 2%—3 mL.
- 25G 1.5″ needle for skin local.
- 18G 1.5″ needle to draw up medications.
- 5 mL syringe with 25G 1.5″ needle for skin local.
- 3 mL syringe for Lidocaine 2%.

Patient Positioning

- Prone with a pillow under the pelvis to help with anatomic visualization.

How to Perform the Procedure

1. Sterilely prep and drape the area with sterile towels.
2. Obtain a true AP view of the pelvis to visualize the targeted sacroiliac joint.
3. To obtain the best image of the posterior SI joint, tilt the C-arm 10–15° cephalad to elongate the posterior plane of the joint and oblique the C-arm 10–20° contralateral to optimize the inferior region of the joint.
   (a) The sacral foramen (S1, S2, S3, S4) should be visible just medial to the sacroiliac joint space.
   (b) The target for the needle is along the path between the sacral foraminal openings and the sacroiliac joint, overlying the lateral branches (Image 12.1).
4. Start at the: superior aspect of the joint space and identify the L5 dorsal ramus at the sacral ala.

5. Anesthetize the skin with Lidocaine 1% and insert the RFA cannula with stylet coaxial to the fluoroscopic beam to the sacral ala until bone is contacted.
6. Repeat Step 5 with targets for the RFA cannulas with stylets 7–10 mm lateral to the S1, S2, and S3 neural foramen.
7. Obtain a lateral view of the RFA cannulas to confirm the position and verify the cannula has not slipped into the foramen.
8. Assess impedance and perform sensory stimulation (if desired) at each level.
   (a) The patient should feel paresthesia only at the location of RFA cannula with 0.3–0.7 V at 50 Hz.
9. Perform motor stimulation at each level. Ensure no lower extremity muscle contractions are elicited with 1.5–2 V at 2 Hz. Muscle contraction observed distally in the lower extremity indicates the RFA cannula is in close proximity to sacral spinal nerves.

10. Administer 0.5 mL Lidocaine 2% to anesthetize lateral branch nerves prior to bipolar ablation. Ensure no needle movement with needle manipulation for local anesthetic administration prior to proceeding with ablation.
11. Commence bipolar thermal ablation at 80 °C for 90 s between adjacent RFA cannulas at each level.
12. Remove: needles, clean the site, and place an adhesive dressing.

Checkpoints to Mastery

Beginner

- Understand the physics and mechanisms of radiofrequency procedures.
- Understand the set up and safety precautions taken for radiofrequency procedures (grounding pad, machine settings: temperature, time).
- Identify the sacroiliac joint and location where the L5 dorsal rami lies.

Intermediate

- Identify the S1, S2, and S3 foramina under fluoroscopic guidance.
- Understand and perform correct needle placement and testing.

Advanced

- Commence with radiofrequency procedure ensuring patient safety.
- Recognize and manage complications of radiofrequency use.

Pearls and Pitfalls

- Consider always performing the diagnostic test in the same manner as the radiofrequency procedure prior to radiofrequency patient selection.
- It is safest to provide local analgesia for the procedure or mild sedation to allow for patient feedback to ensure no injury to a nerve or dorsal ramus occurs.
- Impedance levels will typically decrease following administration of local anesthetic (goal less than 400–500 ohms).
- Pause the ablation if pain to the patient is either not tolerable or radiating down the leg and verify the location of probes.

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Intrathecal Trial

13

Tetyana Marshall and Ankur Patel

Abstract

Intrathecal (IT) drug administration has been shown to be an effective treatment for many chronic pain conditions (Hayek and Hanes, Curr Pain Headache Rep 18(1):388, 2014; Sanford, CNS Drugs 27(11):989–1002, 2013). These conditions include cancer-related pain, neuropathic pain, and nociceptive pain syndromes such as post laminectomy syndrome, spinal stenosis, chronic compression fractures, spondylosis, complex regional pain syndrome, and rheumatoid arthritis (Deer et al., Neuromodulation 20(2):96–132, 2017; Smith et al., J Clin Oncol 20(19):4040–9, 2002). A trial of IT medication is recommended prior to IT pump placement to assess efficacy and side effect profiles (Deer et al., Pain Med 20(4):784–798, 2019). Currently, morphine and ziconotide are the only two agents approved for intrathecal administration for pain, with ziconotide being the only non-opioid agents (McDowell and Pope, Neuromodulation 19(5):522–32, 2016). There are two basic methods to conduct a trial of intrathecal drug delivery systems. The first is a bolus injection, which allows for a quicker trial and for monitor of side effects. The second method is a continuous infusion via a catheter, which allows for dose titration and which may increase success (McDowell and Pope, Neuromodulation 19(5):522–32, 2016). Currently, there is no data to suggest that one method is more advantageous or efficacious than the other (McDowell and Pope, Neuromodulation 19(5):522–32, 2016). The decision on the type of trial to use and the medication to use depends on many factors,

T. Marshall (✉)
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: osadchukt@upmc.edu

A. Patel
Wellspan Health Interventional Pain Medicine Gettysburg Hospital, Hanover, PA, USA

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including patient's clinical status, diagnoses, physician preference/facility capabilities. IT morphine administration may be associated with serious side effects such as respiratory depression and hypotension, and may cause dependence over time (Deer et al., Pain Med 20(4):784–798, 2019). IT ziconotide has a narrow therapeutic window requiring careful dose titrations and is contraindicated in patients with a history of psychosis, but is especially useful in patients for whom intrathecal opioid side effects are unbearable (Deer et al., Pain Med 20(4):784–798, 2019).

Keys to Procedure

- Identify appropriate patients for intrathecal therapy.
- Understand pharmacology of agents administered.
- Identify landmarks and obtain sterile approach to intrathecal access.
- Manage complications associated trial.

What You Will Need

Most of the supplies come in a pre-prepared spinal needle kit

- Sterile towels.
- Chlorhexidine-based soap × 3.
- Spinal Kit.
  - 25G 3.5″ spinal needle.
  - 20G introducer needle.
  - 3 mL syringe for injectate.
- Lidocaine 1% for skin—5 mL.
- Intrathecal drug (morphine, baclofen, ziconotide)—amount per appropriate intrathecal dosing guidelines.
- 25G 1.5″ needle for skin local.
- 18G 1.5″ needle to draw up medications.
- 5 mL syringe with 25G 1.5″ needle for skin local.

Planning of Trial

- There are two basic methods for trialing intrathecal drug delivery systems:
  - Bolus injection—quicker trial and allows for monitoring of side effects.
  - Continuous infusion via catheter—allows for dose titration and may increase success.
- The decision on the type of trial to use depends on many factors including patient's clinical status and diagnoses, reason for trial, type of medication used for trial, billing requirements, and physician preference/facility capabilities.

Typical Dosages of Trial Medications

- Baclofen Bolus: 50–100 μg.
- Ziconotide Bolus: 2–2.5 μg (varies).
- Ziconotide Infusion: initial rate of 0.5–1 μg/day and increase by 0.1–0.2 μg/day/week.
- Morphine Bolus: 0.15–0.3 mg (can vary based on patient's age and prior morphine milligram equivalent (MME)use.

Epidural trials can also be completed to simulate/approximate the type of relief an intrathecal pump would provide.

Patient Positioning

– Prone with pillow under abdomen to minimize lumbar lordosis or lateral decubitus position.

How to Perform the Procedure

1. Sterilely prep and drape with sterile towels.
2. Draw up medication to be administered for the intrathecal trial using the syringe provided in the spinal kit.
3. Obtain a true AP view of the lumbar spine.
4. Square off superior endplate of vertebral body below and inferior endplate of vertebral body above targeted.

5. Anesthetize the skin with Lidocaine 1% slightly paramedian of the targeted interspace.
6. Insert 20G introducer needle in the same trajectory as the skin was anesthetized.
7. Insert 25G spinal needle through the introducer towards targeted interspace.

8. Advance needle, under fluoroscopic guidance, until intrathecal space entered and verified with appropriate clear CSF return.
9. Administer injectate (desired intrathecal drug) slowly.
   (a) Consider aspiration midway through injection to verify CSF return.
10. Remove needle and introducer, clean site, and place adhesive dressing.

Checkpoints to Mastery

Beginner

- Adjust fluoroscopy to obtain true AP view of lumbar spine,
- Optimize fluoroscopy to open target space.

Intermediate

- Insert introducer and spinal needle, then adjust to obtain coaxial view in target space.

  Appreciate tactile feel of tissue planes and ligaments as needle is advanced.

- Make proper adjustments to C-arm to obtain CLO view (Alternate—Lateral and CLO).
- Identify ventral interlaminar line (VILL) in CLO view, and advance needle slightly beyond this until CSF is aspirated.

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Further Reading

Ziconotide dosing and trialing strategies. Pope, J ASRA 2016.

Part III

Regional Nerve Blocks/Radiofrequency Ablation

Occipital Nerve Block with Ultrasound

14

Alexander Stanton, Marissa Pavlinich,
and Alexander Varzari

Abstract

The greater occipital nerve (GON) is a purely sensory nerve that originates from the medial branch of the C2 dorsal ramus and innervates the scalp on the vertex, over the ear, over the parotid gland, and the inferolateral occipital area. The GON is also targeted for treating various complex headache syndromes including cervicogenic headache, tension headache, occipital neuralgia, and migraine due to synapse of the C1, C2, and C3 spinal nerves onto second order neurons in the trigeminocervical nucleus (Baek et al., J Pain Res 11:2033–2038, 2018).

Evidence suggests improved success rate and fewer complications with ultrasound guided GON block than the landmark technique (Kissoon et al., Clin J Pain 38(4):271–278, 2022). The GON is blocked at the C2 level with cadaveric evidence suggesting that with does around 5 ml the clinical effect likely comes from a more widespread blockade of nerves in the suboccipital area—not just blocking of the GON (Baek et al., J Pain Res 11:2033–2038, 2018).

Ultrasound guided pulse radiofrequency ablation (RFA) of the GON is a safe and effective treatment for patients with refractory chronic migraine (Guner and Eyigor, Acta Neurol Belg, 2022). As opposed to the continuous electrical simulation in conventional RFA, pulsed RFA has a rest phase that limits structurally damaging heat production. Instead, it works by repolarizing unmyelinated C fibers thereby modulating pain signal transmission (Cahana et al., Pain Med 7(5):411–423, 2006).

A. Stanton (✉) · A. Varzari
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: stantonad@upmc.edu; varzaria@upmc.edu

M. Pavlinich
South Hills Pain and Rehabilitation, Jefferson Hills, PA, USA

T. Emerick et al. (eds.), *The Pain Procedure Handbook*,
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Keys to Procedure
– Sterile technique with ultrasound usage.
– Understanding cervical musculature anatomy as well as sonographic landmarks.
– Vasculature identification and avoidance.

What You Will Need

- Sterile towels
- Chlorhexidine-based soap or topical iodine
- 18G needle to draw up medications
- 25G 1.5″ needle or echogenic ultrasound needle for injectate
- 5 cc syringe for injectate
- Bupivacaine 0.25% or Ropivacaine 0.2%—3 ml
- Methylprednisolone 40 mg or Dexamethasone 10 mg—1 ml.

Injectate: Anesthetic choice (3 ml) with steroid (1 ml) into 5 cc syringe and 25G 1.5″ needle.

Ultrasound Materials

- Linear transducer
- Sterile probe cover
- Sterile ultrasound gel

Patient Positioning

- Seated upright (pull up hair to move out of way if long) or prone position. Prone position may allow easier ergonomics for holding ultrasound and performing injection.

How to Perform the Procedure

1. Sterile prep occipital area of the head. The C2 area usually lies approximately at the hairline, and the area above the hairline should also be palpated.

2. Place ultrasound gel over upper cervical area and position linear transducer caudal and lateral to the occipital protuberance with the lateral aspect of the transducer rotated up to the C1 transverse process (just inferomedial to the mastoid process) and the medial aspect of the transducer over the C2 spinous process (Image 14.1).
3. Identify the fascial separations of the semispinalis capitis and trapezius muscles superficial to the greater occipital nerve and the obliques capitis inferior beneath (Image 14.2).
4. Use doppler to verify vasculature locations.

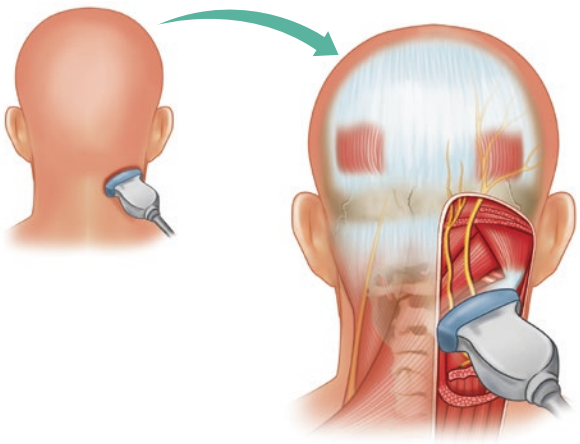

Image 14.1 (Left): Correct transducer oblique angle over occiput and C2 area

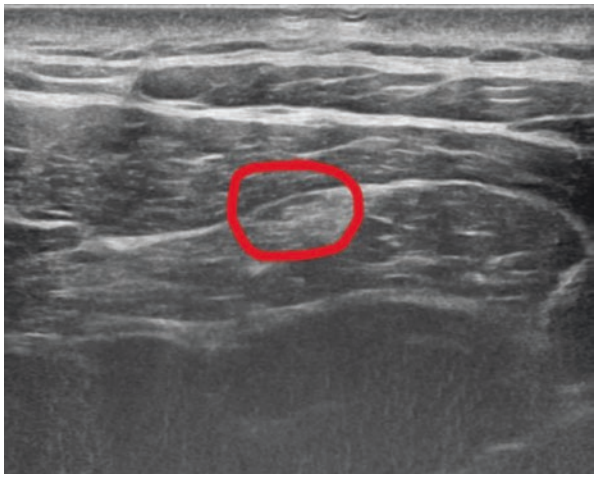

Image 14.2 Greater occipital nerve (red circle) is seen between the semispinalis capitis muscle (superficial) and obliquus capitis inferior muscle (deep)

5. Advance needle adjacent to greater occipital nerve location (mindful of vasculature).
6. Administer nerve block injectate (approximately 4 ml).
7. Remove needle and clean site. Hold light pressure for hemostasis.

Checkpoints to Mastery

Beginner

- Prepare a sterile field for the injection.
- Properly position the patient either in a sitting or prone position while holding the ultrasound probe at an appropriate upper cervical level.

Intermediate

- Identify the C2 spinous process under ultrasound, as well as the trapezius, semispinalis capitis, and the obliquus capitis inferior muscle deep to the greater occipital nerve.

Advanced

- Insert needle in an appropriate in-plane view of the fascial plane and neurovascular bundle between the semispinalis capitis and the obliquus capitis.
- Take all necessary safety precautions with local anesthetic injections, including verification of doppler ultrasound for vascular structures and appropriately dosing of local anesthetics.

Pearls and Pitfalls

- Avoid: foramen magnum, vertebral artery, occipital artery, and other incidental blood vessels.
- In plane ultrasound view is preferred to optimize view.
- The spinous process of the upper cervical vertebrae are the most important osseus sonographic landmark for image acquisition if have difficulties. The oblique trajectory of the obliquus capitis inferior muscle will be at the level of the C2 process.

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Occipital Nerve Pulsed Radiofrequency Ablation (RFA) with Ultrasound

15

Alexander Stanton, Marissa Pavlinich, and Alexander Varzari

Abstract

The greater occipital nerve (GON) is a purely sensory nerve that originates from the medial branch of the C2 dorsal ramus and innervates the scalp on the vertex, over the ear, over the parotid gland, and the inferolateral occipital area. The GON is also targeted for treating various complex headache syndromes including cervicogenic headache, tension headache, occipital neuralgia, and migraine due to synapse of the C1, C2, and C3 spinal nerves onto second order neurons in the trigeminocervical nucleus (Baek et al., J Pain Res 11:2033–2038, 2018).

Evidence suggests improved success rate and fewer complications with ultrasound guided GON block than the landmark technique (Kissoon et al., Clin J Pain 38(4):271–278, 2022). The GON is blocked at the C2 level with cadaveric evidence suggesting that with does around 5 ml the clinical effect likely comes from a more widespread blockade of nerves in the suboccipital area—not just blocking of the GON (Baek et al., J Pain Res 11:2033–2038, 2018).

Ultrasound guided pulse radiofrequency ablation (RFA) of the GON is a safe and effective treatment for patients with refractory chronic migraine (Guner and Eyigor, Acta Neurol Belg, 2022). As opposed to the continuous electrical simulation in conventional RFA, pulsed RFA has a rest phase that limits structurally damaging heat production. Instead, it works by repolarizing unmyelinated C fibers thereby modulating pain signal transmission (Cahana et al., Pain Med 7(5):411–423, 2006).

A. Stanton (✉) · A. Varzari
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: stantonad@upmc.edu; varzaria@upmc.edu

M. Pavlinich
South Hills Pain and Rehabilitation, Jefferson Hills, PA, USA

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Keys to Procedure

– See Chap. 14. An emphasis should be placed on vasculature identification and avoidance.
– Stabilization of RFA cannula during ablation.
– Remember that many payers consider pulsed RFA experimental, and insurance coverage will be limited to billing for the injection component of the procedure.
– Remember that thermal RFA can have significant side effects related to occipital artery cauterization and/or deafferentation pain.

What You Will Need

- Sterile towels
- Chlorhexidine-based soap × 3
- 18G 1.5″ needle to draw up medications
- 25G 1.5″ needle for skin local anesthetic
- 3 ml syringe for superficial skin localization
- 5 ml syringe for injectate
- Lidocaine 1% for skin local—1–2 ml
- Bupivacaine 0.25% or 0.5%—2 ml
- Dexamethasone 10 mg—1 ml.

Local: 5 ml syringe with 1–2 ml of 1% lidocaine (only the most superficial structures should be localized).

Injectate: 3 ml syringe with 2 ml Bupivacaine + 1 ml Dexamethasone (inject after pulsed RFA).

Radiofrequency Ablation/Ultrasound Materials

- RFA Generator that displays impedance, voltage, amperage, and temperature
- Electrode grounding pad (connected to RFA Generator)
- RFA cannula with stylet
- Linear transducer for ultrasound
- Sterile probe cover
- Sterile ultrasound gel.

Patient Positioning

- Seated with neck flexed (and hair pulled up if hair is long) or prone with head in donut pillow

How to Perform the Procedure

1. Mark the site 2 cm lateral to the greater occipital protuberance and approximately 1/3 of the distance between the greater occipital protuberance and the mastoid process.
2. Sterilely prep the occipital area of the head and drape with sterile towels.

3. Place ultrasound gel over occipital area and position linear transducer caudal and lateral to the occipital protuberance, with the lateral aspect of the transducer rotated up to the C1 transverse process (just inferomedial to the mastoid process) and the medial aspect of the transducer over the C2 spinous process.
4. Identify the semispinalis capitis and trapezius muscles superficial to the greater occipital nerve and the obliquus capitis inferior muscle deep to the greater occipital nerve (see Image 14.2 from Chap. 14).
5. Use doppler on the ultrasound to identify vasculature and verify that none are present within the trajectory of final needle placement.
6. Anesthetize the skin with Lidocaine 1% approximately 2 cm caudal and medial to marked target.

7. Insert the RFA cannula with stylet and advance to target point cranially and laterally (at approximately a 30° angle), laying needle over bone at the target site.
8. After appropriate needle placement, remove the stylet and insert the thermal unit into the RFA cannula. Pay specific attention to stabilizing the RFA needle so it does not advance or move.
9. Assess impedance and perform sensory stimulation. Verify a negative response with motor stimulation test at 1.5–2 V, 2 Hz.
   (a) Patient should feel paresthesia only in their occipital region with 0.3–0.5 V at 50 Hz.
10. Commence pulsed ablation.
    (a) Pulsed RF settings: frequency 2 Hz, 20 ms pulsations, 42 °C, for 240 s.
11. Repeat pulsed ablation 2–3 times with slight adjustments of probe position to cover a wider area of possible nerve locations.
12. Administer injectate slowly.
13. Remove needle and clean site. Hold slight pressure for hemostasis.

Checkpoints to Mastery

Beginner

- Understand proper patient positioning, and landmark-based identification of C1 and C2.
- Understand the anatomic considerations for performing a landmark-based occipital nerve block if ultrasound or imaging is not available.
- Understand the distributions and innervations of the greater, lesser, and least occipital nerves, as well as the territory of the occipital artery.

Intermediate

- Identify the C2 spinous process under ultrasound, as well as the trapezius, semispinalis capitis, and the obliquus capitis inferior muscle deep to the greater occipital nerve.

Advanced

- Insert the RFA needle in an appropriate in-plane view of the fascial plane and neurovascular bundle between the semispinalis capitis and the obliquus capitis.
- Take all necessary safety precautions with local anesthetic injections, including verification of Doppler ultrasound for vascular structures and appropriately dosing of local anesthetics.
- Understand the current literature for pulsed RFA of the occipital nerves.

Pearls and Pitfalls

- Make sure you are over calvarium (on bone) when performing the RF to avoid being too close to the foramen magnum.
- Remember that pulsed RFA may not be covered by various insurers and should be discussed in advance.

Images: See Chap. 14.

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Intercostal Nerve Block with Ultrasound

16

Alexander Varzari and Marissa Pavlinich

Abstract

The intercostal nerves provide sensory and motor innervation for much of the back, trunk, and abdominal wall. Each intercostal nerve travels within a neurovascular bundle made up of an intercostal nerve, artery, and vein. This bundle runs along the costal groove at the inferior edge of its accompanying rib. The intercostal nerve lies inferior to both vessels within the neurovascular bundle. The proximity of the nerve to the vessels accounts for the high uptake of local anesthetic into the blood.

Each intercostal nerve originates from the spinal nerve root at the vertebral level of the rib it travels with. Spinal nerves divide into dorsal and ventral branches, with the ventral branches continuing anterolaterally to become the intercostal nerves. The intercostal nerve briefly travels between the parietal pleura and innermost intercostal muscle before continuing anterolaterally between the internal and innermost intercostal muscles. As the intercostal nerve travels towards the midaxillary line the lateral cutaneous branch splits off—traversing the internal and external intercostal muscles and dividing into an anterior and posterior branch which supply the lateral trunk. As the intercostal nerve travels anteriorly it forms another branch called the anterior cutaneous branch that divides into the medial and lateral branches which supply the anterior trunk and abdomen.

Intercostal nerve blocks are indicated as primary or adjunct pain management intervention for patients with rib fractures or chest wall and upper abdominal pain. Indications include thoracic surgery incisional pain, post-thoracotomy pain,

A. Varzari (✉)
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: varzaria@upmc.edu

M. Pavlinich
South Hills Pain and Rehabilitation, Jefferson Hills, PA, USA

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herpes zoster or post herpetic neuralgia, postmastectomy pain, and cholecystectomy. Contraindications are patient refusal, active infection over the injection site, and occasionally coagulation disorders.

Complications arise due to the proximity of the intercostal nerves to the lung and intercostal vasculature. These include pneumothorax, hemothorax, local anesthetic systemic toxicity, and even risk of spinal blockade (Chaudhri et al., Ann Thorac Surg 88(1):283–284, 2009; Shanti et al., J Trauma 51(3):536–539, 2001).

Intercostal nerve blocks can be performed with a landmark technique or under ultrasound or fluoroscopic guidance. Though efficacy and complication rates are similar between ultrasound and fluoroscopic guidance, ultrasound carries the advantage of better visualization of vascular structures, real time visualization of the pleura, and avoids the need for contrast or radiation exposure (Elkhashab and Wang, Curr Pain Headache Rep 25(10):67, 2021).

Keys to Procedure

– Identify the dermatomal distribution required to cover the intended area of analgesia.
– Locate the correct rib associated with the target dermatome.
– Understand proper patient positioning with the scapula pulled laterally to optimize access to posterior rib angles.
– Blockade of at least one dermatome above and below the level of surgical incision is required.
– Understand the complications and corrective steps if encountered.

What You Will Need

- Sterile towels or drape
- Chlorhexidine-based soap
- Ultrasound with linear transducer
- Sterile probe cover
- Sterile ultrasound gel
- 25G 3.5″ spinal needle
- 25G 1.5″ needle for skin local
- 18G 1.5″ needle to draw up medications
- Bupivacaine 0.5%—4 ml (for two level block)
- Dexamethasone 10 mg—1 mL
- 5 mL syringe for injectate (4 mL Bupivacaine 0.25%/0.5% + Dexamethasone 10 mg).

Patient Positioning

– Prone with arms extended overhead.
– Scapula pulled laterally to optimize access to posterior rib angles.

How to Perform the Procedure

Mark site of most severe pain to identify appropriate ribs and intercostal nerves to block.
Sterilely prep over target thoracic area and drape with sterile towels.
Place the ultrasound probe in the sagittal plane approximately 4 cm lateral to the spinous process to identify the target intercostal nerve.
Intercostal nerve runs inferior to the rib within the neurovascular bundle (Image 16.1).

Position linear transducer with the inferior aspect of the target rib level cephalad and the superior aspect of the rib one level below caudad.
Make sure to visualize the intercostal muscles and parietal pleura at the desired level.
Insert the 25G spinal needle caudal to the target, advancing caudal to cranial in-plane to target the intercostal nerve while remaining superficial to the parietal pleura (Image 16.2).

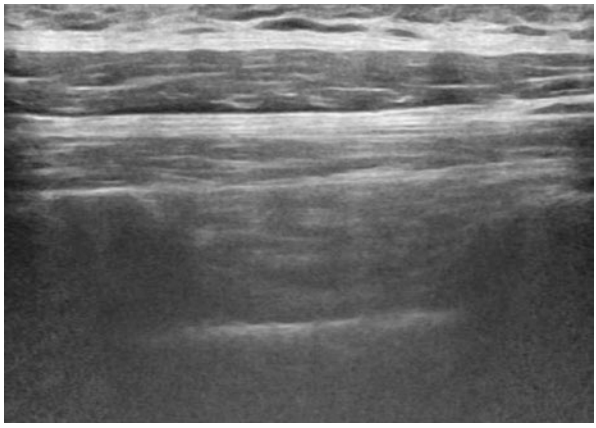

Image 16.1 Ultrasound image of ribs and pleura

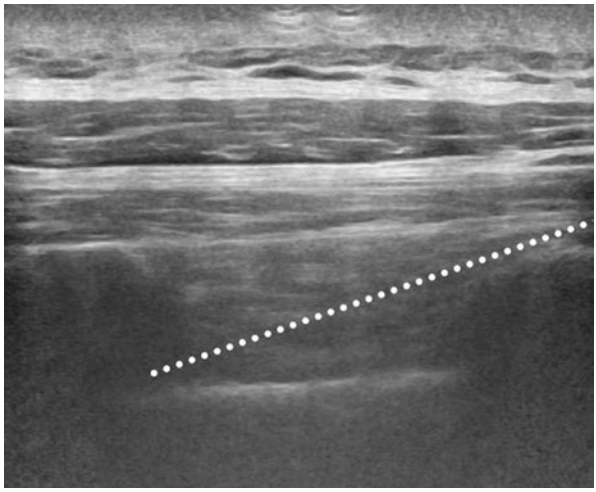

Image 16.2 Ultrasound image of the suggested needle trajectory to target the intercostal nerve (right = inferior, left = superior)

Aspirate and administer 2.5 mL of injectate (4 mL Bupivacaine + Methylpre dnisolone 40 mg) slowly.
Repeat Steps 3–6 for each desired level.
Remove needle, clean site, and place adhesive dressing.

Checkpoints to Mastery

Beginner

- Identify the dermatome(s) associated with the patient's pain.
- Mark the correct rib(s) corresponding with the desired dermatomes to be blocked.
- Position the ultrasound and identify the desired target rib, intercostal muscles, and parietal pleura.

Intermediate

- Localize the skin while holding a consistent image with the ultrasound.
- Insert spinal needle and demonstrate in-plane needle visualization in the subcutaneous tissue prior to advancing through the intercostal muscles.

Advanced

- Advance the needle through the intercostal muscles to the desired target while maintaining in-line needle visualization.

Pitt Pain Pearls and Pitfalls

- Avoid entering the parietal pleura and causing a pneumothorax. The consent process should mention complications such as pneumothorax.
- If visualization of the needle tip is difficult because of body habitus and/or angle of needle trajectory, switch to curvilinear probe or fluoroscopy.
- Target posterior to the posterior axillary line to ensure block of the entire intercostal nerve territory. The intercostal nerve branches at the level of the posterior axillary line, dividing into main and collateral branches. At the mid-axillary line it branches a second time, with the lateral cutaneous branch traveling laterally to innervate the skin and subcutaneous tissue of the lateral trunk and upper abdomen.
- You can use ultrasound doppler to identify the intercostal neurovascular bundle prior to inserting the needle for the injection.

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Further Reading

Intercostal Nerve Block. USRA. http://www.usra.ca/pain-medicine/specific-blocks/trunk/intercostal.php.

Intercostal Nerve Block with Fluoroscopy

17

Alexander Varzari and Marissa Pavlinich

Abstract

The intercostal nerves provide sensory and motor innervation for much of the back, trunk, and abdominal wall. Each intercostal nerve travels within a neurovascular bundle made up of an intercostal nerve, artery, and vein. This bundle runs along the costal groove at the inferior edge of its accompanying rib. The intercostal nerve lies inferior to both vessels within the neurovascular bundle. The proximity of the nerve to the vessels accounts for the high uptake of local anesthetic into the blood.

Each intercostal nerve originates from the spinal nerve root at the vertebral level of the rib it travels with. Spinal nerves divide into dorsal and ventral branches, with the ventral branches continuing anterolaterally to become the intercostal nerves. The intercostal nerve briefly travels between the parietal pleura and innermost intercostal muscle before continuing anterolaterally between the internal and innermost intercostal muscles. As the intercostal nerve travels towards the midaxillary line the lateral cutaneous branch splits off—traversing the internal and external intercostal muscles and dividing into an anterior and posterior branch which supply the lateral trunk. As the intercostal nerve travels anteriorly it forms another branch called the anterior cutaneous branch that divides into the medial and lateral branches which supply the anterior trunk and abdomen.

Intercostal nerve blocks are indicated as primary or adjunct pain management intervention for patients with rib fractures or chest wall and upper abdominal pain. Indications include thoracic surgery incisional pain, post-thoracotomy pain,

A. Varzari (✉)
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: varzaria@upmc.edu

M. Pavlinich
South Hills Pain and Rehabilitation, Jefferson Hills, PA, USA

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herpes zoster or post herpetic neuralgia, postmastectomy pain, and cholecystectomy. Contraindications are patient refusal, active infection over the injection site, and occasionally coagulation disorders.

Complications arise due to the proximity of the intercostal nerves to the lung and intercostal vasculature. These include pneumothorax, hemothorax, local anesthetic systemic toxicity, and even risk of spinal blockade (Chaudhri et al., Ann Thorac Surg 88(1):283–284, 2009; Shanti et al., J Trauma 51(3):536–539, 2001).

Intercostal nerve blocks can be performed with a landmark technique or under ultrasound or fluoroscopic guidance. Though efficacy and complication rates are similar between ultrasound and fluoroscopic guidance, ultrasound carries the advantage of better visualization of vascular structures, real time visualization of the pleura, and avoids the need for contrast or radiation exposure (Elkhashab and Wang, Curr Pain Headache Rep 25(10):67, 2021).

Keys to Procedure

– Identify the dermatomal distribution required to cover intended area of analgesia.
– Identify the correct rib on X-ray associated with desired dermatomes.
– Understand proper patient positioning with scapula pulled laterally to optimize access to posterior rib angles.
– Blockade of at least one dermatome above and below the level of surgical incision is required.
– Understand the complications and corrective steps if encountered.

Anatomy Pearls

– On AP view the inferior angle of the scapula aligns with T7 and the seventh rib. Use this landmark to find your correct rib.
– Alternatively, count up from the twelfth rib.

What You Will Need

- Sterile towels
- Chlorhexidine-based soap
- 25G 1.5″ needle (or 25G 3.5″ spinal needle if too deep for 1.5″ needle)
- Bupivacaine 0.5%—4 ml (for two level block)
- Dexamethasone 10 mg—1 ml
- 18G 1.5″ needle to draw up medications
- 5 ml syringe for injectate (4 ml Bupivacaine + Dexamethasone 10 mg).

Patient Positioning

– Prone with arms extended overhead.
– Scapula pulled laterally to optimize access to posterior rib angles.

How to Perform the Procedure:

1. Mark site of most severe pain to identify appropriate ribs and intercostal nerves to block.
2. Sterilely prep over target thoracic area and drape with sterile towels.
3. Obtain an AP view to identify target ribs.

4. Tilt C-Arm 15–20° caudal to make intercostal nerve running inferior to target ribs more easily accessible.
5. Insert 35G spinal needle coaxial to the fluoroscopic beam 3–5 in. lateral to spine over inferior aspect of target rib.
   (a) Be sure to stay over periosteum as you advance.
6. Advance needle towards inferior aspect of the rib until needle touches the rib.

7. Obtain a true AP view and slightly walk off inferior aspect of the rib.
8. Aspirate and administer 2.5 cc of injectate slowly.
   (a) Injectate (1 cc Bupivacaine and dexamethasone 10 mg).
9. Repeat steps 5–8 for each desired level.
10. Remove needle, clean site, and place adhesive bandage.

Checkpoints to Mastery

Beginner

- Identify the dermatome(s) associated with the patient's pain.
- Mark the correct rib(s) corresponding with the desired dermatomes to be blocked.
- Identify correct target ribs on AP view and point out needle target on the X-ray image.

Intermediate

- Make proper adjustments, tilting C-arm caudally, to achieve appropriate view to make intercostal nerve more easily accessible.
- Insert spinal needle in the appropriate location and obtain coaxial needle view.
- Advance the needle towards inferior aspect of the rib until the needle touches the rib.

Advanced

- Re-demonstrate the AP view and walk off inferior aspect of rib.
- Advance the needle a few mm, maintaining the cephalad angle.
- Appreciate change in resistance of needle passing through internal intercostal muscle.
- Appreciate negative aspiration and administer injectate.

Pitt Pain Pearls and Pitfalls

- Avoid entering the parietal pleura and a resultant pneumothorax.
- Do not advance needle more than 3 mm past rib margin to avoid pneumothorax.
- Using a combination of fluoroscopic and ultrasound guidance is an option to decrease the risk of pneumothorax.

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Transversus Abdominis Plane (TAP) Block

18

Alexander Stanton, Marissa Pavlinich, and Alexander Varzari

Abstract

The muscular layers of the abdominal wall are made up of the external oblique, internal oblique, and transversus abdominis muscles. Upon exiting the intervertebral foramen, the ventral rami of the T6-L1 thoracolumbar nerves travel anteriorly, eventually entering the plane between the transversus abdominis and internal oblique muscles and providing sensory innervation to the anterolateral abdominal wall (Tsai et al., BioMed Res Int 2017:8284363, 2017).

Ultrasound guidance is the gold standard technique for the transversus abdominis plane (TAP) block. Local anesthetic is injected into the plane between the internal oblique and transversus abdominis muscle providing dermatomal coverage over T10-L1 with extension to T9 if using the posterior approach (Narouze and Guirguis, Interventional pain management. Springer, 2018).

TAP blocks have traditionally been used in the acute pain setting for postsurgical analgesia following abdominal surgery. More recently, studies have described using TAP blocks as a diagnostic and therapeutic tool for chronic postsurgical abdominal pain (Rozen et al., Clin Anat 21(4):325–333, 2008; Carney et al. Anaesthesia 66(11):1023–1030, 2011). For example, a positive diagnostic TAP block indicating somatosensory pain originating from the abdominal wall can steer a physician away from a treatment plan targeting visceral pain. Additionally, limited studies have suggested that steroid in addition to local anesthetics may be useful in treating chronic abdominal wall pain (Rozen et al., Clin Anat 21(4):325–333, 2008).

A. Stanton (✉) · A. Varzari
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: stantonad@upmc.edu; varzaria@upmc.edu

M. Pavlinich
South Hills Pain and Rehabilitation, Jefferson Hills, PA, USA

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Keys to Procedure

- Understand the sonographic anatomy of the abdominal wall.
- Perform injection with good needle visualization.
- Identify the target of the facial plane between the internal oblique muscle and the transversus abdominis muscle (just superficial to the transversus abdominis muscle).

Review of Anatomy

See Image 18.1.

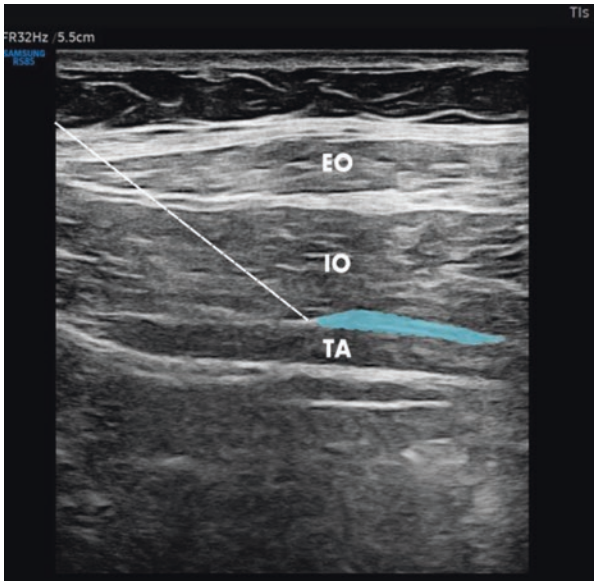

Image 18.1 "Filling" is seen of the plane between the internal oblique (IO) and transversus abdominis (TA) muscles, highlighted in blue. The external oblique (EO) muscle is also seen superficial to the IO and TA. Peritoneum (not labeled) is deep to the TA. Needle trajectory as white dashed line (Tsai et. al)

What You Will Need

- Sterile towels
- Chlorhexidine-based soap
- 22G 4″ hyper-echoic needle or 22G 3.5″ spinal needle
- 25G 1.5″ needle for local anesthetic
- 18G needle to draw up medications
- 5 ml syringe for local anesthetic. 10 ml syringe × 2 for injectate
- Extension tubing (6″)
- Bupivacaine 0.25% or Ropivacaine 0.2% (10–15 ml for unilateral block, 20 ml for bilateral block, 10 ml each side).
- Lidocaine 1% for local anesthetic—5 ml.

Ultrasound Materials

- Linear transducer (curvilinear may be necessary depending on body habitus).
- Sterile probe cover.
- Sterile ultrasound gel.

Patient Positioning

- Supine with arms resting to side or on chest.

How to Perform the Procedure

1. Sterilely prep the abdomen / lateral abdomen and drape sterile towels for field.
2. Place prepared ultrasound probe in the transverse plane at the mid-axillary line (anywhere between iliac crest and lower costal margin can achieve view) and scan anteriorly and posteriorly to clearly identify the external oblique, internal oblique, and transversus abdominis muscles. Peritoneum should also be seen deep to the transversus abdominus muscle to confirm depth.
3. Identify needle trajectory and location with pressure on skin. Medial to lateral needle trajectory approach often used. Confirm by visualization on ultrasound.
4. Anesthetize skin and subcutaneous tissue at point of insertion with lidocaine 1%.
5. Insert hyper-echoic/spinal needle and advance to target fascial plane between internal oblique and transversus abdominus muscles.

6. Aspirate and administer injectate (10–15 ml anesthetic choice, 10 ml if bilateral TAP block planned). Observe injectate filling fascial plane space (Image 18.1).
7. Remove needle, achieve appropriate hemostasis, clean site.
8. Repeat steps as needed on opposite side for bilateral blocks.

Checkpoints to Mastery

Beginner

- Identify the external oblique, internal oblique, transversus abdominus, and peritoneum under ultrasound.
- Know how to calculate maximum dose of various local anesthetics.

Intermediate

- Insert needle with a well-visualized in-plane approach using ultrasound guidance to the transversus abdominus plane.
- Feel comfortable scanning more lateral beyond the TAP block area to visualize the quadratus lumborum muscle for additional orientation.

Advanced

- Be aware of signs and symptoms of local anesthetic toxicity and how to provide immediate treatment if toxicity arises.

Pearls and Pitfalls

- This is a larger volume injection block. Avoid injection of too much local anesthetic (risk of local anesthetic systemic toxicity)—max dose of Bupivacaine is 2.5–3 mg/kg.
- For patients with low tolerance or low BMI consider less injectate overall due to discomfort and to avoid toxicity as above.
- Keep needle in view for entire procedure on ultrasound. There is risk of visceral damage if needle advanced into peritoneum. There is little risk if needle is never advanced deeper than the transversus abdominis muscle.
- Block can be modified for ilioinguinal block—can target more accurately if block is performed nearer to the iliac spine.

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Quadratus Lumborum (QL) Block

19

Connor Richardson, Ankur Patel, and Alexander Varzari

Abstract

The ultrasound guided quadratus lumborum (QL) block is a fascial block with three approaches: QL1 (lateral), QL2 (posterior), and transmuscular or QL3 (anterior). The QL muscle, which originates from the posterior iliac crest and inserts on the twelfth rib and L2-L5 transverse processes, intersects the aponeurosis of the transversus abdominis and internal oblique muscles.

The QL1 block is performed by injecting local anesthetic lateral to the QL muscle at its intersection with the internal oblique and transversus abdominis muscle and results in blockade of the iliohypogastric, ilioinguinal, and subcostal nerves (T12-L1) (Carline et al., Br J Anaesth 117(3):387–394, 2016). The QL1 has been traditionally used in the acute pain setting for lower abdominal surgery, gynecologic surgery, cesarean sections, and hip surgery.

In the QL2 block the needle is positioned posterior to the QL muscle within the thoracolumbar fascia (TLF). In the QL3 block, local anesthetic is injected between the QL and psoas major muscles and has been shown to spread to the lumbar plexus and even thoracic paravertebral space providing both somatic and visceral analgesia (Carline et al., Br J Anaesth 117(3):387–394, 2016; Karmakar et al., Br J Anaesth 87(2):312–316, 2001).

C. Richardson (✉) · A. Varzari
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: varzaria@upmc.edu

A. Patel
Wellspan Health Interventional Pain Medicine Gettysburg Hospital, Hanover, PA, USA

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Keys to Procedure
- Understand and identify anatomy of muscle layers.
- Needle visualization under ultrasound.
- Understand possible complications and treatment if encountered.

Anatomy Pearls

See Image 19.1.

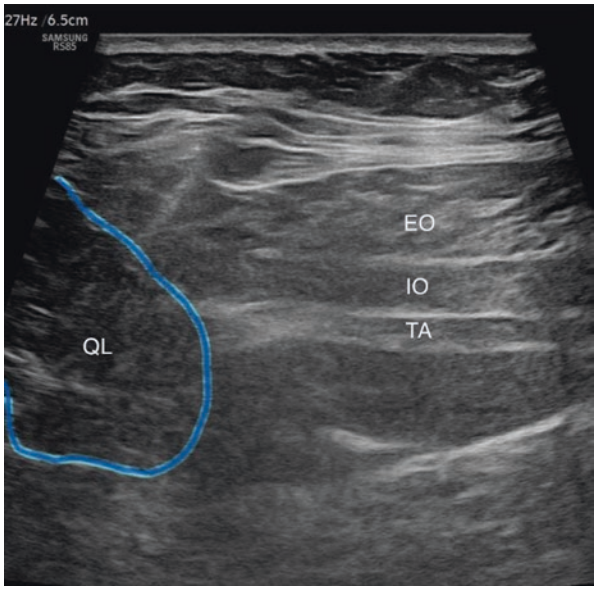

Image 19.1 Ultrasound view of location for lateral QL block approach

What You Will Need

- Sterile towels
- Chlorhexidine-based soap
- Ultrasound with curvilinear transducer
- Sterile probe cover
- Sterile ultrasound gel
- 22G 4″ hyper-echogenic needle or 22G 3.5″ spinal needle
- 22G 1.5″ needle for skin local anesthetic
- 18G 1.5″ needle to draw up medications
- Ropivacaine 0.20%—15 mL for unilateral block or 20 mL for bilateral block (10 mL for each side)
- Extension tubing (6″)
- 5 mL syringe for skin local anesthetic
- 10 mL syringe ×2 for injectate.

Patient Positioning

– Lateral decubitus position or supine (if able to clearly visualize the QL posterior to mid-axillary line).

How to Perform Procedure

1. Sterilely prep the abdomen and drape with sterile towels.
2. Place the ultrasound probe (curvilinear transducer) in the transverse plane at the mid-axillary line and scan posteriorly to clearly identify the point of intersection between the quadratus lumborum, internal oblique muscle, and transversus abdominis muscles.
   (a) Target needle location is deep to the echogenic tail of the transversus abdominus, at the border of the quadratus lumborum.

3. Anesthetize the skin with Lidocaine 1%.
4. Insert the needle and advance the needle in-plane to ultrasound to the target of the border of the quadratus lumborum (Image 19.1).

5. Aspirate and administer injectate slowly (15 mL if unilateral or 10 mL per side if bilateral)
   (a) Observe medication filling space around the quadratus lumborum.
6. Repeat steps 3–5 on opposite side if performing bilateral blocks.
7. Remove needle, clean site, and place adhesive dressing.

Checkpoints to Mastery

Beginner

- Identify all three abdominal muscle layers (external oblique, internal oblique, and transversus abdominis).
- Using ultrasound probe, scan posteriorly and identify quadratus lumborum.

Intermediate

- Insert needle and direct to injection site while visualizing needle continuously on ultrasound.

Advanced

- Identify proper injection site at the border of the quadratus lumborum, deep to the echogenic tail of the transversus abdominus.
- Confirm correct needle placement by observing medication filling space around quadratus lumborum.

Pitt Pain Pearls and Pitfalls

- Avoid injection of too much local anesthetic especially in bilateral blocks for small patients (max dose of ropivacaine is 2–3 mg/kg without epinephrine).
- Make sure that you identify the fascial plane surrounding the QL.
- There is a small risk of leg weakness with the anterior approach to the QL block due to potential spread to lumbar plexus. Kidney injury and pneumothorax are also possible with this approach.
- Local anesthetic spread to the paravertebral space can cause hypotension.
- QL block is useful for unilateral T7-L2 dermatome pain by blocking somatic, sympathetic, and visceral pain fibers.

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Part IV

Sympathetic/Parasympathetic Blocks

Stellate Ganglion Block Under Ultrasound and Fluoroscopy

20

Isaiah Levy and Alexander Varzari

Abstract

The stellate ganglion is a fusion of the inferior cervical and first thoracic ganglions. It lies along the anterior surface of the longus colli muscle anterior to the transverse process of C7, anteromedial to the vertebral artery, and medial to the common carotid artery and jugular vein. Sympathetic fibers from the first thoracic segments ascend through the sympathetic chain, synapse with the superior, middle, and inferior cervical ganglions, and provide sympathetic innervation to the head, neck, heart, and upper extremities.

The stellate ganglion can be blocked to treat vascular, neuropathic, or visceral pain related to the head, neck, upper extremities, and thorax and is thought to work by improving perfusion and inhibiting sympathetic impulses. Examples of conditions treated with stellate ganglion blockade include complex regional pain syndrome, peripheral vascular disease, hyperhidrosis, phantom pain, atypical chest pain, cluster headache, post-herpetic neuralgia, post-traumatic stress disorder, cardiac arrhythmias, and even long COVID (Lee et al., Cleve Clin J Med 89(3):147–153, 2022; Wen et al, Neurol Sci 42(8):3121–3133, 2021).

An image guided approach is highly suggested due to risk of complications including Horner syndrome, tracheal/esophageal injury, thyroid injury, pneumothorax, vascular puncture, and recurrent laryngeal nerve injury. Contraindications include recent myocardial infarction, glaucoma, certain nerve palsies, severe emphysema, and cardiac conduction blocks (Goel et al., Reg Anesth Pain Med rapm-2018-100127, 2019).

Both ultrasound and fluoroscopic guidance can be used. With ultrasound color Doppler should be used to visualize vascular structures. The block is

I. Levy (✉) · A. Varzari
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: levyir2@upmc.edu

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performed at the C6 level because the vertebral artery is unprotected at C7 risking vascular puncture (Wang, Curr Pain Headache Rep 22(1):6, 2018).

Keys to Procedure
– Understand the relevant anatomy surrounding the stellate ganglion.
– Understand how to optimize imaging utilizing ultrasound positioning and ultrasound settings.
– Understand the complications and corrective steps if encountered.

Anatomy Pearls

- The stellate ganglion is formed by the inferior cervical and first thoracic sympathetic ganglia and is located on the anterior surface of the longus colli muscle.
- The longus colli is just anterior to the transverse processes of the cervical vertebrae, anteromedial to the vertebral artery, posterior to the common carotid and jugular vein, and lateral to the trachea and esophagus.

Supplies and Setup

- Sterile towels
- Chlorhexidine-based soap
- 22G or 25G 3.5″ needle
- Lidocaine 1% for skin—5 ml (if using 22G spinal needles)
- Isovue 300—3 ml
- Lidocaine 1% for injectate—2 ml
- Dexamethasone 10 mg
- 25G 1.5″ needle for skin local
- 18G 1.5″ needle to draw up medications
- Extension tubing (3″) for contrast
- 5 ml syringe with 22G 1.5″ needle for skin local
- 3 ml syringe with tubing for contrast
- 5 ml syringe for injectate (4 ml Bupivacaine 0.25% or preservative free lidocaine 1% + 1 ml dexamethasone 10 mg)

Patient Positioning

- Placed in the supine or seated position with the head in a neutral or maximum contralateral rotation.

How to Perform the Procedure

1. Sterilely prep and drape with sterile towels.
2. Identify the medial border of the sternocleidomastoid muscle at the level of the cricothyroid notch via palpation.
3. Place linear high-frequency linear ultrasound transducer over medial border of the sternocleidomastoid muscle in the transverse position at the level of the cricoid notch (approximately at the C6 level). Images 20.1 and 20.2.
4. Identify the level of the C6 vertebral body which is distinct in its appearance with an anterior tubercle that is typically longer than the posterior tubercle (known as the Chassaignac/carotid tubercle). Also, identify the C6 nerve root, the carotid artery, the jugular vein, and the longus colli muscle.
   (a) The C6 level is more easily identified via palpation and on ultrasound, but some clinicians prefer to inject at the C7 for closer access to the stellate ganglion, though medication should flow along the prefascial space in front of the longus colli muscle regardless of level.
   (b) Once the C6 vertebral is identified, the transducer is moved caudally and slightly dorsally until the C7 transverse process comes into view. The C7 transverse process can be easily distinguished from the C6 transverse process by the lack of an anterior tubercle on the C7 transverse process, with the C7 nerve root located just anterior to the posterior tubercle. The C6 level is most commonly approached (see Pearls below).
5. Use color doppler to identify that the inferior thyroid, carotid, and vertebral arteries are not in proximity to the intended path of the needle.

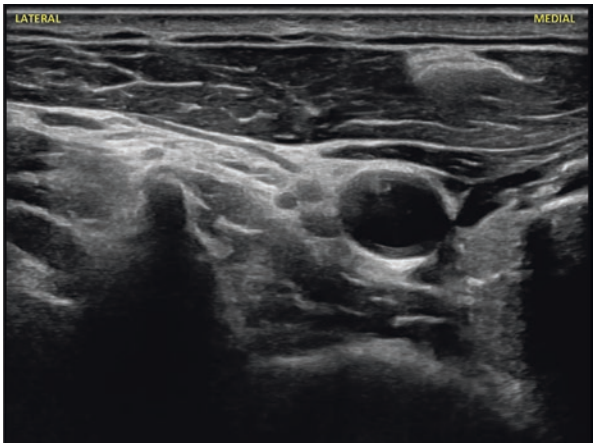

Image 20.1 Ultrasound visualization of stellate ganglion block (unlabeled)

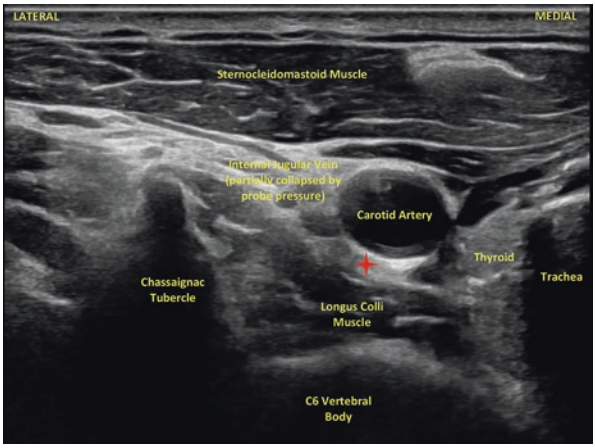

Image 20.2 Ultrasound visualization of stellate ganglion block (anatomy labeled). Red cross indicates needle tip target at sympathetic chain

6. Identify the correct needle path to the anterior prefascial surface of the longus colli muscle where the sympathetic nerves and ganglion are located.
7. Typically, an in-plane approach can be used to advance the needle from lateral to medial avoiding all neurovascular structures. With this approach, head positioning may be important as maximum contralateral rotation or neutral head position may move relationship of neurovascular structures with your target and may be needed for safe needle path to the target. This lateral to medial approach helps avoid contact with both the thyroid and esophageal tissue, which will lie left of midline near trachea.
8. Utilize a 22 or 25-gauge, 3.5-in. spinal needle under continuous ultrasound guidance toward the anterior prefascial surface of the longus colli muscle while avoiding the carotid artery and other vessels previously identified by color Doppler. If a 25G needle is used, one option is to skip local topicalization with 1% lidocaine given this needle is also a 25G needle.
9. If fluoroscopy is used, once the needle is advanced just anterior to the longus colli muscle, the needle placement can be confirmed by visualizing the needle against the periosteum in the posteroanterior view along the anterior portion of the vertebral body.
   (a) Needle placement against the anterior aspect of the vertebral body should confirm that the needle is not inadvertently transdiscal or in the spinal cord.
   (b) If the needle strays postero-lateral, can pierce the vertebral artery.

(c) If needle strays superior or inferior it can pierce the intervertebral disc.
(d) If needle strays ventro-medial it can pierce the trachea, thyroid, or esophagus.
(e) Ultrasound and fluoroscopy together can doubly confirm needle placement away from vital structures.

10. If fluoroscopy is used, contrast can be injected and seen to be tracking superiorly and inferiorly along the longus colli muscle where the sympathetic trunk runs (see Image 20.3).

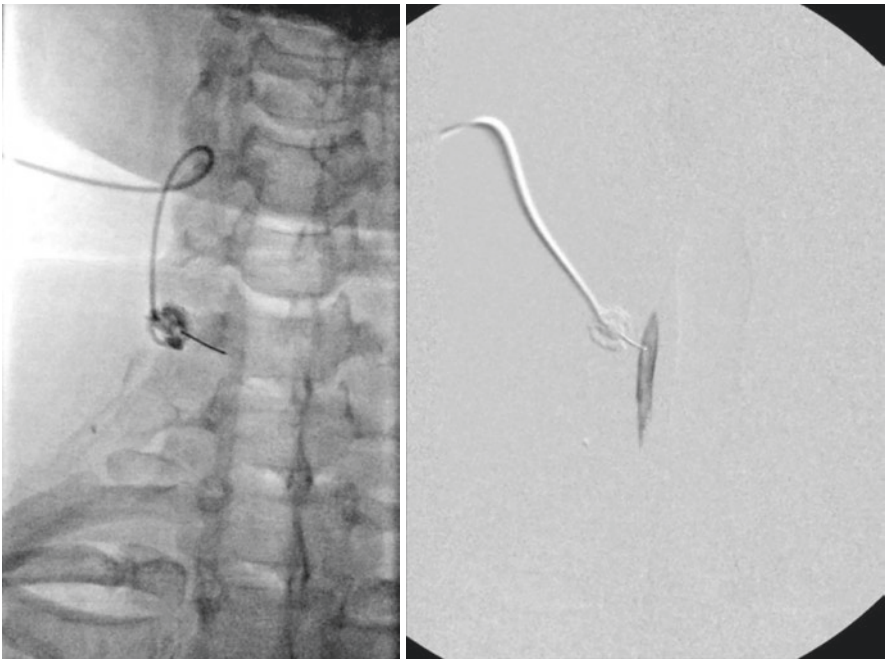

Image 20.3 X-ray visualization of stellate ganglion area

11. When correct placement is concerned and after gentle aspiration, injectate is injected under real-time ultrasound imaging to observe the ballooning of the anterior prefascial space of the longus colli muscle and pushing up of thyroidal tissue.
12. Withdraw needle and place pressure on the injection site to avoid hematoma or ecchymosis
13. Following procedure ipsilateral Horner's syndrome can be seen.

Checkpoints to Mastery

Beginner

- Familiarize knob settings of ultrasound probe including adjustment of image depth, gain, and utilization of doppler.
- Consistent distinguish muscle, tendons, vasculature, and neural anatomy.
- Place ultrasound probe on the C6 and C7 vertebral bodies and identify carotid artery, vertebral artery, esophagus, trachea, thyroid, sternocleidomastoid, scalene, and the longus colli musculature.

Intermediate

- Maintain ultrasound probe in optimized position as needle is advanced in plane to US probe.
- Utilize doppler imaging to verify that there are no blood vessels in path of needle.
- Visualize needle tip just lateral to the longus coli musculature at the C6 level.

Advanced

- Confirm needle placement under fluoroscopy.
- Visualize contrast flow under fluoroscopy along the longus colli musculature.
- Visualize the ballooning of the anterior prefascial space of the longus colli muscle.
- Observe postprocedural Horner's syndrome suggestive of sympathetic block.

Pitt Pain Pearls and Pitfalls

- Turning the head in maximum contralateral rotation may increase the distance between the trachea and neurovascular structures with the carotid artery.
- Utilize doppler to confirm carotid and vertebral arterial flow. With additional pressure of the ultrasound probe, the internal jugular and vertebral veins can be compressed so utilize doppler to confirm location as well.

- Asking patients to avoid swallowing during the procedure can help prevent inadvertent piercing of the esophagus or other medial structures.
- If the carotid artery blocks access to the cervical sympathetic chain, the ultrasound transducer can be slowly moved laterally to help delineate a more lateral needle trajectory to avoid the carotid artery.
- While the stellate ganglion is located closest to the skin at the level of the seventh cervical and first thoracic vertebrae, when using the landmark technique, it is most commonly blocked at the C6 level to avoid the possibility of pneumothorax as the dome of the lung lies at the C7–T1 interspace in many patients.

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Further Reading

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Stellate Ganglion Block: Fluoroscopic Guidance, Atlas of Image-Guided Spinal Procedures, 2nd Edition, Furman.

Celiac Plexus Block (Retrocrural Approach)

21

Anne Pribonic, Brandon Staub, and Alexander Varzari

Abstract

The celiac plexus is found anterior to the aorta at the T12-L2 level just anterior to the crura of the diaphragm. It provides sensory and autonomic innervation to visceral abdominal structures including the liver, gallbladder, pancreas, mesentery, omentum, and the GI tract from the lower esophagus to the transverse colon. The ganglia receive sympathetic fibers from the greater (T5-9), lesser (T10-11), and least (T12) splanchnic nerves, postganglionic sympathetic nerves, visceral afferent nerves, and parasympathetic and sensory fibers from the vagus nerve (Yang et al., Clin Anat 21(2):171–177, 2008). Pain from the celiac plexus can manifest as epigastric, periumbilical, mid thoracic, or left/right upper quadrant pain.

Celiac plexus blocks can be used to treat primary and metastatic cancer related upper abdominal pain as well as non-cancer abdominal pain syndromes such as chronic pancreatitis. Hypotension is an expected complication of the celiac plexus nerve block and intravenous or oral fluids are commonly given to attenuate this (de Leon-Casasola, Cancer Control 7(2):142–148, 2000). Other complications include interscapular back pain, retroperitoneal hematoma, diarrhea, hiccups, and even aortic dissection or paraplegia.

The celiac plexus block can be approached via retrocrural, transcrural, anterocrural, transaortic, or other approaches. It can be done under fluoroscopic or ultrasound guidance. Denervation can be attained with radiofrequency ablation or alcohol/phenol neurolysis after a test dose of local anesthetic confirms

A. Pribonic (✉) · A. Varzari
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: pribonicap@upmc.edu; varzaria@upmc.edu

B. Staub
Chronic Pain Division, University of Pittsburgh Medical Center, Pittsburgh, PA, USA

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placement. This chapter will describe the highly effective classic retrocrural approach using a fluoroscopic guided technique (Tewari et al., Indian J Palliat Care 22(3):301–306, 2016).

Keys to Procedure

– Understand relevant thoracolumbar anatomy on AP, ipsilateral oblique, and lateral views.
– Understand complications.

Anatomy Pearls

See Images 21.1, 21.2, 21.3, and 21.4.

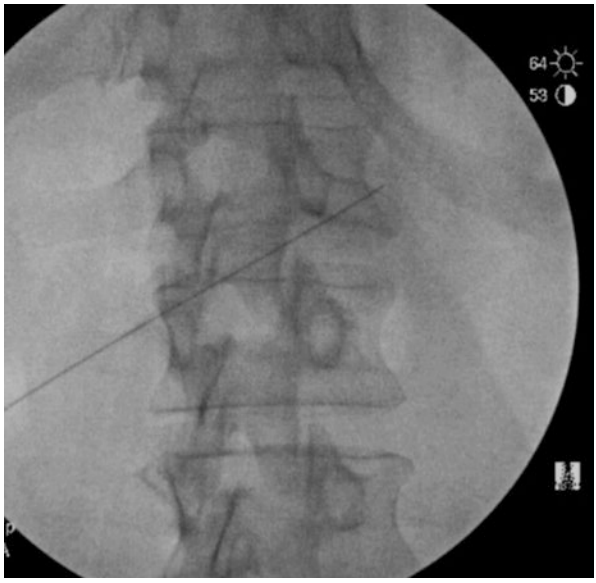

Image 21.1 Oblique angle at L1, under twelfth rib and above transverse process

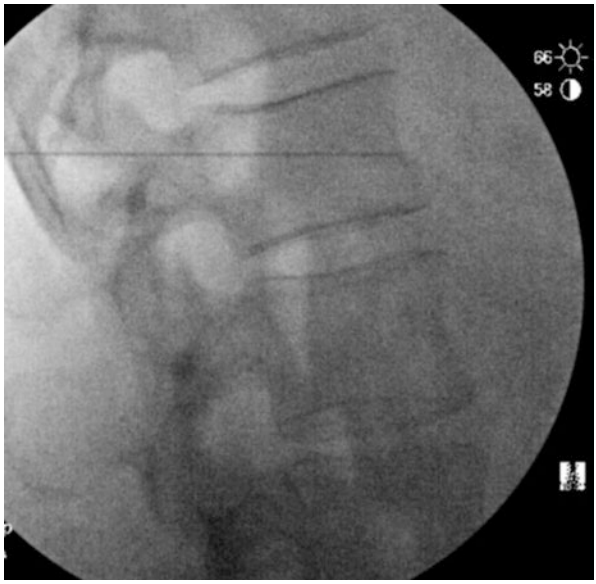

Image 21.2 Lateral view of final needle position on one side

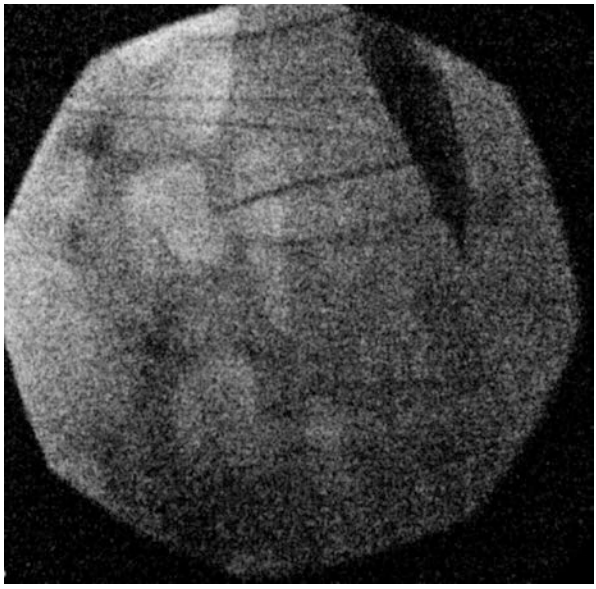

Image 21.3 Lateral view of contrast spread (both needles now in place)

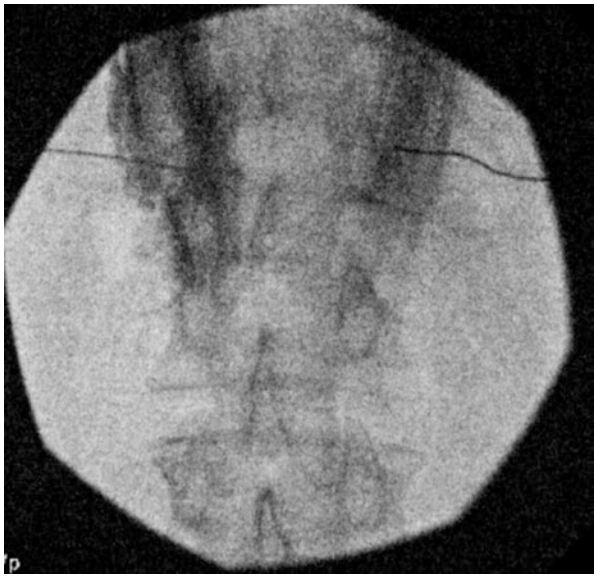

Image 21.4 AP view of contrast spread

What You Will Need

- Sterile towels
- Chlorhexidine/alcohol/betadine
- Sterile C-arm cover
- 22G 7″ spinal needle ×2 (consider placing slight bend at tip of needle for steering capability)
- Lidocaine 1% for skin—10 ml
- Isovue 300—10 ml (split between two 10 ml syringes)
- Bupivacaine 0.5%—14 ml
- Lidocaine 1% preservative free for injectate—5 ml
- Dexamethasone 10 mg—1 ml
- 25G 1.5″ needle for skin local
- 18G 1.5″ needle to draw up medications
- Extension tubing (18″) × 2
- 10 ml syringe with 25G 1.5″ needle for skin local
- 10 ml syringe ×2 with tubing for contrast
- 20 ml syringe for injectate (14 ml Bupivacaine + 5 ml Lidocaine + Dexamethasone10 mg)

Patient Positioning

– Prone with pillow under abdomen to flex thoracolumbar spine and minimize lumbar lordosis.

How to Perform the Procedure

1. Sterilely prep back and drape with sterile towels.
2. Obtain a true AP view of the lumbar spine and identify L1 vertebral body.
3. Square off the superior endplate of L1 using caudad or cephalad tilt.

4. First needle placed will be the one that is contralateral to the side of the patient that you are standing on.
5. Oblique the C-arm image intensifier approximately 15–20° to ipsilateral to the side that you are working on so that the lateral margin of the L1 transverse process is at the edge of the vertebral body. Oblique views of more than 30° should be approached with caution due to concern for needle movement through retroperitoneal structures. The facet joint line will be approximately 1/3–1/2 the distance between the borders of the L1 vertebral body. Target for needle is just superolateral to the transverse process or lateral to the most concave portion of the L1 vertebral body. (Image 21.1). If the twelfth rib is in the immediate vicinity of the injection target, consider 5–10° of caudal tilt of the image intensifier to move the rib cephalad and out of the L1 vertebrae concavity.
6. Anesthetize the skin with Lidocaine 1%.
7. Insert the 22G spinal needle coaxial to the fluoroscopic beam—initial distance depends on patient's body habitus but typically around 6 cm.

8. Intermittently obtain a lateral view to determine if the needle tip has reached the midpoint of the L1 vertebral body. If needle tip has not reached midpoint of the vertebral body, return to ipsilateral oblique view and advance the approximate distance required to reach the midpoint of the vertebral body.
9. Return to the lateral view once the needle has reached the midpoint of the vertebral body and advance the needle until tip is 1–2 mm anterior to the anterior border of the L1 vertebral body. (Image 21.2)
10. Repeat Steps 5–9 for the opposite side (side of the patient that you are standing on) and confirm that the tips of the needles are just anterior to the L1 vertebral body.
11. Attach an extension tubing and contrast syringe to each needle. With one needle at a time, aspirate and administer 2–3 ml of contrast to ensure no vascular uptake and a smooth, posterior curvilinear contour corresponding to the psoas fascia. (Image 21.3) If patient has a contrast allergy,

consider administering 1.5 ml of Lidocaine 1% with epinephrine 1:100,000 to use the epinephrine as a surrogate marker for intravascular uptake.
12. Repeat Step 11 with the second needle.
13. Obtain AP view and repeat contrast administration through each needle to ensure that contrast pattern is confined to the midline and concentrated near the L1 vertebral body. (Image 21.4)
14. Administer 10 ml of injectate (14 ml Bupivacaine + 5 ml Lidocaine + 1 ml Dexamethasone) in 2–3 ml aliquots to each needle.
15. Monitor patient for signs/symptoms of intravascular administration (tinnitus, perioral numbness, dizziness, fainting, hypotension, bradycardia).
16. Remove needles, clean site, and place adhesive dressings.

Checkpoints to Mastery

Beginner

- Make proper adjustments on AP view of thoracolumbar spine.
- Locate the L1 vertebral body and be able to point it out on fluoroscopic image.

Intermediate

- Make proper adjustments to C-arm and obtain ipsilateral oblique view.
- Identify target for needle placement (superolateral to transverse process).
- Insert spinal needle coaxial to fluoroscopic beam.

Advanced

- Advance needle tip to midpoint of vertebral body by intermittently obtaining lateral views.
- Confirm needle placement just anterior to anterior border of L1 vertebral body.
- Manage any potential complications.

Pitt Pain Pearls and Pitfalls

- Prior to performing block consider administering oral or 500ml intravenous fluids to attenuate any hypotension associated with celiac nerve block.
- Proximity of sympathetic nerves to vascular structures requires careful aspiration and monitoring for signs of unrecognized intravascular injection.
- It is crucial that both needles be placed medially against the vertebral body and not too cephalad to reduce the incidence of pneumothorax.
- If the needles are placed too laterally (too far oblique), trauma to the kidneys and ureters is a risk.
- Needle placement that is too medial may result in:
- Epidural, subdural, or subarachnoid injection or trauma to the spinal cord and exiting nerve roots.
- Intradiscal placement and resultant diskitis.

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Superior Hypogastric Plexus Block

22

Merna Naji, Brandon Staub, and Alexander Varzari

Abstract

The superior hypogastric plexus is a retroperitoneal network of nerves that lies at the L4-S1 level anterior to the bifurcation of the aorta into the iliac vessels. It receives sympathetic innervation from the lumbar splanchnic nerves (L1-L2) and gives origin to the left and right hypogastric nerves and inferior hypogastric plexus (Eid et al., World Neurosurg 120:163–167, 2018). These sympathetic nerves are joined by pelvic sensory afferent fibers making the superior hypogastric plexus a target for the blockade of these nerves when suspected in chronic lower abdominal pelvic pain.

Blocking the superior hypogastric plexus can target nerves that provide sensory innervation to visceral structures of the lower abdomen and pelvis including the bladder, urethra, ureters, ovaries, uterus, vagina, testicles, penis, prostate and can help diagnose and treat several chronic lower abdominal or pelvic pain syndromes (Plancarte et al., Anesthesiology 73(2):236–239, 1990). The superior hypogastric plexus block has been used to treat gynecologic, colorectal, and genitourinary cancer and non-cancer related chronic pain (de Leon-Casasola et al., Pain 54(2):145–151, 1993).

Several approaches have been described including the classic posterior, transdiscal, and intra-discal approaches. Though routinely performed under fluoroscopic guidance, ultrasound and CT guided procedures have been successfully performed as well (Ghoneim and Mansour, Saudi J Anaesth 8(3):378–383, 2014; Mishra et al., Pain Med 14(6):837–842, 2013). Additionally, the block can be

M. Naji (✉) · A. Varzari
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: najimr@upmc.edu; varzaria@upmc.edu

B. Staub
Chronic Pain Division, University of Pittsburgh Medical Center, Pittsburgh, PA, USA

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done with various injectates including local anesthetics, steroids, or neurolytic agents such as phenol or alcohol.

Due to the proximity of the superior hypogastric plexus to vascular structures and pelvic viscera, careful aspiration and monitoring for signs of intravascular injection are paramount. Additionally, similarly to the celiac plexus block described in the previous chapter, hypotension can be seen and oral or intravenous fluids are often given during this procedure.

Keys to Procedure

– Understand the anatomy of the hypogastric plexus and structures to avoid anteriorly.
– Understand the innervation of the superior hypogastric plexus and the indications for this block.
– Articulate the difference between performing a sympathetic ganglia block vs. a superior hypogastric block at the same vertebral level.

Review of Anatomy

- The superior hypogastric plexus is a confluence of the lumbar sympathetic chains and comes together just anterior to the L5 and S1 bodies. It innervates the pelvic viscera (Image 22.1).
- The goal is for the needle tip to be placed at the anterior border of L5 on a lateral view and between the lateral and midline border of the vertebral body on an AP view (and the same on the contralateral side).

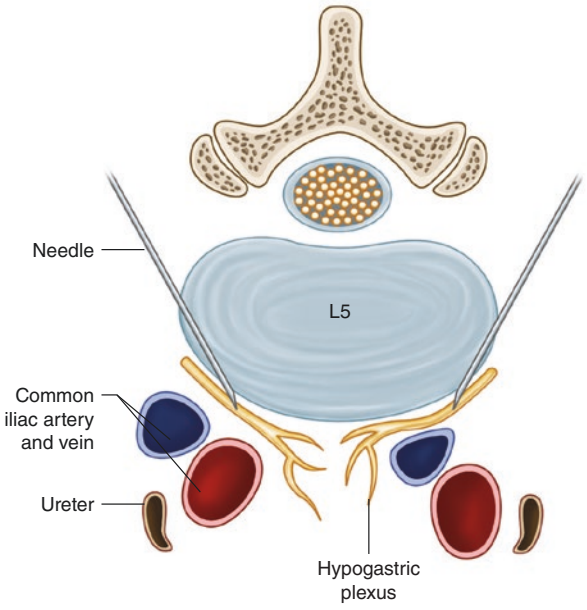

Image 22.1 Diagram of superior hypogastric plexus anterior to the L5 vertebral body with needle trajectories

What You Will Need

- Sterile towels
- Chlorhexidine-based soap
- Sterile C-arm cover
- 22G 7″ spinal needle ×2 (place a slight bend at the tip of the needle for improved steering)
- Lidocaine 1% for skin: 10 ml
- Isovue 300: 10 ml × 2 (two 10 ml syringes)
- Bupivacaine 0.25%: 14 ml Preservative free lidocaine 1% for injectate: 5 ml
- Dexamethasone 10 mg: 1 ml
- 25G 1.5″ needle for skin local
- 18G 1.5″ needle to draw up medications
- Extension tubing (18″) ×2
- 10 ml syringe with 25G 1.5″ needle for skin local
- 10 ml syringe ×2 with tubing for contrast
- 20 ml syringe for injectate (14 ml Bupivacaine + 5 ml Lidocaine + Dexamethasone 10 mg)

Patient Positioning

- Prone with a pillow under the abdomen to flex the thoracolumbar spine and minimize lumbar lordosis.

How to Perform the Procedure

Note: The overall approach and general appearance of the images for the superior hypogastric plexus block is similar to the celiac plexus block, but performed at the L5 vertebral level as opposed to the L1 vertebral level.

1. Sterilely prep the back with chlorhexidine-based soap and drape with sterile towels.
2. Obtain a true AP view of the lumbar spine to identify the L5 vertebral body.
3. Square off the superior endplate of L5 using caudad or cephalad tilt.

4. Starting on the right side, oblique the C-arm image intensifier approximately 15–25° ipsilateral so that the lateral margin of the L5 transverse process is at the edge of the vertebral body. The facet joint line will be approximately 1/3–1/2 the distance between the borders of the L5 vertebral body. If the iliac crest covers the lateral edge of the vertebrae, it may be necessary to minimize the oblique angle until an open space lateral to the vertebrae is visualized.
   (a) The target for the needle is just superolateral to the transverse process or lateral to the most concave portion of the L5 vertebral body.

5. Anesthetize the skin with Lidocaine 1%.
6. Insert the 22G spinal needle coaxial to the fluoroscopic beam.
7. Intermittently obtain a lateral view to determine if the needle tip has reached the midpoint of the L5 vertebral body. If the needle tip has not yet reached the midpoint of the vertebral body, return to the ipsilateral oblique view and advance the needle.
8. Return to the lateral view once the needle has reached the midpoint of the vertebral body and advance the needle until the tip is 1–2 mm anterior to the anterior border of the L5 vertebral body.
9. Repeat Steps 5–9 for the opposite side (side of the patient that you are standing on) and confirm that the tips of the needles are just anterior to the L5 vertebral body.
10. With one needle at a time, aspirate and administer 3–5 ml of contrast under live views to ensure no vascular uptake and a smooth, posterior curvilinear contour corresponding to the psoas fascia but not intramuscular (Image 22.1).
11. Repeat Step 10 with the needle on the contralateral side.
12. Obtain a true AP view and repeat live contrast administration through each needle to ensure that the contrast pattern is confined to the midline and concentrated near the L5 vertebral body (Image 22.2).
13. Administer 10 ml of injectate (7 ml Bupivacaine + 2.5 ml Lidocaine + Dexamethasone 5 mg on each side) in 2–3 ml aliquots to each needle. Monitor patient for signs/symptoms of intravascular administration (tinnitus, perioral numbness, dizziness, fainting, hypotension, bradycardia).
14. Remove needles, clean site, and place adhesive dressings.

Image 22.2 Lateral view of contrast spread anterior to L5 vertebral body

Checkpoints to Mastery

Beginner

- Identify the L5 vertebrae, obtain a true AP X ray, and square off the end plates of L5.

Intermediate

- Orient the X-ray at an appropriate ipsilateral angle on each side to move the facet line approximately 1/3 of the distance across the width of the vertebrae while still having a free ipsilateral margin of the L5 vertebrae for needle insertion medial to the iliac crest.

Advanced

- Advance the needle in a coaxial manner adjacent to the L5 vertebrae while switching between ipsilateral oblique and lateral X rays to gauge depth.

- The needle tip's final destination should be 1–2 mm anterior to the anterior aspect of the vertebrae on each side.
- Inject contrast on each side in AP and lateral view under live fluoroscopy and recognize contrast patterns of incorrect needle: placement (muscle uptake, intravascular, epidural, intrathecal).

Pearls and Pitfalls

- Prior to performing block consider administering 500 ml intravenous fluids to attenuate any hypotension.
- The proximity of sympathetic nerves to vascular structures and pelvic viscera (including ureters) requires careful aspiration and monitoring for signs of unrecognized intravascular injection.
- If the patient has an iodine allergy, consider administering 1.5 ml of Lidocaine 1% with epinephrine 1:100,000, and using any hemodynamic response of the epinephrine as a surrogate marker for intravascular uptake.
- If the needles are placed too laterally, trauma to the kidneys and ureters is a risk.
- Needle placement that is too medial may result in:
  - Epidural, subdural, or subarachnoid injection or trauma to the spinal cord and exiting nerve roots.
  - Intradiscal placement and resultant discitis.

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Lumbar Sympathetic Block

23

Joseph P. Staszel, Brandon Staub, and Alexander Varzari

Abstract

The lumbar sympathetic trunk runs along the anterolateral aspect of the L1-L4 lumbar vertebra. It is made up of preganglionic sympathetic fibers from the ventral roots of the corresponding spinal nerves that synapse at lumbar sympathetic ganglia with postganglionic neurons that innervate target structures. The lumbar sympathetic block disrupts sympathetic innervation to the lower extremities and is used to treat lower extremity conditions such as complex regional pain syndrome, phantom limb pain, neuropathic pain, hyperhidrosis, and postherpetic neuralgia (Zechlinski and Hieb, Tech Vasc Interv Radiol 19(2):163–168, 2016).

The lumbar sympathetic block is performed under fluoroscopic guidance with injectates including local anesthetics, steroids, neurolytic agents such as phenol and alcohol, and even botulinum (Yoo et al., Anesthesiology 136(2):314–325, 2022). Since the lumbar sympathetic trunk is most dense around L2-4 the block is typically performed at this level (An et al., Korean J Pain 29(2):103–109, 2016). Complications include genitofemoral and lateral femoral cutaneous nerve damage, perforation of visceral structures, kidney or ureter injury, and bleeding. We described the posterior approach to the lumbar sympathetic block.

J. P. Staszel (✉)
Upper Allegheny Health System, Olean General Hospital, Olean, NY, USA

Upper Allegheny Health System, Bradford Regional Medical Center, Bradford, PA, USA

B. Staub
Chronic Pain Division, University of Pittsburgh Medical Center, Pittsburgh, PA, USA

A. Varzari
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: varzaria@upmc.edu

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Keys to Procedure

- Understand the relevant lumbar spine anatomy on AP, ipsilateral oblique, and lateral.
- Understand proper patient positioning to optimize image.
- Understand the complications and corrective steps if encountered.

What You Will Need

- Sterile drape
- Chlorhexidine-based soap ×3
- Sterile C-arm cover
- 22G 5″ or 7″ spinal needle (depending on body habitus)
- Lidocaine 1% for skin: 5 mL
- Dexamethasone 10 mg: 1 mL
- Isovue 300: 5 mL
- Bupivacaine 0.5%: 4 mL
- Lidocaine 1% (preservative-free) for injectate: 5 mL
- Dexamethasone 10 mg: 1 mL
- 25G 1.5″ needle for skin local
- 18G 1.5″ needle for drawing up medications
- Extension tubing (18″)
- 5 mL syringe with 25G 1.5″ needle for skin local
- 10 mL syringe with extension tubing attached for contrast
- 20 mL syringe for injectate (4 mL Bupivacaine + 5 mL Lidocaine + Dexamethasone 10 mg)

Patient Positioning

– Prone with pillow under abdomen to flex thoracolumbar spine and minimize lumbar lordosis.

How to Perform the Procedure

1. Sterilely prep posterior back and drape with sterile drape.
2. Obtain a true AP view of the lumbar spine and identify L3 vertebral body. This block can also be performed at the L2 level, but for consistency all targets will reference L3 for the remainder of this procedure description.
   - The largest portion of the lumbar sympathetic ganglia is located at the L2 and L3 vertebral bodies. A single level block at lower third of L2 or the upper third of L3 is usually sufficient as long as there is adequate medication spread.
3. Square off superior endplate of L3 using caudad or cephalad tilt.

4. Oblique the C-arm image intensifier approximately 20–25° to ipsilateral side so that the lateral margin of the L3 transverse process is at the edge of the vertebral body. The facet joint line will be approximately 1/3–1/2 the distance between the borders of the L3 vertebral body (Image 23.1).
   - Target for needle is just superolateral or inferolateral to the transverse process of lateral to the most concave portion of the L3 vertebral body.
5. Anesthetize the skin at target entry site with Lidocaine 1%.

6. Insert the 22G spinal needle coaxial to the fluoroscopic beam. Initial depth depends on patient's body habitus but typically a good place to start checking lateral imaging is at 4–5 cm.
7. Intermittently obtain a lateral view to determine if the needle tip has reached the midpoint of the L3 vertebral body.
   - If needle tip has not reached midpoint of the vertebral body, then return to ipsilateral oblique trajectory view and advance the approximate distance required to reach the midpoint of the vertebral body.
   - If performing bilateral lumbar sympathetic blocks, then at this point would return to step 4 and oblique to the contralateral side in order to obtain trajectory view for the second needle.

Image 23.1 Oblique view of needle position in concavity of vertebral body

8. Once the needle has reached the midpoint of the vertebral body, in the lateral view advance the needle until the needle tip is 1–2 mm posterior to the anterior border of the L3 vertebral body (Image 23.2).
9. After negative aspiration, administer a 4–5 cc of contrast under live fluoroscopy to ensure no vascular uptake and that contrast spreads along the anterior aspect of the L3 vertebral body and is not intramuscular (Image 23.3).
    - If patient has a contrast allergy and no premedication treatment has been given, one possible alternative is to administer 1.5 mL of Lidocaine 1% with epinephrine 1:100,000 to use as a surrogate marker for intravascular uptake.
10. Obtain AP view and repeat live fluoroscopy contrast administration to ensure the contrast pattern is confined to the midline and concentrated near the L3 vertebral body (Image 23.4).
11. Administer 10 mL of injectate (4 mL Bupivacaine + 5 mL preservative-free Lidocaine + Dexamethasone 10 mg) in 2–3 mL aliquots in each needle (total of 20 mL of injectate if performing bilateral lumbar sympathetic block with 10 mL of injectate administered per side).
    - Monitor patient for signs/symptoms of intravascular administration (tinnitus, perioral numbness, metallic taste in the mouth, dizziness, fainting, hypotension, bradycardia).

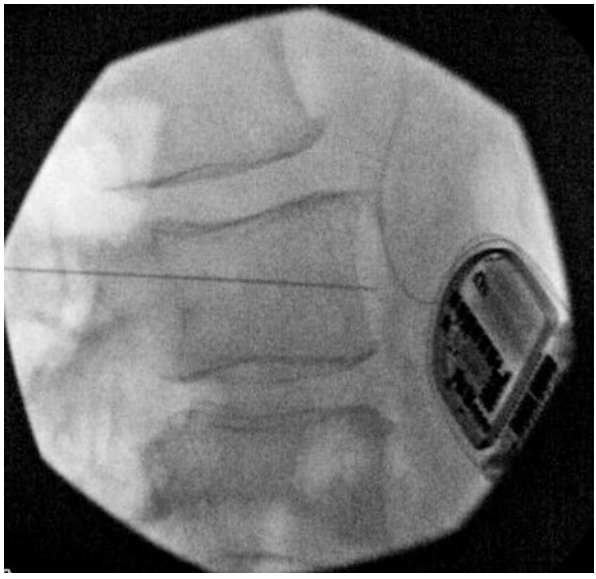

Image 23.2 Lateral view prior to contrast injection

Image 23.4 AP view with contrast

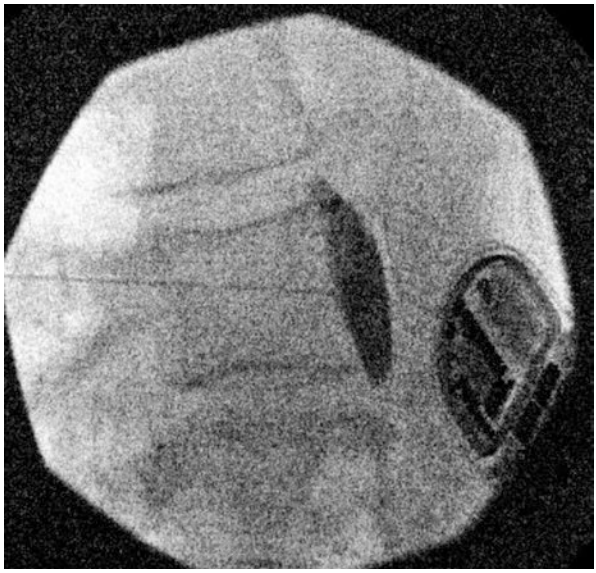

Image 23.3 Lateral view with contrast

12. Withdraw needle, clean site, and apply a dressing.

Checkpoints to Mastery

Beginner

- Identify the L3 level by counting down from the 12th rib (ideally starting at T1 for most accurate count).
- Make proper adjustments on AP view to "square off" the L3 endplate.
- Oblique the image intensifier ipsilateral until the facet joint line is approximately 1/3–1/2 the distance between the borders of the L3 vertebral body to obtain the trajectory view.
- Be able to tell patients potential warning signs to be aware of for local anesthetic toxicity.

Intermediate

- Adjust cranial and caudal tilt of image intensifier to move the transverse process out of the way in order to see the waste of the vertebral body.
- Insert spinal needle and obtain coaxial needle view while driving the spinal needle to the most concave aspect of the L3 vertebral body.

Advanced

- Obtain lateral view to determine depth of the spinal needle. Advance the spinal needle until the tip of the needle is 1–2 mm posterior to the anterior border of the L3 vertebral body (Image 23.2).
- Confirm correct needle placement by injecting live contrast in both the lateral and AP view to ensure no vascular uptake or fascial spread. Consider use of digital subtraction if available.

Pitt Pain Pearls and Pitfalls

- When obtaining the trajectory view, ipsilateral oblique of the image intensifier greater than 25–30° will put you at risk of damaging retroperitoneal structures such as the kidney.
- The great vessels are ventral to the vertebral bodies. Therefore, unlike the celiac plexus block, the needle tip should be 3–5 mm posterior to the anterior border of the vertebral body to avoid puncturing the inferior vena cava (when performing the procedure on the right) or the aorta (when performing the procedure on the left).
- Avoid suboptimal contrast flow that demonstrates a fascial pattern (amorphous contrast spread info the soft tissues) rather than over the sympathetic chain.

Anatomy Pearls

See Images 23.1, 23.2, 23.3, and 23.4.

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Further Reading

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Sphenopalatine Ganglion/Trigeminal Nerve V2 Branch Block (Infrazygomatic Approach with Fluoroscopy)

24

Alexander Stanton, Marissa Pavlinich, and Tetyana Marshall

Abstract

The sphenopalatine ganglion (SPG), also commonly known as the pterygopalatine ganglion or Meckel's ganglion, is a large extracranial ganglion that is comprised of sensory, sympathetic, and parasympathetic neurons (Ho et al., J Headache Pain 18(1):118, 2017). It is located in the pterygopalatine fossa, posterior to the middle nasal turbinate and maxillary sinus (Alexander and Dua, Sphenopalatine ganglion block, National Library of Medicine, 2022). SPG gives rise to the pharyngeal branch of the maxillary nerve, nasopalatine nerve, the superior, posterior, and lateral nasal nerves, and the greater and lesser palatine nerves (Ho et al., J Headache Pain 18(1):118, 2017). The ganglion is involved in sensory innervation of the nasal cavity, nasopharynx, soft palate, portions of the oropharynx, and cerebral and meningeal blood vessels (Lundy and McNary, Neuroanatomy, pterygopalatine ganglion, National Library of Medicine, 2022). Given that the ganglion is connected to many structures involved in neurological pain syndromes of the head and neck, local anesthetic blockade and radiofrequency ablation (RFA) of the ganglion have been used as treatments of these pain syndromes. The most common indications of SPG blockade include cluster headache, V2 trigeminal neuralgia, migraine headache, and analgesia post endoscopic sinus surgery (Tolba et al., Ochsner J 19(1):32–37, 2019). Ablation is typically used in intractable cluster headache, but has also been used for atypical trigeminal neuralgia, posttraumatic headache, atypical facial pain, and postherpetic neuralgia (Tolba et al., Ochsner J 19(1):32–37, 2019). Reported side effects

A. Stanton (✉) · T. Marshall
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: stantonad@upmc.edu; osadchukt@upmc.edu

M. Pavlinich
South Hills Pain and Rehabilitation, Jefferson Hills, PA, USA

T. Emerick et al. (eds.), *The Pain Procedure Handbook*,
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include temporary paraesthesia of the cheek, palate, and upper gums, as well as rare reports of reflex bradycardia during procedure, permanent hypoesthesia of the cheek, epistaxis, cheek hematoma, and inadvertent ablation of the maxillary nerve (Ho et al., J Headache Pain 18(1):118, 2017). Contraindications include anticoagulation, history of facial trauma, allergy to medications used during procedure, and patient refusal.

Keys to Procedure

- Understand appropriate patient positioning to obtain a true lateral with good visualization of the pterygomaxillary fissure is essential to effective injection technique.
- Understand relevant anatomical dimensions of bony structures and spaces to ensure proper needle positioning, contrast, and injectate volumes.
- Locate and identify the needle target on AP view just lateral to the nasal bone and maxillary sinus.

Anatomy Pearls

See Image 24.1.

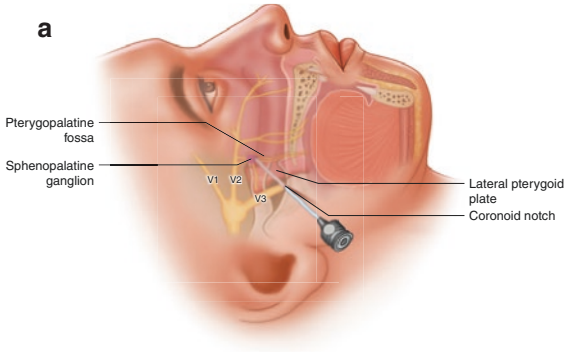
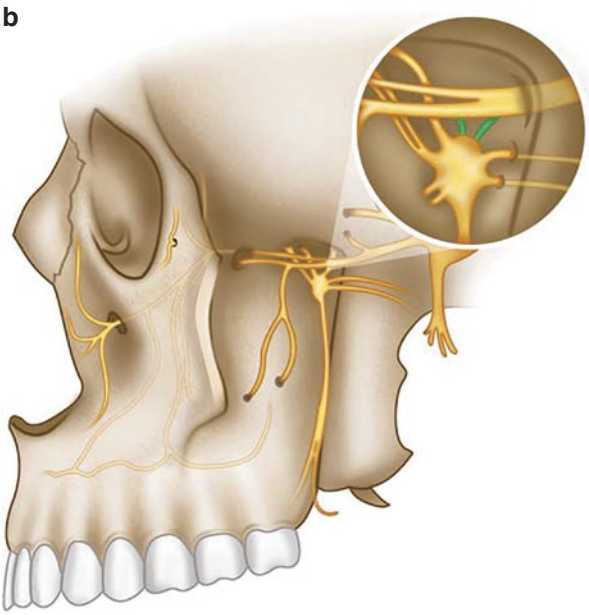


Image 24.1 (**a**) Trajectory of needle for infrazygomatic approach to sphenopalatine ganglion. (**b**) Enlarged view of sphenopalatine ganglion and adjacent maxillary nerve

Fig. 24.1 (continued)



What You Will Need

- Sterile towels
- Chlorhexidine-based soap
- 25G 1.5″ needle for skin local anesthetic
- 18G 1.5 needle to draw up medications
- 22G 3.5″ spinal needle for procedure
- Extension tubing (6″) ×2 5 mL syringe for skin local
- 3 mL syringe for contrast
- 1 mL syringe or 3 mL syringe for injectate
- Lidocaine 1% for skin: 5 mL
- Ropivacaine 0.5%: 1 mL
- Isovue 300 (contrast agent): 3 mL
- Dexamethasone 10mg: 1 mL

Skin local anesthetic: 5 mL syringe, 5 mL lidocaine 1%, 25G 1.5″ needle.
Contrast: 3 mL syringe, 3 mL Isovue 300, extension tubing; prime tubing.
Injectate: 3 mL syringe, 1 mL Ropivacaine + Dexamethasone 10 mg, extension tubing; prime tubing.

Patient Positioning

- Supine (consider forehead lightly taped to maintain in a neutral position)
- Overall approach seen in Image 24.1a with Image 24.1b showing sphenopalatine ganglion and adjacent maxillary nerve

How to Perform the Procedure

1. Sterilely prep the side of the face (caution not to get too close to the eye) and drape with sterile towels.
2. Obtain a lateral view to identify the pterygomaxillary fissure (Image 24.2).
   - Tilt the patient's head to optimize your view. Look for a clear V-shape (tall, thin V) at the pterygomaxillary fissure site and well-delineated external auditory meatus and superimposed mandibular rami.

Image 24.2 Lateral view of borders of sphenopalatine fossa and needle in coaxial view at bottom third of triangle

3. Create skin wheal inferior to the zygomatic arch and near the coronoid notch with local to anesthetize skin.
   - Use no more than 2 mL of Lidocaine and no deeper than 1 cm.
4. Insert the spinal needle coaxial to the fluoroscopic beam.
5. Advance the needle superiorly and medially toward the pterygopalatine fossa.
   - Check anteroposterior (AP) views intermittently to check needle depth to avoid nasal wall and turbinate breach.
   - If you hit bone, assess whether you hit the zygomatic arch or the mandible and withdraw needle slightly, adjusting trajectory accordingly. Trajectory may need to be adjusted repeatedly given the small size of the fossa (1 cm wide, 2 cm high).
6. When nearing the maxillary sinus, obtain an AP view and advance until the needle tip is immediately lateral to the ipsilateral nasal bone and maxillary sinus.

7. Administer 0.2 mL of contrast in AP view (Image 24.2) and lateral view (Image 24.3) to ensure the contrast in pterygopalatine fossa without intravascular flow.
   - Do not inject more than 0.5 mL of contrast as this will limit space for medication to spread.
8. Administer 0.5 mL of injectate (1 mL Ropivacaine + Dexamethasone 10 mg) slowly.
9. Obtain an AP view to confirm flow of medication (washout of contrast) into the pterygopalatine fossa and administer the remaining 0.5 mL of injectate.
10. Remove needle, clean site, ensure hemostasis, apply bandage.

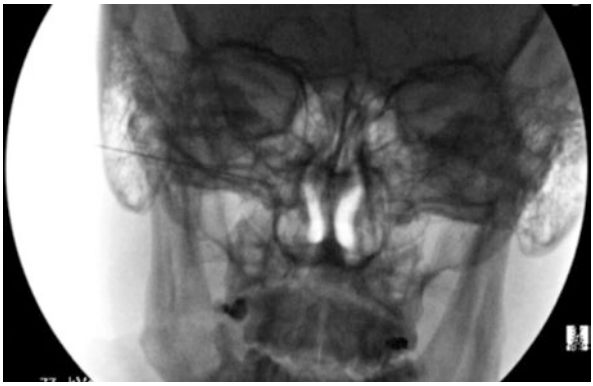


Image 24.3 AP view of final needle placement

Checkpoints to Mastery

Beginner

- Obtain a true lateral view and be able to identify the pterygomaxillary fissure.
- Palpate and identify the zygomatic arch.
- Identify the needle target of the pterygopalatine fossa.

Intermediate

- Create a proper skin wheel to anesthetize the skin inferior to the zygomatic arch near the coronoid notch.
- Insert the needle coaxial to the fluoroscopic beam.
- Advance the needle toward the pterygopalatine fossa identifying the target.

Advanced

- Understand when to obtain AP view to position the needle tip lateral to nasal bone and maxillary sinus.
- Administer contrast and confirm that the needle is in the appropriate space.
- Aspirate and complete the injection with washout of contrast.

Pearls and Pitfalls

- Without light sedation, many patients have difficulty tolerating the procedure due to the location of the injection.
- Advise patient/staff to apply ice for about 20 min in recovery area to diminish bruising at injection site. Retrobulbar hematoma is a potential complication of this procedure due to maxillary artery location within the fossa.
- Do not inject local anesthetic too deeply. This can result in intravascular lidocaine injection as the area is quite vascularized.
- Appropriate contrast flow prior to administering injectate is essential. You can minimally advance or rotate the needle if needed to achieve improved contrast flow. Be cautious not to inject too much contrast and fill the fossa. The needle tip needs to be medial to the mid-point of the orbit to allow for contrast flow into the pterygopalatine fossa.
- Do not advance the needle too far medially and violate the maxillary sinus. This increases the risk of infection, bleeding, and other complications with the injection.

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Sphenopalatine Ganglion/Trigeminal Nerve V2 Branch Pulsed Radiofrequency Ablation (RFA)

25

Tetyana Marshall

Abstract

The sphenopalatine ganglion (SPG), also commonly known as the pterygopalatine ganglion or Meckel's ganglion, is a large extracranial ganglion that is comprised of sensory, sympathetic, and parasympathetic neurons (Ho et al., J Headache Pain 18(1):118, 2017). It is located in the pterygopalatine fossa, posterior to the middle nasal turbinate and maxillary sinus (Alexander and Dua, Sphenopalatine ganglion block, National Library of Medicine, 2022). SPG gives rise to the pharyngeal branch of the maxillary nerve, nasopalatine nerve, the superior, posterior, and lateral nasal nerves, and the greater and lesser palatine nerves (Ho et al., J Headache Pain 18(1):118, 2017). The ganglion is involved in sensory innervation of the nasal cavity, nasopharynx, soft palate, portions of the oropharynx, and cerebral and meningeal blood vessels (Lundy and McNary, Neuroanatomy, pterygopalatine ganglion, National Library of Medicine, 2022). Given that the ganglion is connected to many structures involved in neurological pain syndromes of the head and neck, local anesthetic blockade and radiofrequency ablation (RFA) of the ganglion have been used as treatments of these pain syndromes. The most common indications of SPG blockade include cluster headache, V2 trigeminal neuralgia, migraine headache, and analgesia post endoscopic sinus surgery (Tolba et al., Ochsner J 19(1):32–37, 2019). Ablation is typically used in intractable cluster headache, but has also been used for atypical trigeminal neuralgia, posttraumatic headache, atypical facial pain, and postherpetic neuralgia (Tolba et al., Ochsner J 19(1):32–37, 2019). Reported side effects include temporary paraesthesia of the cheek, palate, and upper gums, as well as rare reports of reflex bradycardia during procedure, permanent hypoesthesia of the cheek, epistaxis, cheek hematoma, and inadvertent ablation of the maxillary

T. Marshall (✉)
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: osadchukt@upmc.edu

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nerve (Ho et al., J Headache Pain 18(1):118, 2017). Contraindications include anticoagulation, history of facial trauma, allergy to medications used during procedure, and patient refusal.

Keys to the Procedure

- Understand imaging and needle target from the Sphenopalatine Ganglion/Trigeminal Nerve Block with Fluoroscopy chapter.
- Identify potential complications of performing radiofrequency ablation of the sphenopalatine ganglion.
- Know the settings and time required to perform a pulsed radiofrequency ablation.
- Pulsed RFA reimbursement and coverage varies and needs to be considered before offering this procedure.

What You Will Need

- Sterile towels
- Chlorhexidine-based soap
- RFA Generator that displays impedance, voltage, amperage, and temperature
- Electrode grounding pad (connected to RFA Generator)
- RFA cannula with stylet
- Lidocaine 1% for skin: 5 mL
- 25G 1.5″ needle for skin local
- 18G 1.5″ needle to draw up medications
- 5 ml syringe with 25G 1.5″ needle for skin local anesthetic

Patient Positioning

– Supine with head lightly taped to maintain a neutral position

How to Perform the Procedure

1. Sterilely prep the side of the face (CAUTION: do not get too close to the eye) and drape with sterile towels.
2. Obtain a lateral view to identify the pterygomaxillary fissure.
   - Wig-wag the image intensifier or tilt the patient's head to optimize your view. Look for a clear V-shape at the pterygomaxillary fissure site and well-delineated external auditory meatus and superimposed mandibular rami.
3. Anesthetize the skin with Lidocaine 1%.
   - Use no more than 2 mL of Lidocaine and no deeper than 1 cm to avoid accidental block.

4. Insert the RFA cannula coaxial to the fluoroscopic beam
5. Advance the needle into the pterygopalatine fossa, medially, anteriorly, and slightly cephalad, checking AP and lateral views to confirm needle trajectory.
   - If you hit bone, assess whether you hit the zygomatic arch or the mandible and withdraw needle slightly, adjusting trajectory accordingly. Trajectory may need to be adjusted repeatedly given the small size of the fossa (1 cm wide, 2 cm high).
6. When nearing the maxillary sinus, obtain an AP view and advance until the needle tip is just lateral to the ipsilateral nasal bone and maxillary sinus.
7. After appropriate needle placement, remove the stylet and insert the thermal unit into the RFA cannula.

8. Assess impedance and perform sensory stimulation.
   - Patient should feel paresthesia only in their occipital region with 0.3–0.5 V at 50 Hz.
   - If paresthesia is felt in the hard palate, redirect needle cephalad and medial.
   - If paresthesia is felt in the upper teeth, redirect caudal and medial.
9. Commence pulsed RFA.
   - Pulsed RF settings: frequency 2 Hz, 20 ms, 42 °C for 120 s.
10. Repeat pulsed thermal ablation for a total of 4 min.
11. Remove needle, clean site, and place adhesive dressing.
12. Apply ice for about 30 min in the recovery area to diminish bruising at the injection site.

Checkpoints to Mastery

Beginner

- Obtain a true lateral view and be able to identify the pterygomaxillary fissure.
- Palpate and identify the zygomatic arch.
- Identify the needle target of the pterygopalatine fossa on AP and lateral images.

Intermediate

- Create a proper skin wheel to anesthetize the skin inferior to the zygomatic arch.
- Insert the RFA cannula coaxial to the fluoroscopic beam.
- Advance the needle toward the pterygopalatine fossa identifying the target.

Advanced

- Assess the impedance and determine safety.
- Understand potential complications of performing pulsed RFA in this region.
- Know the proper pulsed RF settings on the RF Generator.

Images: See ‘Sphenopalatine Ganglion/Trigeminal Nerve V2 Branch Block with Fluoroscopy’ (Chap. 24).

For Additional Pitt Pain Pearls and Pitfalls: See ‘Sphenopalatine Ganglion/Trigeminal Nerve V2 Branch Block with Fluoroscopy’ (Chap. 24).

Pitt Pain Pearls and Pitfalls

- Potential complications of radiofrequency ablation of the sphenopalatine ganglion
  - Temporary or permanent hypoesthesia/dysesthesia of the palate, maxilla, or posterior pharynx
  - Reflex bradycardia due to lesioning the parasympathetic fibers of the ganglion can lso occur and can be prevented with pre-procedure administration of atropine or glycopyrrolate, if desired.
  - These complications are less likely with pulsed RF than with traditional RF.

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4. Tolba R, Weiss AL, Denis DJ. Sphenopalatine ganglion block and radiofrequency ablation: technical notes and efficacy. Ochsner J. 2019;19(1):32–7.

Ganglion Impar Block

26

Merna Naji, Marissa Pavlinich, and Alexander Varzari

Abstract

The ganglion impar (Walther's ganglion) is a retroperitoneal sympathetic ganglion that lies behind the rectum anterior to the sacrococcygeal junction (Gunduz et al., Pain Med 16(7):1278–1281, 2015). It provides afferent visceral innervation of the perineum, anus, distal rectum, distal urethra, vulva, and distal third of the vagina. The ganglion impar block has been used to treat coccygodynia as well as several perineal and genital malignant and non-malignant chronic pain conditions.

The ganglion impar block has been performed under fluoroscopic, computerized tomography, and ultrasound guidance via a trans-sacrococcygeal or transcoccygeal approach. All approaches have been found to be safe and effective (Malhotra et al., J Anaesthesiol Clin Pharmacol 37(1):90–96, 2021). The fluoroscopic guided trans-sacrococcygeal approach is described in this chapter. Injectates include local anesthetics and steroids; however, recent reports have found success with ganglion impar radiofrequency ablation (Li et al., World J Clin Cases 9(9):2153–2159, 2021).

M. Naji (✉) · A. Varzari
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: najimr@upmc.edu; varzaria@upmc.edu

M. Pavlinich
South Hills Pain and Rehabilitation, Jefferson Hills, PA, USA

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Keys to the Procedure

- Understand the relevant anatomy and location of the ganglion impar.
- Identify the injection target site on lateral fluoroscopic imaging.
- Understand the importance of needle tip depth lateral imaging to avoid the rectum.

Anatomy Pearls

See Images 26.1 and 26.2.

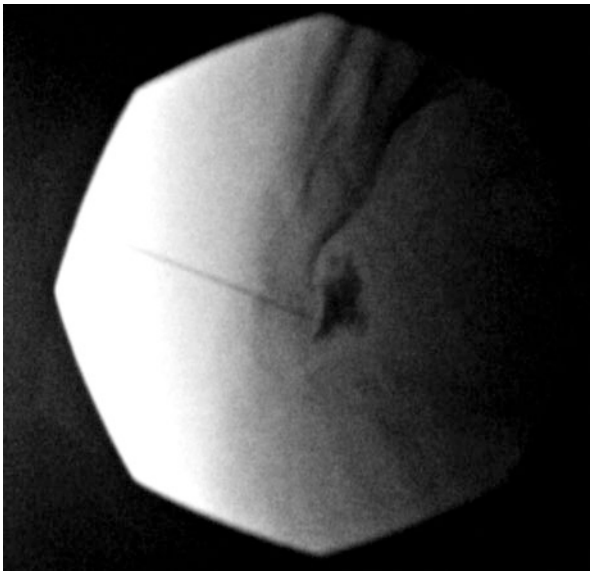

Image 26.1 Lateral view with contrast ventral to the coccyx

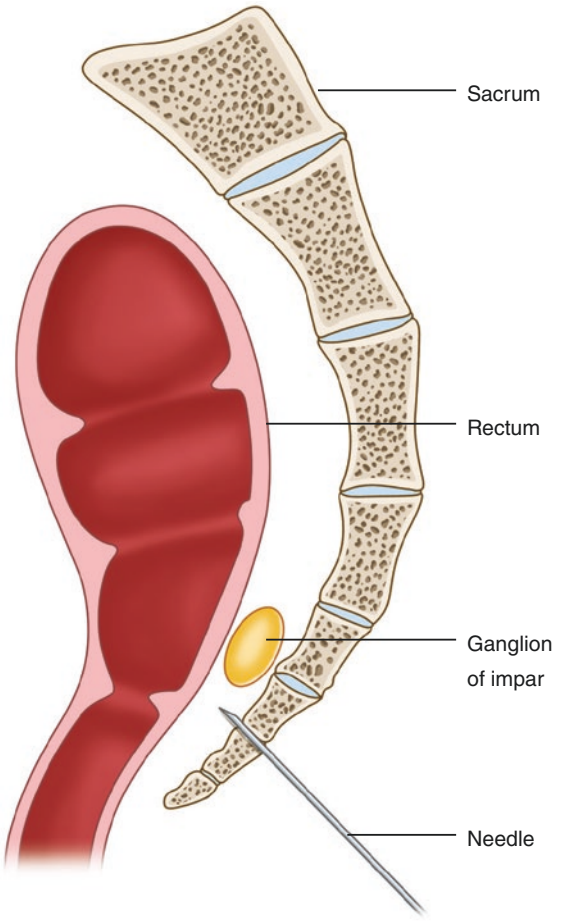

Image 26.2 Anatomic reference

What You Will Need

- Sterile towels
- Chlorhexidine-based soap
- 22G 3.5″ spinal needle
- Lidocaine 1% for skin: 5 mL
- Isovue 300: 3 mL
- Bupivacaine 0.25%: 2 mL
- Dexamethasone 10 mg: 1 mL
- 25G 1.5″ needle for skin local
- 18G 1.5″ needle to draw up medications
- Extension tubing (3″) for contrast
- 5 mL syringe with 25G 1.5″ needle for skin local
- 3 mL syringe with tubing for contrast
- 3 mL syringe for injectate (2 mL Bupivacaine + dexamethasone 10 mg)

Patient Positioning

- Prone with a pillow under the abdomen to flex the thoracolumbar spine and minimize lumbar lordosis.

How to Perform the Procedure

1. Sterilely prep the lower back, sacral hiatus, and coccyx. Drape with a sterile drape.
2. Obtain a lateral view to visualize the sacrococcygeal junction.
3. Place a marker on the patient to get a sense of where to insert the needle. You will look for a sacrococcygeal segment that looks like it can accommodate the needle passing through and one that does not require your entry point to be too inferior.

4. Once you know your entry point and trajectory, anesthetize the skin with Lidocaine 1%.
5. Insert the spinal needle. Guide the needle through the sacrococcygeal segment and land the tip just anterior to the bone.

6. Administer 0.5–1 mL of contrast to ensure retroperitoneal contrast spread (Images 26.1 and 26.2).
7. Administer injectate (2 mL Bupivacaine + dexamethasone 10 mg) slowly.
8. Remove the needle, clean the site, and place a adhesive dressing.

Checkpoints to Mastery

Beginner

- Identify on a lateral image the sacrococcygeal junction.
- Identify the needle target dept on lateral imaging.
- Place a marker on the patient to get a sense of the needle insertion and trajectory.

Intermediate

- Sterilely prep the area and place a drape with sterile technique.
- Anesthetize the skin.
- Insert the needle with a good trajectory directed toward the sacrococcygeal segment stopping before crossing anterior.

Advanced

- Advance the needle through the sacrococcygeal segment and land just anterior to bone.
- Administer contrast and identify retroperitoneal spread pattern.
- Administer injectate following negative aspiration.

Pitt Pearls and Pitfalls

- There may be several sacrococcygeal segments available to enter. Avoid starting too low as the lower the segment, the more curved it is, which will lead to a more difficult trajectory.
- Take care not to perforate the rectum by advancing too deep, which can lead to infection (including potential discitis) if the lumen is penetrated.

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Further Reading

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Part V

Other Common Injections

Trigger Point Injections for Myofascial Pain

27

Leath Abdullah, Brandon Staub, and Alexander Varzari

Abstract

Myofascial trigger points are often described by patients as "knots" and can be felt by a practitioner as a taut band of skeletal muscle compared to surrounding tissue. Examination of a trigger point elicits a muscle twitch response on palpation accompanied by local pain. At times trigger points can also cause repeatable referred pain that mimics radiculopathy. Painful trigger points can lead to a sensation of muscle tension and guarding which results in stiffness and decreased range of motion.

There are several hypotheses regarding the pathophysiology of trigger point. The most widely accepted suggests that trigger points form following acute trauma to a muscle belly or from overuse leading to microtrauma of the muscle fibers (Alvarez and Rockwell, Am Fam Physician 65(4):653–660, 2002). It is thought that abnormal activity at the motor endplates at these damaged microfibers leads to nerve sensitization and a subsequent spinal cord response (Hong and Simons, Arch Phys Med Rehabil 79(7):863–872, 1998). On electromyography this is seen as spontaneous action potential generation within trigger points and on muscle biopsies fiber hypercontracture can be seen consistent with continuous sarcoplasmic reticulum calcium release (Jafri, Int Sch Res Notices 2014:523924, 2014).

Treatments include physical therapy, ultrasound, stretching, muscle relaxants, and trigger point injections (Alvarez and Rockwell, Am Fam Physician

L. Abdullah (✉)
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA

Chronic Pain Division, University of Pittsburgh Medical Center, Pittsburgh, PA, USA
e-mail: abdullahlr4@upmc.edu; varzaria@upmc.edu

B. Staub
Chronic Pain Division, University of Pittsburgh Medical Center, Pittsburgh, PA, USA

A. Varzari
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA

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65(4):653–660, 2002). The philosophy behind trigger point injections is that by relaxing the taut band of muscle there is improved blood flow to the muscle which flushes metabolic waste and replenishes ATP, thus releasing actin-myosin chains and allowing the muscle fiber to lengthen (Wong and Wong, Anesthesiol Res Pract 2012:492452, 2012).

Contraindications are similar to other types of injections and include active infection over injection site and patient refusal. Since trigger point injections are blind technique,e they require extra caution in instances where a patient's anatomical landmarks may not be easily identifiable. Complications include but are not limited to pain, hematoma, vascular injury, pneumothorax if working along the ribcage, and vasovagal response.

Keys to Procedure

- Be able to identify trigger point targets and differentiate from tender points.
- Identify safe locations particularly over the chest wall.
- Understand the benefits of dry needling vs. wet needling.

Anatomy Pearls

- Most common muscular targets include masseter, levator scapulae, gluteus medius, quadratus lumborum, trapezius, sternocleidomastoid, and temporalis.
- Key to finding trigger points: Identify tender nodule with twitch response on palpation, can have referred pain.
  - Trigger Points: can be defined as active or latent
    Active: Twitch response on palpation with referred pain elsewhere
    Latent: Twitch response on palpation without referred pain
    Tender Point: Pain on palpation without twitch response or referred pain

What You'll Need

- Required items
  - Small gauge (25G–27G) 1.5 in. needles for injection (consider use of 5/8 in. 25 G needle in cervical or thoracic region to avoid pneumothorax)
  - Acupuncture needles for dry needling
  - Syringes
  - PPE such as non-sterile gloves, face masks
  - Alcohol prep pads, chlorhexidine prep, or if necessary, iodine
  - Flesh marker
- Optional items
  - Local anesthetics for injection
  - Spray-on topical anesthetic
  - Corticosteroids for injection (dexamethasone, triamcinolone)
  - Buffer agents (sodium bicarbonate)
  - Sterile saline or D5W for injection

Patient Positioning

– Positioning of the patient should be performed in whichever way the patient is comfortable providing reasonable access to the trigger point locations for the provider while maintaining proper ergonomics. As trigger points can appear on any skeletal muscle, this will vary patient to patient.
– Most common positioning is in a seated position facing away from the proceduralist. Supine or prone positioning is also common.

Pitt Pain Pearl: Local anesthetic injection is not superior to dry needling or sterile fluid injection. It does, however, reduce the post-needling soreness in the immediate post-procedural period.

How to Perform the Procedure

1. First identify the trigger point locations via palpation and verbal confirmation from the patient.

2. Mark each trigger point location with a flesh marker until all locations are identified.
3. The proceduralist will then use their non-dominant gloved hand to pinch up the skin of the identified trigger point and clean that location with the prep of choice.
4. Then, the needle can be inserted at an acute angle into the muscle. Then, rhythmic partial removal of the needle is followed by reinsertion several times in different directions. The needle can be "fanned" in different directions to help break up the muscle bands.
   (a) For muscles over the lung fields, particular attention should be paid to remain shallow or with image guidance in real time using ultrasound.
5. If an injection is planned, it can be performed during the rhythmic insertions with up to 1 mL of fluid injected per trigger point. Aspiration should be performed prior to injection to ensure no intravascular injections occur.
6. This process is repeated for each trigger point.

Checkpoints to Mastery

Beginner

– Performed a detailed history and physical exam focused on the musculoskeletal system.
– Ensure the patient has no allergies to injected medications.

– Set up for injection using safe techniques to prevent accidental needle sticks and proper disposal of all equipment used.

Intermediate

– Differentiate trigger points from tender points on examination.
– Avoid locations where risk of vascular/neurologic injuries or accidental vascular injection may occur.
– At each site of injection, perform dry needling technique for maximal therapeutic benefit.

Advanced

– Perform trigger point injections over the chest wall.
– Understand that pneumothorax is also possible but a rare complication of needle insertion. This should be discussed during the consent process. Prevention includes fully pinching the tissue away from the intercostal muscles with careful needle insertion to ensure the pleura is not violated or use of image guidance using ultrasound.

Pitt Pain Pearls and Pitfalls

- Patient should be briefly monitored for post-procedural complications such as allergy, hematoma, local anesthetic systemic toxicity syndrome, vasovagal/syncopal events.
- During needling, "crunching" sensations may be felt as the muscle is broken up, which is a positive sign for a trigger point.

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Knee Intra-articular Injection Under Ultrasound

28

Isaiah Levy and Alexander Varzari

Abstract

Osteoarthritis is a common, debilitating progressive disease that most commonly affects the knees and hips. Progression of osteoarthritis often results in need for total arthroplasty of the knee or hip. First line treatments include oral acetaminophen and nonsteroidal anti-inflammatory drugs. Intra-articular corticosteroid injections are routinely performed for patients with refractory pain or dysfunction or for those with contraindications to long-term systematic treatment with acetaminophen or nonsteroidal anti-inflammatories. The goal in managing osteoarthritis with intra-articular corticosteroid injections is to provide pain relief, improvement in function, and to delay the need for arthroplasty. This is thought to be achieved via decrease in inflammation in the joint by the corticosteroids.

Evidence suggests that intra-articular injections can be helpful to relieve pain and improve function in the short term, however the long-term safety and effects on the progression of osteoarthritis are unclear (Maricar et al., Arthritis Res Ther 19:88, 2017; Jüni et al. Cochrane Database Syst Rev 2015(10):CD005328, 2015). A growing body of evidence has suggested accelerated rates of osteoarthritis progression, whereas other studies find no significant difference in progression of joint destruction (Zeng et al., Osteoarthritis Cartilage 27(6):855–62, 2019). Intra-articular corticosteroid injections remain one of the most common treatments for osteoarthritis of the knee and hip, and it is important for the treating pain physician to weigh the risks and benefits with each patient.

I. Levy (✉) · A. Varzari
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: levyir2@upmc.edu; varzaria@upmc.edu

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https://doi.org/10.1007/978-3-031-40206-7_28

Keys to Procedure

- Understand the relevant knee joint anatomy on short and long axis ultrasound views.
- Understand how to optimize imaging utilizing ultrasound positioning and knobology.
- Understand the complications and corrective steps if encountered.

Anatomy Pearls

- Suprapatellar bursa lies between the anterior surface of the distal femur above the prefemoral fat pad and below the distal quadriceps musculotendinous unit.
- The quadriceps tendon is made up of joining fibers from the vastus lateralis, the vastus intermedius, the vastus medialis, and the rectus femoris which comprise the quadriceps muscles (Images 28.1, 28.2, 28.3 and 28.4).

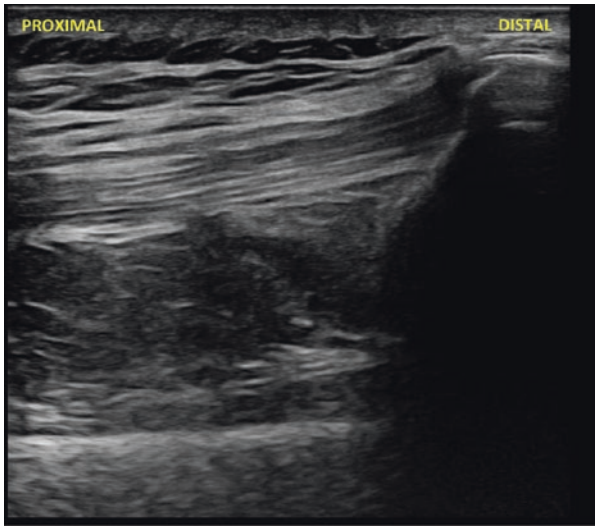

Image 28.1 Proximal to distal long axis ultrasound view (unlabeled)

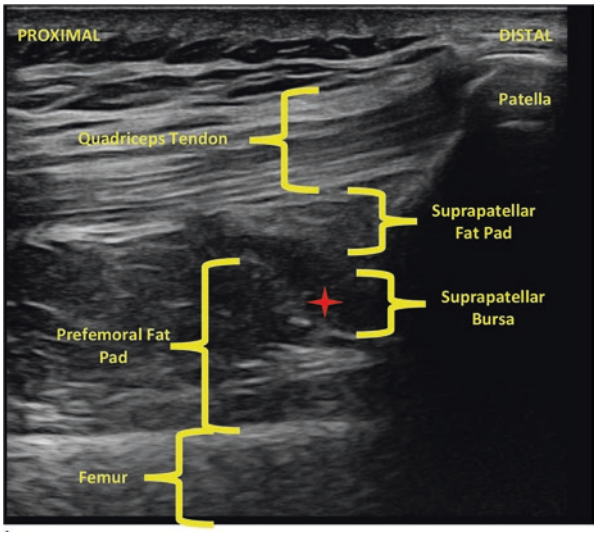

Image 28.2 Proximal to distal long axis ultrasound view (anatomy labeled). Red cross indicates needle tip target in suprapatellar bursa

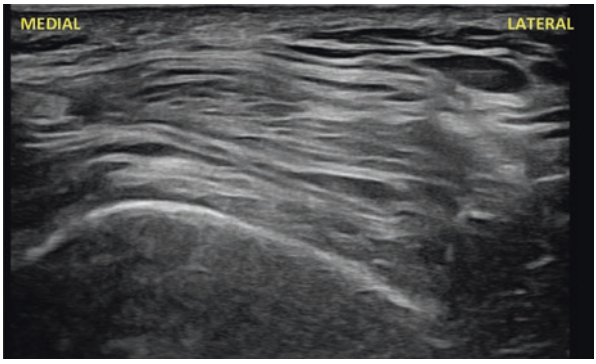

Image 28.3 Medial-lateral short axis ultrasound view (unlabeled)

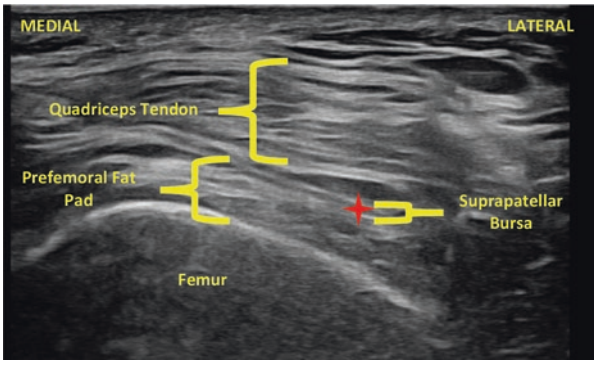

Image 28.4 Medial-lateral short axis ultrasound view (anatomy labeled). Red cross indicates needle tip target in suprapatellar bursa

What You Will Need

- Sterile towels
- Chlorhexidine-based soap
- 22G 1.5″ needle
- Lidocaine 1% for skin: 5 mL
- Bupivacaine 0.25%: 4 mL
- Methylprednisolone 40 mg: 1 mL
- 25G 1.5″ needle for skin local
- 18G 1.5″ needle to draw up medications
- 5 mL syringe with 22G 1.5″ needle for skin local
- 5 mL syringe for injectate (4 mL Bupivacaine + 1 mL Methylprednisolone 40 mg)

Patient Positioning

- Placed in the supine position with the knee slightly flexed and supported by a rolled-up towel under the knee

How to Perform the Procedure

1. First identify the superior pole of the patella via palpation.
2. Sterilely prep and drape with sterile towels.
3. Place linear high-frequency ultrasound transducer over the superior pole of the patella in an initial long axis, proximal to distal orientation (see Images 28.1 and 28.2). Identify the quadriceps tendon which can be visualized upon surveying the joining fibers of the quadriceps muscles. The tendon can be appreciated by aligning the ultrasound probe to visualize the anisotropy of the tendon. The suprapatellar bursa is the hypoechoic region lying beneath the tendon and above the hyperechoic prefemoral fat pad and communicates with the intra-articular knee joint. Long axis orientation can help verify bursa depth and largest cross sectional area to target.
4. Rotate the ultrasound transducer 90 degrees to obtain short axis, lateral to medial orientation (see Images 28.3 and 28.4). Again, identify the quadriceps tendon, the suprapatellar bursa, and the prefemoral fat pad (see Images 28.1, 28.2, 28.3 and 28.4).

5. After the quadriceps tendon and suprapatellar bursa are identified, a 3½-in. needle is placed through the skin ~1 cm from the center of medial aspect of the transducer and is then advanced using an in-plane lateral to medial approach with the needle trajectory adjusted under real-time ultrasound guidance to place the needle tip into just beneath the quadriceps tendon within the suprapatellar bursa.

6. Confirm appropriate needle placement by injecting a small amount of local anesthetic to visualize flow within the suprapatellar bursa.
7. After confirmation of positioning, the remainder of the contents of the syringe are slowly injected.
   (a) There should be minimal resistance to injection.

Checkpoints to Mastery

Beginner

- Familiarize oneself with settings of ultrasound probe including adjustment of image depth, gain, and utilization of doppler.
- Consistently distinguish muscle, tendons, vasculature, and neural anatomy.
- Place ultrasound probe proximal to superior pole of the patella and identify the quadriceps tenson, prefemoral fat pad, the distal femur, and the suprapatellar bursa in both long and short axis views.

Intermediate

- Maintain the ultrasound probe in optimized position as needle is advanced in plane to the ultrasound probe.
- Utilize Doppler imaging to verify that there are no blood vessels in path of needle.

Advanced

- Visualize needle tip in the suprapatellar bursa.
- Visualize injectate entering the suprapatellar bursa.

Pitt Pain Pearls and Pitfalls

- Via medial or lateral approach, needle is likely advanced through the vastus medialis or vastus lateralis, respectively.
- Ensure that the needle does not enter the quadriceps tendon to avoid tendon injury.

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Further Reading

Ultrasound-Guided Intra-articular Injection Technique for Intra-articular Injection of the Knee, Comprehensive Atlas of Ultrasound-Guided Pain Management Injection Techniques, 2nd Edition, Waldman.

Knee Diagnostic Genicular Nerve Block with Fluoroscopy

29

Michael E. Farrell II, Brandon Staub, and Alexander Varzari

Abstract

Knee osteoarthritis is a progressive degenerative joint disease that can be challenging to treat. Conservative measures include acetaminophen and nonsteroidal anti-inflammatory medications, weight loss, and physical therapy. Intraarticular injections can be performed with corticosteroids, hyaluronic acid, or autologous blood-based therapies such as platelet enriched plasma and mesenchymal stem cells. When conservative treatments fail surgical treatment is often the definitive therapy which consists of total knee arthroplasty.

For patients who have failed conservative treatment, are not surgical candidates, or have pain after surgery, the genicular nerve blocks may be a promising option. The knee joint is innervated by sensory branches of the femoral, common peroneal, saphenous, tibial, and obturator nerves. Together these are known as the genicular nerves. When dividing the knee into four quadrants the genicular nerves are referred to as the superolateral, superomedial, inferolateral, and inferomedial genicular nerves. Though cadaveric studies demonstrate high variability in the exact location of the genicular nerves, good outcomes have been demonstrated when targeting the superomedial, inferomedial, and superolateral genicular nerves (Conger et al., Pain Med 22(Suppl 1):S20–S23, 2021). Due to the

M. E. Farrell II (✉)
ECMC Center for Interventional Spine & Pain, Buffalo, NY, USA

B. Staub
Chronic Pain Division, University of Pittsburgh Medical Center, Pittsburgh, PA, USA

A. Varzari
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: varzaria@upmc.edu

T. Emerick et al. (eds.), *The Pain Procedure Handbook*,
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proximity of the inferolateral genicular nerve to the common peroneal nerve, the inferolateral quadrant is avoided due to risk of foot drop.

A genicular nerve block using local anesthetic can be used a test dose prior to pursuing genicular nerve radiofrequency ablation (RFA)—which can be expected to provide roughly 3–6 months of relief. Genicular nerve RFA is ultimately a temporary solution as the genicular nerves can regenerate over time.

The genicular nerve block can be performed under fluoroscopic or ultrasound guidance with similar results in terms of pain relief and improvement in function (Kim et al., Pain Physician 22(2):139–146, 2019). Genicular nerve RFA is performed using fluoroscopy.

Keys to Procedure

- Identify 3 main targets on the superomedial, superolateral, and inferomedial borders.
- Understand medication selection for blocks including steroid addition.
- Understand the alternate nerves that can be blocked including the suprapatellar.

Anatomy Pearls

See Image 29.1.

Pitt Pain Pearl: Avoid blocking/ablating the inferolateral genicular nerve (marked with red X) due to its motor branches that innervate the anterior compartment and possibility to cause a foot drop.

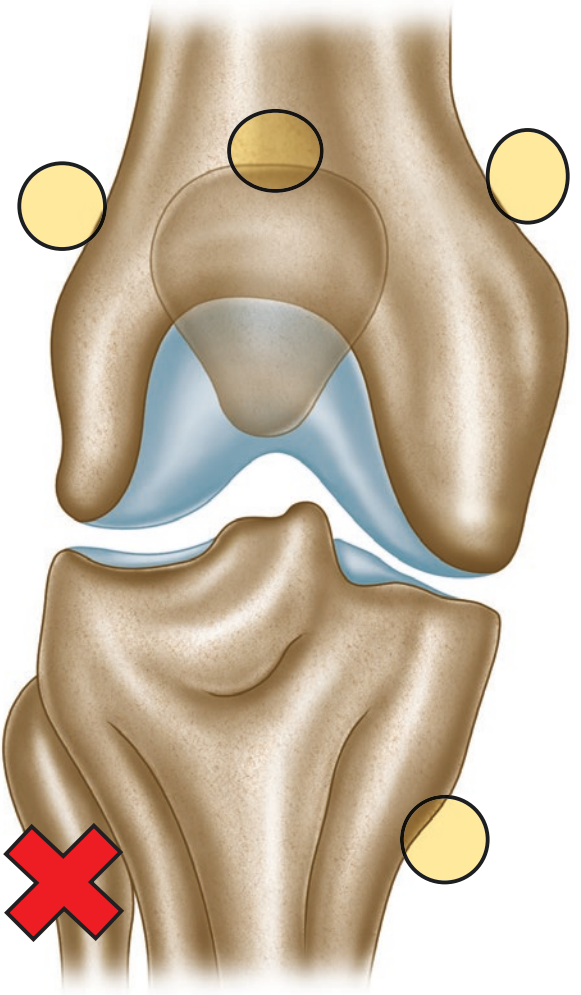

Image 29.1 Target locations for knee genicular nerve blocks

What You Will Need

- Sterile towels
- Chlorhexidine-based soap
- Leg positioning wedge or pillows
- Marking pen
- Hemostat
- 25G 3.5″ spinal needle ×3
- Bupivacaine 0.5%: 3 mL
- 18G 1.5″ needle to draw up medications
- 3 mL syringe for injectate (3 mL Bupivacaine)

Patient Positioning

- Semi-Fowlers/reclined, target knee elevated using positioning wedge and/or pillows.
- Leg must be elevated to ensure contralateral leg will not be superimposed on lateral X-rays.
- Hips should be flat with as little hip rotation as possible to ensure that the femur is not rotated.

How to Perform the Procedure with Fluoroscopy

1. Sterilely prep knee (from distal 1/2 of the thigh to proximal 1/2 of the lower leg) and drape with sterile towels.
2. Obtain AP view of the knee with the patella centered in the patellar trochlea to determine target needle locations
   Identify Targets on AP:
   Superolateral, superomedial, and inferomedial genicular nerves (suprapatellar) (Image 29.1)
   - Superolateral and superomedial genicular nerves
     - Located where the lateral and medial femoral shaft meets the epicondyle
   - Inferomedial genicular nerve
     - Located where the medial tibial shaft meets the condyle
   - Suprapatellar
     - Located –2 cm above the patella and just lateral or medial to avoid the quadriceps tendon
3. Obtain a true lateral view of the knee where femoral condyles perfectly align to determine target needle locations (Image 29.4)
   Identify Targets on Lateral:
   - Needle target is approximately 1/2 the distance between the anterior and posterior borders of the femur or tibia (Image 29.5).

4. To identify the needle insertion sites for the superomedial and superolateral genicular nerves, place an open hemostat over the width of the distal thigh and obtain an AP view (Image 29.2)
   - Adjust the hemostat as needed until it is positioned over the most concave portions of the femur where the diaphysis meets the metaphysis at the shaft–epicondyle junction
5. Once the hemostat is in the correct position, draw a line on the skin along the hemostat from the medial to the lateral aspects of the thigh
6. Obtain lateral view and ensure the femoral condyles are aligned (Compare Image 29.3 and Image 29.4)
7. Along the line drawn on the lateral thigh in Step 5, use the hemostat to identify and mark 1/2 the distance between the anterior and posterior borders of the femur (Image 29.5)
8. Anesthetize the skin (only superficial tissue) with Lidocaine 1% and insert the 25G spinal needle coaxial to the fluoroscopic beam (Image 29.4)
9. Advance the needle until you reach bone at the midpoint between the anterior and posterior borders of the femur
10. Repeat Steps 7–9 along the line drawn on the medial thigh for the superomedial genicular nerve site
11. Obtain AP view to ensure the needles have contacted the femur at the junction of the femoral shaft and lateral and medial epicondyles (Image 29.6)

Image 29.2 AP view of hemostat over the most concave portions of the femoral-epicondyle junction

Image 29.3 Lateral view of the femoral condyles not algined

Image 29.4 Lateral view of the femoral condyles aligned

Image 29.5 Lateral view of hemostat pointing at midpoint between anterior and posterior borders of the femur

Image 29.6 AP view of needles contacting femur at femoral-epicondyle junction

12. To identify the needle insertion sites for the inferior medial genicular nerve, place an open hemostat over the width of the proximal lower leg and obtain an AP view
    - Adjust the hemostat as needed until it is positioned over the most concave portions of the tibial shaft–condyle junction (Image 29.7)
13. Once the hemostat is in the correct position, draw a line along the hemostat on the medial aspects of the proximal lower leg
14. Obtain lateral view and with the femoral condyles aligned
15. Along the line drawn on the medial proximal lower leg in Step 13, use the hemostat to identify and mark 1/2 the distance between the anterior and posterior borders of the tibia
16. Anesthetize the skin with Lidocaine 1% and insert the 25G spinal needle coaxial to the fluoroscopic beam
17. Advance the needle until you reach bone at the midpoint between the anterior and posterior borders of the tibia
18. Obtain AP view to ensure the needle contacted the tibia at the junction of the medial tibial shaft and condyle (Image 29.8)
19. Administer 1 mL of Bupivacaine 0.5% through each of the three spinal needles
20. Remove needles, clean site, and apply an adhesive dressing.

Image 29.7 AP view of hemostat over the most concave portions of the tibial shaft-condyle junction

Image 29.8 AP view of needles contacting femur at tibial shaft-condyle junction

Checkpoints to Mastery

Beginner

- Ensure proper patient and c-arm vs. US position (see Chap. 30) to obtain true AP and lateral images
- Identify the four possible genicular nerve targets on AP X-ray
- Identify the needle target on the femur and tibia on lateral X-ray
- Be able to scan the knee using US and identify the target areas (Chap. 30)

Intermediate

- Fluoro: Use a hemostat and skin marker prep the patient to triangulate your targets
- Fluoro: Drive the needle to the targets by keeping needle coaxial and on target
- Read about the differences of using bupivacaine over lidocaine regarding length of the block
- Confidently rotate the US probe 90° while keeping your target centered on the screen (Chap. 30)
- Drive needle using out-of-plane technique while keeping the needle tip in view (Chap. 30)

Pitt Pain Pearls and Pitfalls

- Do not attempt to block the inferolateral genicular nerve as the common fibular (peroneal) nerve could be accidentally blocked resulting in motor weakness (including foot drop).
- Pay close attention to the depth of tissue that is overlying the bone at the various sites, particularly over the medial proximal tibia (the inferior medial genicular nerve site). In order to safely perform radiofrequency ablation (RFA), there needs to be >1.5 cm of tissue overlying the area in question to ensure that a superficial thermal/burn injury is not incurred (Images 29.8, 29.9, and 29.10).

Image 29.9 Alternatively AP views can be used for initial placement of the needles at needles at medial and lateral femoral-epicondyle junction and medial tibial shaft-condyle junction as shown here with depth confirmation on lateral imaging (Image 29.10)

Image 29.10 Lateral view demonstrating needles at the depth of the midpoint between anterior and posterior borders of femur and tibia

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1. Conger A, Gililland J, Anderson L, Pelt CE, Peters C, McCormick ZL. Genicular nerve radiofrequency ablation for the treatment of painful knee osteoarthritis: current evidence and future directions. Pain Med. 2021;22(Suppl 1):S20–3. https://doi.org/10.1093/pm/pnab129.
2. Kim DH, Lee MS, Lee S, Yoon SH, Shin JW, Choi SS. A prospective randomized comparison of the efficacy of ultrasound- vs fluoroscopy-guided genicular nerve block for chronic knee osteoarthritis. Pain Physician. 2019;22(2):139–46.

Knee Diagnostic Genicular Nerve Block with Ultrasound

30

Michael E. Farrell II, Brandon Staub, and Alexander Varzari

Abstract

Knee osteoarthritis is a progressive degenerative joint disease that can be challenging to treat. Conservative measures include acetaminophen and nonsteroidal anti-inflammatory medications, weight loss, and physical therapy. Intraarticular injections can be performed with corticosteroids, hyaluronic acid, or autologous blood-based therapies such as platelet enriched plasma and mesenchymal stem cells. When conservative treatments fail surgical treatment is often the definitive therapy which consists of total knee arthroplasty.

For patients who have failed conservative treatment, are not surgical candidates, or have pain after surgery, the genicular nerve blocks may be a promising option. The knee joint is innervated by sensory branches of the femoral, common peroneal, saphenous, tibial, and obturator nerves. Together these are known as the genicular nerves. When dividing the knee into four quadrants the genicular nerves are referred to as the superolateral, superomedial, inferolateral, and inferomedial genicular nerves. Though cadaveric studies demonstrate high variability in the exact location of the genicular nerves, good outcomes have been demonstrated when targeting the superomedial, inferomedial, and superolateral genicular nerves (Conger et al., Pain Med 22(Suppl 1):S20–S23, 2021). Due to the proximity of the inferolateral genicular nerve to the common peroneal nerve, the inferolateral quadrant is avoided due to risk of foot drop.

A genicular nerve block using local anesthetic can be used a test dose prior to pursuing genicular nerve radiofrequency ablation (RFA)—which can be expected

M. E. Farrell II (✉)
ECMC Center for Interventional Spine & Pain, Buffalo, NY, USA

B. Staub
Chronic Pain Division, University of Pittsburgh Medical Center, Pittsburgh, PA, USA

A. Varzari
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: varzaria@upmc.edu

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to provide roughly 3–6 months of relief. Genicular nerve RFA is ultimately a temporary solution as the genicular nerves can regenerate over time.
The genicular nerve block can be performed under fluoroscopic or ultrasound guidance with similar results in terms of pain relief and improvement in function (Kim et al., Pain Physician 22(2):139–146, 2019). Genicular nerve RFA is performed using fluoroscopy.

What You Will Need

- Sterile towels
- Chlorhexidine-based soap ×3
- Leg positioning wedge or pillows
- Marking pen
- Hemostat
- Ultrasound with linear transducer
- Sterile probe cover
- Sterile ultrasound gel
- 25G 3.5″ spinal needle ×3
- Bupivacaine 0.5%: 3 mL
- 18G 1.5″ needle to draw up medications
- 3 mL syringe for injectate (3 mL Bupivacaine)

Patient Positioning

- Semi-fowlers/reclined, knee elevated using positioning wedge and/or pillows

How to Perform the Procedure

1. Sterilely prep knee (from distal 1/2 of the thigh to proximal 1/2 of the lower leg) and drape with sterile towels.
2. Target superior lateral, superior medial, and inferior medial genicular nerves.
   - Superior lateral and medial genicular nerves—where the lateral and medial femoral shaft meets the epicondyle.
   - Inferior medial genicular nerve—where the medial tibial shaft meets the condyle.
   - Target needle position is approximately 1/2 the distance between the anterior and posterior borders of the femur or tibia.
3. To identify the needle insertion site for the superior medial genicular nerve, place the linear transducer of the ultrasound probe on the medial side of the distal thigh parallel to long axis of femur to identify the junction of distal femoral shaft and epicondyle (Image 30.1).

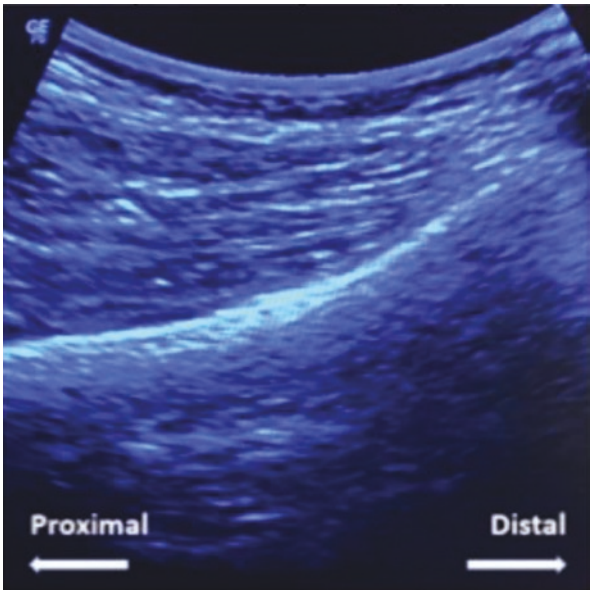

Image 30.1 Ultrasound image parallel to long axis of femur to identify femoral-epicondyle junction

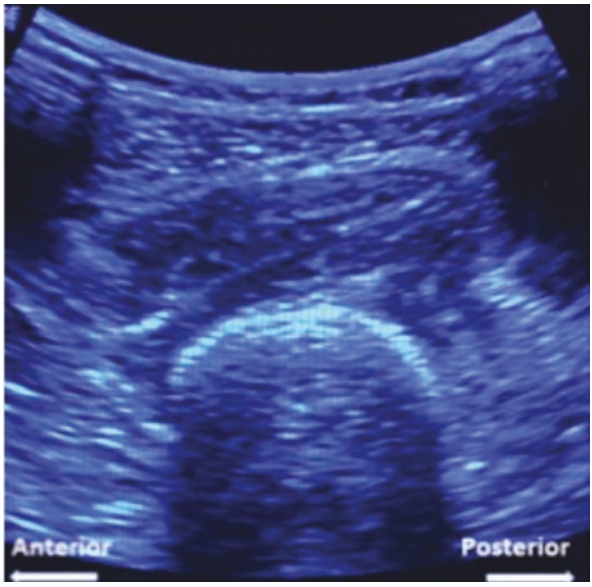

Image 30.2 Ultrasound image perpendicular to long axis of femur to identify center of femur

4. Rotate the ultrasound probe 90° so that it is perpendicular to the long axis of femur and center shaft of femur (Image 30.2).
5. Draw a line perpendicular to the ultrasound probe to mark the center of the femur between the anterior and posterior borders.

6. Rotate the ultrasound probe back parallel to the long axis of femur, along the line drawn in Step 5.
7. Center the most concave portion of the femoral epicondyle region on the screen.
8. Insert the 25G spinal needle and advance out-of-plane until bone is touched.
9. Administer 1 mL of Bupivacaine 0.5%.
10. Remove needle, clean site, and place adhesive dressings.
11. Repeat Steps 3–10 along the lateral side of the distal thigh for the superior lateral genicular nerve.
12. To identify the needle insertion site for the inferior medial genicular nerve, place the linear transducer of the ultrasound probe on the medial side of the proximal lower leg parallel to long axis of tibia to identify the junction of proximal tibial shaft and epicondyle (Image 30.3).
13. Rotate the ultrasound probe 90° so that it is perpendicular to the long axis of tibia and center shaft of tibia (Image 30.4).
14. Draw a line perpendicular to the ultrasound probe to mark the center of the tibia between the anterior and posterior borders.
15. Rotate the ultrasound probe back parallel to the long axis of tibia, along the line drawn in Step 5.
16. Center the most concave portion of the tibial epicondyle region.
17. Insert the 25G spinal needle and advance out-of-plane until bone is touched.
18. Administer 1 mL of Bupivacaine 0.5%.
19. Remove needle, clean site, and place adhesive dressings.

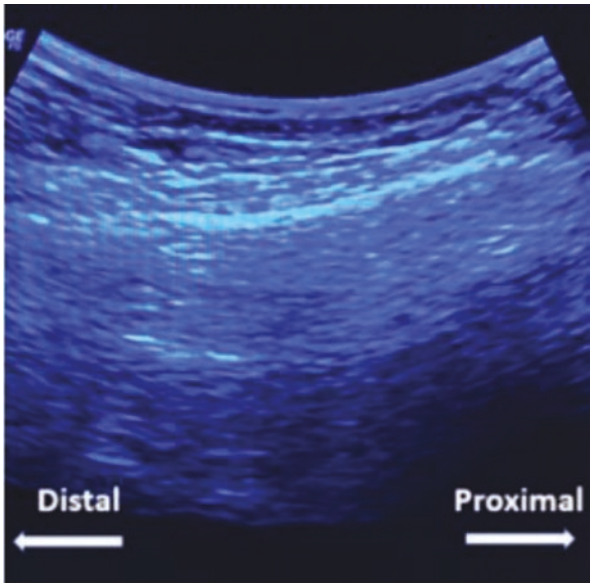

Image 30.3 Ultrasound image parallel to long axis of tibia to identify tibial shaft-condyle junction

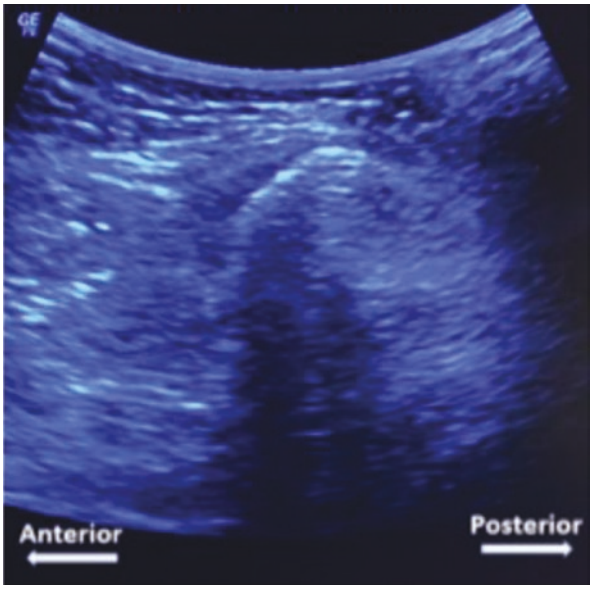

Image 30.4 Ultrasound image perpendicular to long axis of tibia to identify center of tibia

For Checkpoints to Mastery and more Pearls and Pitfalls regarding this procedure: See Chap. 29

- Due to the cross-sectional shape and the superficial location of the tibia it may be difficult to approximate the anterior–posterior midpoint with the ultrasound because the probe may not contact the entirety of the medial lower leg. In this case, it may be necessary to utilize fluoroscopy.

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Knee Genicular Nerve Radiofrequency Ablation (RFA)

31

Michael E. Farrell II, Brandon Staub, and Alexander Varzari

Abstract

Knee osteoarthritis is a progressive degenerative joint disease that can be challenging to treat. Conservative measures include acetaminophen and nonsteroidal anti-inflammatory medications, weight loss, and physical therapy. Intraarticular injections can be performed with corticosteroids, hyaluronic acid, or autologous blood-based therapies such as platelet enriched plasma and mesenchymal stem cells. When conservative treatments fail surgical treatment is often the definitive therapy which consists of total knee arthroplasty.

For patients who have failed conservative treatment, are not surgical candidates, or have pain after surgery, the genicular nerve blocks may be a promising option. The knee joint is innervated by sensory branches of the femoral, common peroneal, saphenous, tibial, and obturator nerves. Together these are known as the genicular nerves. When dividing the knee into four quadrants the genicular nerves are referred to as the superolateral, superomedial, inferolateral, and inferomedial genicular nerves. Though cadaveric studies demonstrate high variability in the exact location of the genicular nerves, good outcomes have been demonstrated when targeting the superomedial, inferomedial, and superolateral genicular nerves (Conger et al., Pain

M. E. Farrell II (✉)
ECMC Center for Interventional Spine & Pain, Buffalo, NY, USA

B. Staub
Chronic Pain Division, University of Pittsburgh Medical Center, Pittsburgh, PA, USA

A. Varzari
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: varzaria@upmc.edu

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https://doi.org/10.1007/978-3-031-40206-7_31

Med 22(Suppl 1):S20–S23, 2021). Due to the proximity of the inferolateral genicular nerve to the common peroneal nerve, the inferolateral quadrant is avoided due to risk of foot drop.

A genicular nerve block using local anesthetic can be used a test dose prior to pursuing genicular nerve radiofrequency ablation (RFA)—which can be expected to provide roughly 3–6 months of relief. Genicular nerve RFA is ultimately a temporary solution as the genicular nerves can regenerate over time.

The genicular nerve block can be performed under fluoroscopic or ultrasound guidance with similar results in terms of pain relief and improvement in function (Kim et al., Pain Physician 22(2):139–146, 2019). Genicular nerve RFA is performed using fluoroscopy.

Keys to Procedure

- Prior to the procedure, ensure patients with pacemaker/ICD are safe to undergo procedure.
- Identify genicular targets on the superomedial, superolateral, and inferomedial borders.
  - Know additional site at the suprapatellar region.
- Know the times and desired temperatures expected for both traditional and cooled RF.
- Understand the effects of anesthetic or other fluid injection on impedance and ablation.
- Know the signs and symptoms that will require abortion of the procedure.

Anatomy Pearls

See Chap. 29 Anatomy Pearls.

Radiofrequency Pearls

What is RF-Ablation:

- High-frequency alternating current (approximately 375–480 kHz) generates an electromagnetic field which induces oscillating movements of ions.

How is the nerve "lesioned"?

- Oscillation converts electromagnetic energy into heat by frictional or resistive energy loss to increase temperatures between 60 and 100 °C.

What are the types of radiofrequency systems used?

- Monopolar
  - The probe's electrode has a single active tip placed near the nerve.
  - The circuit is closed by a large conductive pad representing neutral electrode which is placed on the patient's skin (usually the calf).
- Bipolar
  - The probe uses two electrodes at the tip to create the circuit.
  - Can be within the same probe or use two probes to create circuit.

What You Will Need

- Sterile towels
- Chlorhexidine-based soap
- Leg positioning wedge or pillows
- Marking pen
- Hemostat
- Radiofrequency needle and probes ×3 or 4 if Suprapatellar burn
- 2% lidocaine: 3 ml
- 18 G 1.5″ needle to draw up medications
- 3 ml syringe for injectate (3 ml Bupivacaine)

Patient Positioning

- Semi-Fowlers/reclined, target knee elevated using positioning wedge and/or pillows
  - Leg must be elevated to ensure contralateral leg will not be superimposed on lateral X-rays.
  - Hips should be flat with as little hip rotation as possible to ensure that the femur is not rotated.

How to Perform the Procedure

1. Apply a grounding pad to the patient's calf and sterilely prep knee (from distal 1/2 of the thigh to proximal 1/2 of the lower leg) and drape with sterile towels.
2. Obtain AP view of the knee with the patella centered in the patellar trochlea to determine target needle locations:
   Identify targets on AP (Image 31.1):
   Superolateral, superomedial, and inferomedial genicular nerves (Additional target: suprapatellar)
   (a) Superolateral and superomedial genicular nerves
      Located where the lateral and medial femoral shaft meets the epicondyle
   (b) Inferomedial genicular nerve
      Located where the medial tibial shaft meets the condyle
   (c) Suprapatellar
      Located 1–2 cm above the patella and just lateral or medial to avoid the tendon.
3. Obtain a true lateral view of the knee where femoral condyles perfectly align to determine target needle locations:
   Identify targets on lateral:
   (a) The needle target is approximately 1/2 the distance between the anterior and posterior borders of the femur or tibia (Image 31.2).
4. To identify the needle insertion sites for the superomedial and superolateral genicular nerves, place an open hemostat over the width of the distal thigh and obtain an AP view.
   (a) Adjust the hemostat as needed until it is positioned over the most concave portions of the femoral where the diaphysis meets the metaphysis at the shaft–epicondyle junction.
5. Once the hemostat is in the correct position, draw a line on the skin along the hemostat from the medial to the lateral aspects of the thigh.
6. Obtain lateral view and ensure the femoral condyles are aligned.
7. Along the line drawn on the lateral thigh in Step 5, use the hemostat to identify and mark 1/2 the distance between the anterior and posterior borders of the femur.

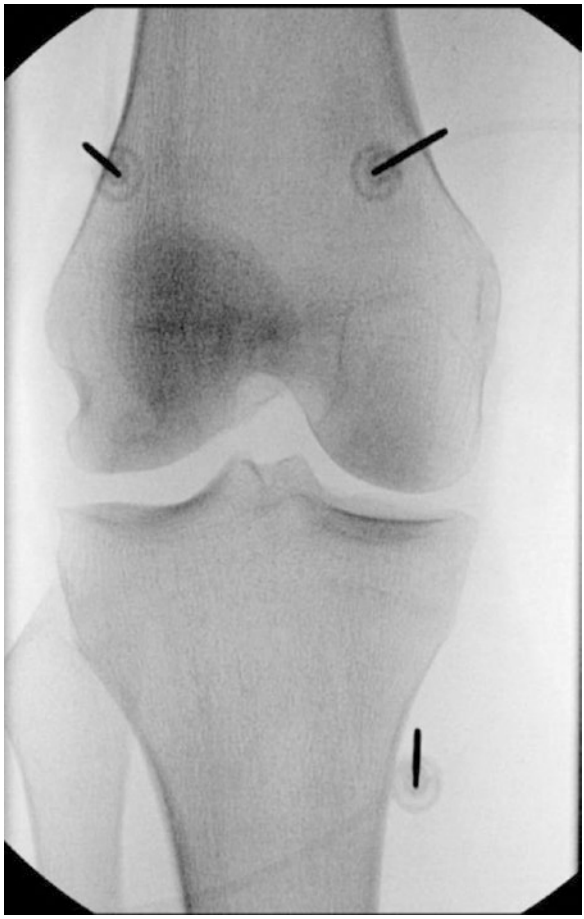

Image 31.1 AP of the knee with three needles in place for the primary genicular targets at the superomedial, superolateral, and inferomedial locations

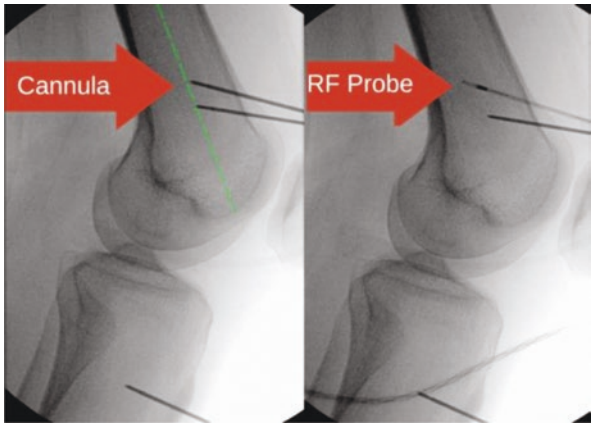

Image 31.2 Lateral X-ray of the knee with three probes at mid femur and mid tibia; also demonstrating difference in appearance of the cannula and RF probe in place

8. Anesthetize the skin (superficial tissues only) with Lidocaine 1% and insert the RFA cannula coaxial to the fluoroscopic beam.
   (a) Can use 18G 1.5" needle to puncture skin and make inserting the RFA cannula easier.
9. Advance the needle until you reach the bone at the midpoint between the anterior and posterior borders of the femur.
10. Repeat steps 7–9 along the line drawn on the medial thigh for the superomedial genicular nerve site.
11. Obtain AP view to ensure the needles have contacted the femur at the junction of the femoral shaft and lateral and medial epicondyles.
12. To identify the needle insertion sites for the inferior medial genicular nerve, place an open hemostat over the width of the proximal lower leg and obtain an AP view.
   (a) Adjust the hemostat as needed until it is positioned over the most concave portions of the tibial shaft–condyle junction.
13. Once the hemostat is in the correct position, draw a line along the hemostat on the medial aspects of the proximal lower leg.
14. Obtain lateral view and ensure the femoral condyles are aligned.
15. Along the line drawn on the medial proximal lower leg in Step 13, use the hemostat to identify and mark 1/2 the distance between the anterior and posterior borders of the tibia.
16. Anesthetize the skin with Lidocaine 1% and insert the RFA cannula coaxial to the fluoroscopic beam.
17. Advance the needle until you reach bone at the midpoint between the anterior and posterior borders of the tibia:
   (a) Check the depth of your cannula at maximum insertion to ensure >1.5 cm of tissue.
   (b) There must be >1.5 cm of tissue at this site to ensure that a superficial thermal/burn injury is not incurred.
18. Administer 1 ml of Lidocaine 2% to anesthetize each of the genicular nerves prior to ablation:
   (a) Ensure no needle movement with needle manipulation for local anesthetic administration prior to proceeding with ablation.
   (b) Impedance levels will typically decrease following administration of local anesthetic (goal less than 400–500 Ω).
   (c) Consider injection of additional fluid to impact lesion size.

19. Insert the RF probe into the cannula and ensure connection to the RF generator.
20. Ensure that the lesioning parameters are stable by evaluating impedance and temperature readings from the probe.
21. Perform both sensory and motor testing per your generators protocol at each site prior to lesioning
    (a) Monitor for radiation of pain down to the foot on sensory testing and muscle contraction on motor testing; if present return to Step 7 and recheck needle positioning.
22. Commence thermal ablation at 80 °C for 90 s (or 60 °C for 150 s if cooled RF) at each genicular nerve site.
    (a) Advise patient that initial 10–20 s typically most painful as the probe heats up.
    (b) Temperature should ramp up to 80 °C, or 60 °C, and then plateau.
    (c) Pause ablation if pain not tolerable or pain radiating down the leg and verify location of probes by returning to step 7 above.
23. Remove needles, clean site, and place an adhesive dressing.

Beginner

- Ensure proper patient and c-arm positioning to obtain true AP and lateral images.
- Identify the three main nerve targets on AP images (Image 31.1).
- Identify the needle depth target on the femur and tibia on lateral images (Image 31.2).
- Discuss the basic principles of monopolar vs bipolar RF.

Intermediate

- Fluoro: Use a hemostat and skin marker prep the patient to triangulate your targets.
- Fluoro: Drive the needle to the targets by keeping needle coaxial and on target.
- Identify the benefits injecting before lesioning in terms of impedance and lesion size.

Advanced

- Insert the RF probe and analyze the RF generator for signs of stability before lesioning.

- Know the target temperatures and durations of lesioning for traditional and cooled RF.
- Understand the warning signs that would necessitate stopping the procedure.

Pitt Pain Pearls and Pitfalls

- See Chap. 29 Anatomy Pearls.
  - Studies from Provenzano et al. have demonstrated that injection of a solution prior to RF lesioning has been shown to create a larger lesion size. In these studies 0.7 cc of 0.9% sodium chloride, 1% lidocaine, or 6% hydroxyethyl starch were shown to increase lesion size compared to controls and sterile water in ex vivo chicken samples [3].

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Hip Intra-articular Injection

32

Michael Glicksman, Neeraj Sriram, and Alexander Varzari

Abstract

Osteoarthritis is a common, debilitating progressive disease that commonly affects the hips (Choueiri M, Chevalier X, Eymard F. Intraarticular Corticosteroids for Hip Osteoarthritis: A Review. Cartilage. 2021 Dec;13(1_suppl):122S-131S). Progression of osteoarthritis often results in the need for total arthroplasty of the hip. First-line treatments include oral acetaminophen and nonsteroidal anti-inflammatory drugs. Intra-articular corticosteroid injections are routinely performed for patients with refractory pain or dysfunction, or for those with contraindications to long-term systemic treatment with acetaminophen or nonsteroidal anti-inflammatories. The goal in managing osteoarthritis with intra-articular corticosteroid injections is to provide pain relief, improvement in function, and to delay the need for arthroplasty. This is thought to be achieved via decreasing the inflammation in the joint by the corticosteroids (Choueiri M, Chevalier X, Eymard F. Intraarticular Corticosteroids for Hip Osteoarthritis: A Review. Cartilage. 2021 Dec;13(1_suppl):122S-131S).

Evidence suggests that intra-articular injections can be helpful to relieve pain and improve function in the short term, however the long-term safety and effects on the progression of osteoarthritis are unclear (Choueiri M, Chevalier X, Eymard F. Intraarticular Corticosteroids for Hip Osteoarthritis: A Review. Cartilage. 2021 Dec;13(1_suppl):122S-131S). A growing body of evidence has suggested accelerated rates of osteoarthritis progression, whereas other studies find no significant difference in progression of joint destruction (Zeng et al.,

M. Glicksman (✉) · A. Varzari
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: glicksmanm@upmc.edu; varzaria@upmc.edu

N. Sriram
Palmetto Pain Management, Columbia, SC, USA

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Osteoarthritis Cartilage 27(6):855–62, 2019). Intra-articular corticosteroid injections remain one of the most common treatments for osteoarthritis of the hip, and it is important for the treating pain physician to weigh the risks and benefits with each patient.

Keys to Procedure

- Understand the relevant hip anatomy on AP view.
- Understand the complications and corrective steps if encountered.

Anatomy Pearls

- The femoral nerve, femoral artery, and femoral vein (lateral to medial) lie anterior to the medial aspect of the hip joint.
  - The femoral artery branches posterolaterally to give rise to the deep femoral artery, which then gives rise to both the medial femoral circumflex artery (MFCA) and lateral femoral circumflex artery (LFCA) [1].
- The MFCA provides most of the blood supply to the femoral neck and courses medially to the hip joint.
- The LFCA gives off multiple branches, including an ascending branch that courses along the anterior intertrochanteric line and femoral neck before anastomosing with the MCFA to contribute to the blood supply of the femoral neck [1].
- Slightly below the inguinal ligament (~4 cm), the femoral nerve divides into anterior and posterior divisions, which gives rise to several terminal branches that serve motor and sensory functions [2].

What You Will Need

- Sterile towels
- Chlorhexidine-based soap
- 22 G 5″ spinal needle
- Lidocaine 1% for skin: 3 ml
- Isovue 300: 3 ml (if fluoroscopy is used)
- Bupivacaine 0.25%: 4 ml
- Dexamethasone 10 mg: 1 ml
- 25 G 1.5″ needle for skin local
- 18 G 1.5″ needle to draw up medications
- Extension tubing (3″) for contrast (if fluoroscopy is used)
- 3 ml syringe with 25 G 1.5″ needle for skin local
- 3 ml syringe with tubing for contrast
- 5 ml syringe for injectate (4 ml Bupivacaine 0.25% + Dexamethasone 10 mg)

Patient Positioning

- Supine with the hip in a neutral position and groin exposed.

How to Perform the Procedure

1. Place the patient in a supine position
2. Sterilely prep the hip and groin and drape with sterile towels
3. Set-up the trajectory view by placing the C-arm over the target hip joint and tilt the C-arm both caudally and oblique medially (or laterally). If ultrasound is used, use a curvilinear probe to identify the neck of the femur in a longitudinal (long-axis) view
4. The target of the needle tip is the midline of the anterior femoral head-neck junction

5. After identifying the initial target, anesthetize the skin with Lidocaine 1% and insert a 22 G spinal needle
6. Penetrate the joint capsule by advancing the needle from lateral to medial toward the junction between the femoral head and femoral neck (in-plane approach if ultrasound is used), until the needle tip contacts bone (Image 32.1)

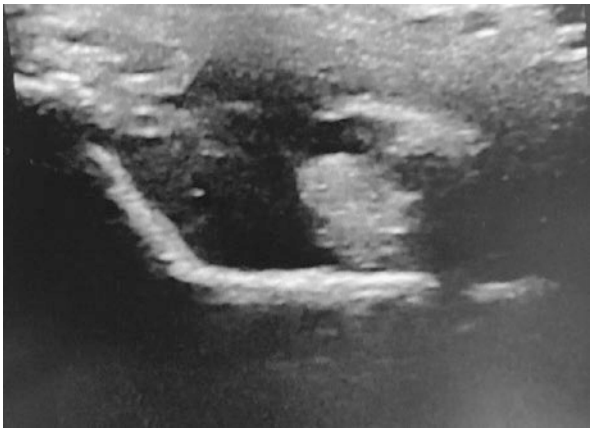

Image 32.1 Ultrasound view of femoral neck and shaft of femur

7. Slightly withdraw the needle to avoid injection into the posterior aspect of the capsule
8. Administer 1 ml of contrast to ensure appropriate contrast spread (if using fluoroscopy) within the joint space and note the contrast flowing around the femoral neck
9. Aspirate and administer injectate (4 ml Bupivacaine 0.25% + Dexamethasone 10 mg)
10. Remove needle, clean site, and place adhesive dressing

Checkpoints to Mastery

Beginner

- Understand the anatomy of the hip joint, particularly its relationship to the nearby neurovascular structures.
- Be able to identify the location of appropriate needle placement to target the anterior femoral head–neck junction.

Intermediate

- Insert and advance the needle until bone is hit, taking extra caution to avoid any nearby neurovascular structures.

Advanced

- Confirm correct needle placement with contrast, ensuring that there is no vascular flow.

Pitt Pain Pearls and Pitfalls

- Take extra caution to avoid the medial aspect of the joint, where the neurovascular structures lie.
- Care should be taken to insert the needle inferior to the inguinal crease to ensure correct entry into the proximal thigh and to avoid incorrect entry into the abdomen [3].
- Encountering resistance when attempting to inject contrast after touching bone with the needle tip may indicate that the bevel is in the periosteum or the hip capsule. This can be corrected by withdrawing the needle slightly and reattempting to inject contrast [3].

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Further Reading

Atlas of image-guided spinal procedures. Second Edition. Furman.

Hip Diagnostic Nerve Blocks: Femoral and Obturator Articular Branches

33

Tetyana Marshall and Neeraj Sriram

Abstract

The hip joint is innervated by branches of the femoral, obturator, and sciatic nerves (Birnbaum et al., Surg Radiol Anat 19(6):371–375, 1997). Local anesthetic blockade and ablation of these nerves has been used as intervention for hip joint pain that has failed conservative measures (Tinnirello et al., Pain Physician 21(4):407–414, 2018). The anterior innervation of the hip joint is provided by the femoral and obturator nerves, and the articular branches of these nerves can be easily accessed for local anesthetic blockade and ablation (Tinnirello et al., Pain Physician 21(4):407–414, 2018). Targeting the articular nerves as opposed to the parent trunk nerves is important to avoid unwanted sensory and motor loss (Locher et al., Pain Med 9(3):291–298, 2008). The posterior innervation of the hip joint is provided by the sciatic nerve and its articular branches are not easily accessible and hence are not frequently used for blockade or ablation (Tinnirello et al., Pain Physician 21(4):407–414, 2018). Intervention typically begins with trials of local anesthetic blockade as a form of diagnostic testing. Significant reduction of hip pain after two blocks provides a positive diagnostic test for likely positive response to ablation, which is used for longer pain relief (Tinnirello et al., Pain Phys 21(4):407–414, 2018). This treatment is beneficial for patients who are not surgical candidates or those who are awaiting hip joint replacement. Side effects can include neuritis, permanent nerve damage, loss of hip sensation, hematoma, and neuroma formation (Tinnirello et al., Pain Physician 21(4):407–414, 2018; Chye et al., Clin Interv Aging 10:569–574, 2015; Wu and

T. Marshall (✉)
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: osadchukt@upmc.edu

N. Sriram
Palmetto Pain Management, Columbia, SC, USA

T. Emerick et al. (eds.), *The Pain Procedure Handbook*,
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Groner, Pain Pract 7(4):341–344, 2007). Contraindications are similar to those of any local anesthetic blockade such as skin infection at the site of injection, bacteremia, anticoagulation, and patient refusal.

Keys to Procedure
- Identify relevant anatomy under fluoroscopic and ultrasound imaging to identify targets.
- Understand the nerve innervation of the hip capsule.

Anatomy Pearls

Innervation of the hip joint:

- Femoral lateral branch: located at 12'o clock position on the superior acetabulum (hollow circle)
- Obturator lateral branch: located at the incisura acetabuli (filled circle)

What You Will Need

- Sterile towels
- Chlorhexidine-based soap
- 22 G 5″ spinal needle ×2 (place slight bend at tip of needle for better steering of needle)
- Lidocaine 1% for skin: 5 ml
- Isovue 300: 3 ml
- Bupivacaine 0.5%: 3 ml
- 25 G 1.5″ needle for skin local
- 18 G 1.5″ needle to draw up medications
- Extension tubing (3″) for contrast
- 5 ml syringe with 25 G 1.5″ needle for Lidocaine
- 3 ml syringe with tubing for contrast
- 3 ml syringe for injectate (3ml Bupivacaine)

Patient Positioning

- Supine with hip, inguinal region, and medial thigh exposed

Pitt Pain Pearls and Pitfalls
- The obturator articular lateral branches lie deep to important neurovascular structures (femoral nerve, artery, and vein). It is highly recommended to use ultrasound to first locate the femoral neurovascular structures prior to needle

advancement to ensure the needle is below these important structures. Consider also tracing the femoral vasculature with a sterile marking pen on the patient.

How to Perform the Procedure

1. Sterilely prep the hip and groin and drape with sterile towels
2. Place ultrasound at the inguinal area to locate the femoral neurovascular structures and mark the borders of the femoral nerve, artery, and vein.
3. Obtain an AP view of the pelvis to ensure both obturator foramens look the same.
4. Center the femoral head of the ipsilateral hip.

Identify targets of femoral articular branch and obturator articular branch

   (a) Femoral articular branch: 12 o'clock position on the superior acetabulum
   (b) Obturator articular branch: teardrop shape at the junction of the inferolateral pubic ramus and the ischium

5. To target the femoral articular branch, anesthetize the skin lateral to the femoral nerve and artery with Lidocaine 1%

6. Insert the 22 G spinal needle and advance until the needle touches bone at the 12 o'clock position on the superior acetabulum
7. Administer 1 ml of contrast to ensure appropriate contrast spread and anatomical coverage
8. Aspirate and administer 1 ml of Bupivacaine 0.5%
9. To target the obturator articular branch, anesthetize the skin medial to the medial to the femoral vein with Lidocaine 1%

10. Insert the 22 G spinal needle and advance until the needle touches bone at the teardrop shape at the junction of the inferolateral pubic ramus and the ischium. Can use ultrasound while advancing needle to avoid the femoral neurovascular structures
11. Administer 1ml of contrast to ensure appropriate contrast spread and anatomical coverage
12. Aspirate and administer 1 mL of Bupivacaine 0.5%
13. Remove needles, clean the site, and place an adhesive dressing

Checkpoints to Mastery

Beginner

- Know the two major nerves that provide innervation of the hip joint.
- Identify anatomic targets of femoral and obturator articular branches on AP images.
- Perform ultrasound to femoral triangle to identify neurovascular structures.

Intermediate

- Anesthetize skin and insert spinal needles coaxially over the intended target for femoral branch.
- Advance needle until it touches down on bone at 12 o'clock position.
- Identify non-vascular contrast flow pattern and administer injectate.

Advanced

- Using ultrasound identify neurovascular structures.
- Advance needle under ultrasound guidance under neurovascular structures.
- Touch down on bone at the incisura acetabuli.
- Identify non-vascular contrast flow pattern and administer injectate.

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Further Reading

Avanos Hip Articular Branch Cooled RF Guide.

Hip Radiofrequency Ablation (RFA): Femoral and Obturator Branches

34

Tetyana Marshall and Neeraj Sriram

Abstract

The hip joint is innervated by branches of the femoral, obturator, and sciatic nerves (Birnbaum et al., Surg Radiol Anat 19(6):371–375, 1997). Local anesthetic blockade and ablation of these nerves has been used as intervention for hip joint pain that has failed conservative measures (Tinnirello et al., Pain Physician 21(4):407–414, 2018). The anterior innervation of the hip joint is provided by the femoral and obturator nerves, and the articular branches of these nerves can be easily accessed for local anesthetic blockade and ablation (Tinnirello et al., Pain Physician 21(4):407–414, 2018). Targeting the articular nerves as opposed to the parent trunk nerves is important to avoid unwanted sensory and motor loss (Locher et al., Pain Med 9(3):291–298, 2008). The posterior innervation of the hip joint is provided by the sciatic nerve and its articular branches are not easily accessible and hence are not frequently used for blockade or ablation (Tinnirello et al., Pain Physician 21(4):407–414, 2018). Intervention typically begins with trials of local anesthetic blockade as a form of diagnostic testing. Significant reduction of hip pain after two blocks provides a positive diagnostic test for likely positive response to ablation, which is used for longer pain relief (Tinnirello et al., Pain Phys 21(4):407–414, 2018). This treatment is beneficial for patients who are not surgical candidates or those who are awaiting hip joint replacement. Side effects can include neuritis, permanent nerve damage, loss of hip sensation, hematoma, and neuroma formation (Tinnirello et al., Pain Physician 21(4):407–414, 2018; Chye et al., Clin Interv Aging 10:569–574, 2015; Wu and

T. Marshall (✉)
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: osadchukt@upmc.edu

N. Sriram
Palmetto Pain Management, Columbia, SC, USA

T. Emerick et al. (eds.), *The Pain Procedure Handbook*,
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Groner, Pain Pract 7(4):341–344, 2007). Contraindications are similar to those of any local anesthetic blockade such as skin infection at the site of injection, bacteremia, anticoagulation, and patient refusal.

Keys to the Procedure
- Understand the anatomic targets of the femoral and obturator articular branches.
- Understand the locations for lesioning of the obturator articular branch.
- Assure safe needle insertion using ultrasound for the obturator articular branch.
- Be aware of steps needed for emergent management of femoral artery puncture.

Anatomy Pearls

Remember the targets for hip innervation:

- Femoral articular branch
  - One lesion at the 12 o'clock position of the superior acetabulum
- Obturator articular branch
  - Two locations: One at the incisura acetabuli and one 1 cm inferior to incisura acetabuli

What You Will Need

- Sterile towels
- Chlorhexidine-based soap
- RFA Generator that displays impedance, voltage, amperage, and temperature
- Electrode grounding pad (connected to RFA Generator)
- RFA cannula with stylet ×2
- Lidocaine 1% for skin: 5 ml
- Lidocaine 2%: 3 ml
- 25 G 1.5″ needle for skin local
- 18 G 1.5″ needle to draw up medications
- 5 ml syringe with 25 G 1.5″ needle for skin local
- 3 ml syringe for Lidocaine 2%

Patient Positioning

Supine with hip, inguinal region, and medial thigh exposed.

Pearls and Pitfalls
- Major targets of hip innervation lie deep to important neurovascular structures (femoral nerve, artery, and vein). Use ultrasound to locate, verify, and map out the femoral neurovascular structures.

- It is essential to avoid femoral artery puncture. If femoral artery is punctured, additional instructions and delayed discharge need to be considered to avoid serious sequalae.
- Emergent management of inadvertent femoral artery puncture.

How to Perform the Procedure

1. Sterilely prep the hip and groin and drape with sterile towels.
2. Place ultrasound at the inguinal area to locate the femoral neurovascular structures and mark the borders of the femoral nerve, artery, and vein.
3. Obtain a true AP view of the pelvis.
4. Move the C-arm to center the femoral head of the ipsilateral hip.
   (a) Identify target of the femoral articular branch and obturator articular branch
      Femoral articular branch: 12 o'clock position on the superior acetabulum
      Obturator articular branch: teardrop shape at the junction of the inferolateral pubic ramus and the ischium
5. To target the femoral articular branch, anesthetize the skin lateral to the lateral aspect of femoral nerve and artery markings with Lidocaine 1%.

6. Insert the RFA cannula with stylet and advance until the needle touches bone at the 12 o'clock position on the superior acetabulum.
7. After appropriate needle placement on the femoral articular branch, remove the stylet and insert the thermal unit into the RFA cannula.
8. Assess impedance and perform sensory stimulation (if desired)
   (a) Patient should feel paresthesia only in their hip with 0.3–0.7 V at 50 Hz.
9. Perform motor stimulation
   (a) Ensure no muscle contractions in the leg elicited with 2 V at 2 Hz.
10. Administer 1 ml Lidocaine 2% to anesthetize the femoral articular branch prior to ablation
    (a) Ensure no needle movement with needle manipulation for local anesthetic administration prior to proceeding with ablation.
    (b) Impedance levels will typically decrease following administration of local anesthetic (goal less than 300–500 Ω).
11. Commence thermal ablation at 80 °C for 90 s (or 60 °C for 150 s if cooled RF)
    (a) Initial 10–20 s typically most painful as probe heats up.
    (b) Pause ablation if pain not tolerable or radiating down leg and verify location of probes.

12. Remove needle, clean site, and place adhesive dressing.
13. To target the obturator articular branch, the needle entry point is at inferior aspect of the pubic ramus relative to the 6 o'clock position of the target on the incisura acetabuli.
14. Anesthetize the skin with Lidocaine 1%.
15. Insert the RFA cannula under ultrasound guidance with stylet and maintain intermittent contact with the anterior ischial surface while advancing until the needle touches bone at the teardrop shape at the junction of the inferolateral pubic ramus and the ischium.
    (a) Use ultrasound while advancing needle to avoid the femoral neurovascular structures until the needle tip is deep to the femoral neurovascular sheath.
16. After appropriate needle placement on the incisura acetabuli confirmed by fluoroscopic images, remove the stylet and insert the thermal unit into the RFA cannula.
17. Assess impedance and perform sensory stimulation (if desired).
18. Perform motor stimulation testing (2 V, 2 Hz).
19. Administer 1 ml Lidocaine 2% to anesthetize the femoral articular branch prior to ablation.
20. Commence thermal ablation at 80 °C for 90 s (or 60 °C for 150 s if cooled RF).
21. Prior to removing the needle, reposition the RFA cannula 1 cm inferior to incisura acetabuli for repeat ablation.
22. Repeat thermal ablation at 80 °C for 90 s (or 60 °C for 150 s if cooled RF).
23. Remove needle, clean site, and place adhesive dressing.

Checkpoints to Mastery

Beginner

- Adjust the C-Arm to obtain a true AP image of the hip with both obturator foramens looking the same.
- Identify the targets of the femoral and obturator articular branches on AP imaging.

Intermediate

- Insert RF cannula using fluoroscopic guidance to 12 o'clock position of superior acetabulum.

- Assess impedance, perform motor stimulation—correctly identify muscles to observe.
- Perform ablation using the correct machine parameters.

Advanced

- Utilize ultrasound and fluoroscopic guidance to advance RF cannula to the incisura acetabuli while avoiding neurovascular structures.
- Reposition RF cannula for second lesion location.

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Further Reading

Avanos Hip Articular Branch Cooled RF Guide.

Greater Trochanteric Bursa Injection with Ultrasound

35

Isaiah Levy and Alexander Varzari

Abstract

Greater trochanteric pain syndrome encompasses several syndromes related to lateral hip and buttock pain. Causes include gluteus minimus and/or medius tendinitis at the insertion site on the greater trochanter, iliotibial band pain, or bursitis. Pain upon palpation of the greater trochanter helps differentiate these pain generators from primary hip pathologies that cause pain that radiates toward the groin (Le and Shah, StatPearls. StatPearls Publishing, Treasure Island, 2022).

Trochanteric bursitis can be caused by injury, overuse, or inflammation due to tendinopathy of the gluteus medius or minimus tendons. Conservative treatments include physical therapy, acetaminophen, and nonsteroidal anti-inflammatories. Greater trochanteric bursa injections are offered as an alternative treatment to patients who have failed conservative therapy or for whom the disease is particularly disabling. Greater trochanteric bursa injections have been successfully performed using anatomical landmarks and fluoroscopy; however, this chapter will highlight the ultrasound-guided approach due to its safety and accuracy.

Greater trochanteric bursa injections are safe and complications are rare but can include septic arthritis, bleeding, allergic reaction, focal fat necrosis, and intra-tendon injection (Reid, J Orthop 13(1):15–28, 2016).

Keys to Procedure

- Understand the relevant greater trochanter anatomy on short and long axis view.
- Understand how to optimize imaging utilizing ultrasound positioning and knobology.
- Understand the complications and corrective steps if encountered.

I. Levy (✉) · A. Varzari
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: levyir2@upmc.edu; varzaria@upmc.edu

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Anatomy Pearls

- The deep greater trochanteric bursa lies between the greater trochanter and the tendon of the gluteus medius and the iliotibial band. The superficial greater trochanteric bursa lies above the gluteus medius and under the traversing gluteal maximus/iliotibial band.
- The gluteus minimus attaches to the anterior aspect of the greater trochanter.
- The gluteus medius attaches to the lateral surface of the greater trochanter.
- The gluteus maximus converges with the tensor fascia lata to form the iliotibial band which traverses over the gluteus medius and greater trochanter.

What You Will Need

- Sterile towels
- Chlorhexidine-based soap
- 22 G 1.5″ needle
- Lidocaine 1% for skin: 5 ml
- Bupivacaine 0.25%: 4 ml
- Dexamethasone 10 mg: 1 ml
- 25 G 1.5″ needle for skin local
- 18 G 1.5″ needle to draw up medications
- 5 ml syringe with 22 G 1.5″ needle for skin local
- 5 ml syringe for injectate (4 ml Bupivacaine + 1 ml Dexamethasone 10 mg)

Patient Positioning

- Placed side lying on the unaffected hip in a modified Sims position.

How to Perform the Procedure

1. First identify the greater trochanter of the hip via palpation. Anatomy is outlined in Image 35.1.
2. Sterilely prep and drape with sterile towels.
3. Place linear high-frequency ultrasound transducer over the greater trochanter with probe placed in an anterior–posterior orientation (Image 35.2 and 35.3).
4. Identify the greater trochanter under ultrasound which will have a pyramidal shape. Identify the gluteus minimus inserting along the anterior aspect, the gluteus medius inserting along the lateral aspect, and the traversing gluteus maximus/tensor fascia lata musculature. Identifiy inflamed bursa (either deep or superficial). Vertification of anatomy can be done with passive abduction of the patient's hip with the greater trochanter under ultrasound to visualize movement of the gluteal minimus/medius under the traversing gluteus maximus/tensor fascia lata musculature.

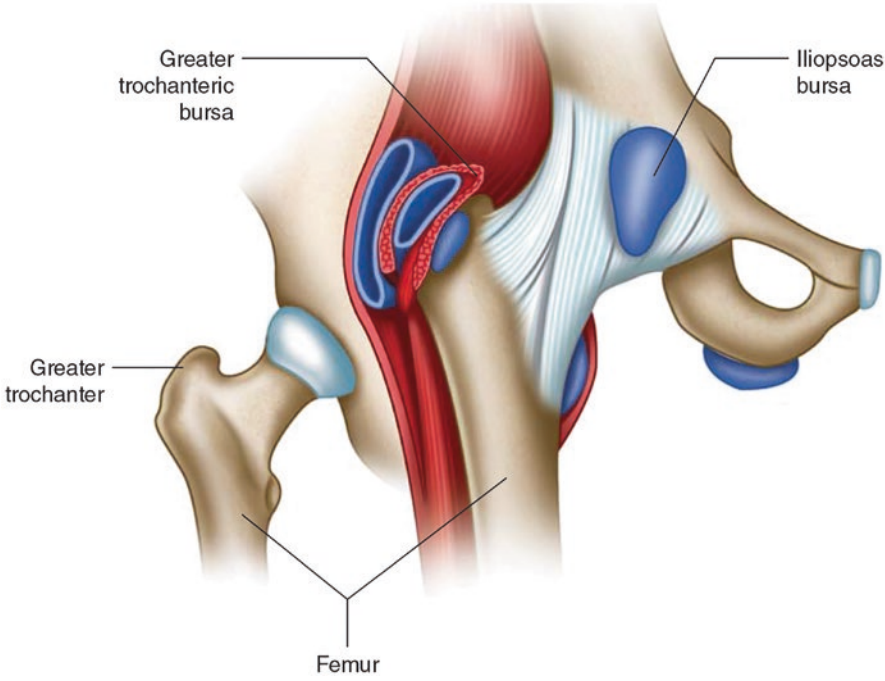


Image 35.1 Anatomy of greater trochanteric bursa

Image 35.2 Anterior-posterior greater trochanteric bursa with iliotibial band ultrasound view (unlabeled)

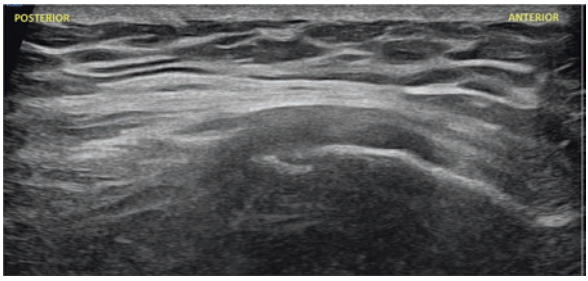
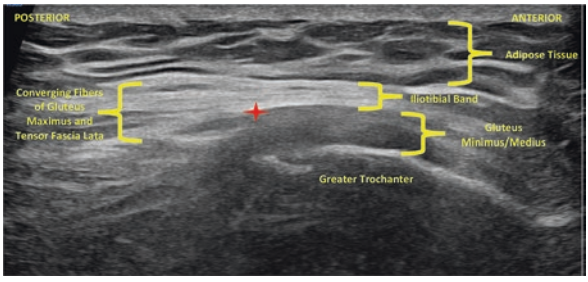


Image 35.3 Anterior-posterior greater trochanteric bursa with iliotibial band ultrasound view (anatomy labeled). Red cross indicates needle tip target at superficial greater trochanteric bursa



5. Place the needle through the skin ~1 cm from the anterior end of the transducer and advance using an in-plane approach, passing through the gluteus maximus and into the bursa.

6. Confirm appropriate needle placement by injecting a small amount of local anesthetic to visualize flow within the bursa.
7. After confirmation of positioning, the remainder of the contents of the syringe are slowly injected.
   (a) There should be minimal resistance to injection.

Checkpoints to Mastery

Beginner

- Familiarize knobology of ultrasound probe including adjustment of image depth, gain, and utilization of Doppler.
- Consistently distinguish muscle, tendons, vasculature, and neural anatomy.
- Place ultrasound probe on the greater trochanter. Identify the gluteus minimus, medius, and maximus.

Intermediate

- Maintain ultrasound probe in optimized position as needle is advanced in plane to US probe.
- Utilize Doppler imaging to verify that there are no blood vessels in path of needle.

Advanced

- Visualize needle tip in the greater trochanteric bursa.
- Visualize injectate entering the greater trochanteric bursa.

Pitt Pain Pearls and Pitfalls

- True greater trochanteric bursitis is generally rare. Greater trochanteric pain syndrome is more often related to gluteal tendinopathy.
- Avoid injecting steroid direction into the gluteal tendons due to risk of tendon rupture. Upon injection, visualize injectate flowing in between muscle planes.
- Utilize post-injection compression and icing to minimize immediate post injection discomfort or swelling.

References

1. Le DT, Shah S. Greater trochanteric bursitis injection. In: StatPearls. Treasure Island: StatPearls Publishing; 2022.
2. Reid D. The management of greater trochanteric pain syndrome: a systematic literature review. J Orthop. 2016;13(1):15–28. https://doi.org/10.1016/j.jor.2015.12.006.

Further Reading

Ultrasound-Guided Intra-articular Injection Technique for Gluteus Medius Bursitis, Comprehensive Atlas of Ultrasound-Guided Pain Management Injection Techniques, 2nd Edition, Waldman.

Glenohumeral Joint Injection Under Ultrasound

36

Isaiah Levy and Alexander Varzari

Abstract

Glenohumeral joint injections are used to treat shoulder conditions such as subacromial bursitis, rotator cuff pathology, impingement, and adhesive capsulitis. They can also be used as diagnostic nerve blocks to differentiate between several types of pain generators in the shoulder. Though they have been successfully performed using anatomical landmarks and fluoroscopy, ultrasound is used more and more due to its real-time visualization, lack of radiation exposure, and near 100% accuracy when used to inject into the glenohumeral joint (Ogul et al., Clin Imaging 38(1):11–17, 2014; Zwar et al., AJR Am J Roentgenol 183(1):48–50, 2004). The injection can be performed via the anterior rotator interval or posterior approach. The posterior approach is preferred and will be described below as it is easier to perform, has decreased rates of extravasation, and avoids risking puncture of the axillary neurovascular structures (Ogul et al., Clin Imaging 38(1):11–17, 2014).

Complications of glenohumeral joint injections include septic arthritis, hemarthrosis, or inadvertent puncture of the labrum, long head of the biceps, articular cartilage, and surrounding neurovascular structures.

Keys to Procedure

- Understand the relevant anatomy of the glenohumeral joint.
- Understand how to optimize imaging utilizing ultrasound positioning and knobology.
- Understand the complications and corrective steps if encountered.

I. Levy (✉) · A. Varzari
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: levyir2@upmc.edu; varzaria@upmc.edu

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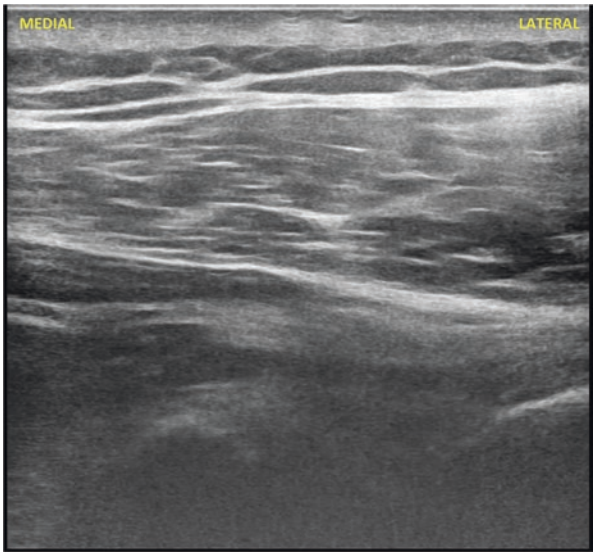

Image 36.1 Medial-lateral glenohumeral joint ultrasound view (unlabeled).

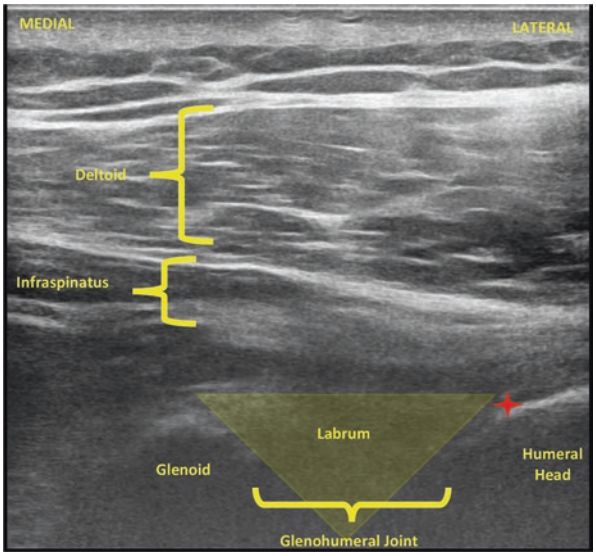

Image 36.2 Medial-lateral glenohumeral joint ultrasound view (anatomy labeled). Red cross indicates needle tip target lateral to labrum and superficial to humeral head

Anatomy Pearls

- The glenohumeral joint is stabilized by a surrounding capsule, ligaments, and the surrounding musculature of the supraspinatus, infraspinatus teres minor, and subscapularis musculature of the rotator cuff.
- The glenoid labrum is a fibrocartilaginous layer which surrounds the glenoid fossa.
- The glenohumeral joint can be approached anteriorly, posteriorly, or via the rotator cuff interval (bordered anteriorly by the subscapularis tendon, posteriorly by the supraspinatus tendon, and medially by the coracoid process).
- Posterior approach preferred due to less extravasation in comparison to other approaches.

What You Will Need

- Sterile towels
- Chlorhexidine-based soap
- 22 G 1.5″ needle
- Lidocaine 1% for skin: 5 ml
- Bupivacaine 0.25%: 2 ml
- Methylprednisolone 40 mg or Dexamethasone 10 mg: 1 ml
- 25 G 1.5″ needle for skin local
- 18 G 1.5″ needle to draw up medications
- 5 ml syringe with 22 G 1.5″ needle for skin local
- 5 ml syringe for injectate (4 ml Bupivacaine + 1 ml Dexamethasone 10 mg)

Patient Positioning

- Placed side lying on the unaffected shoulder

How to Perform the Procedure

1. Sterilely prep and drape with sterile towels.
2. Place linear high-frequency ultrasound transducer over the scapular spine and angled toward the scapula. Identify the superficial deltoid and deeper infraspinatus musculature.
3. Follow the infraspinatus muscle laterally with the scapular spine visualized deep to it until able to visualize the glenoid.
4. Identify the humeral head. Identify the triangular shaped labrum. Identify the glenohumeral joint between the glenoid and the humerus. The GH joint should appear as a hypoechoic space though inflammation and may make joint appear anechoic. The joint space communicates superficial to the medial humeral head.
   (a) Oblique approach shoulder avoids accidental puncture of the suprascapular neurovascular structures.

5. After the joint space is identified, the needle is placed through the skin ~1 cm lateral to the end of the transducer and is then advanced through the infraspinatus muscle using an in-plane approach to enter the glenohumeral joint lateral to the labrum and superficial to the cartilage of the humeral head.
   (a) While advancing, needle may be deflected off course. Keep the bevel of the needle facing upward during needle advancement to prevent deflection.

6. When the tip of needle is thought to be within the joint space, a small amount of local anesthetic is injected under real-time ultrasound guidance to confirm intra-articular placement by the characteristic spreading swirl of hyperechoic injectate within the joint.
7. After intra-articular needle tip placement is confirmed, the remainder of the contents of the syringe are slowly injected.
   (a) There should be minimal resistance to injection.
8. Withdraw needle, clean area, and apply bandage.

Checkpoints to Mastery

Beginner

- Familiarize oneself with settings of ultrasound and probe including adjustment of image depth, gain, and utilization of doppler.
- Consistently distinguish muscle, tendons, vasculature, and neural anatomy.
- Place ultrasound probe on the scapular spine and identify the deltoid, infraspinatus, glenoid, humerus, labrum, and the glenohumeral joint.

Intermediate

- Maintain ultrasound probe in optimized position as needle is advanced in plane to US probe.
- Utilize Doppler imaging to verify that there are no blood vessels in path of needle.

Advanced

- Visualize needle tip just lateral to the labrum. Avoid piercing the labrum.
- Visualize injectate entering the glenohumeral joint.

Pitt Pain Pearls and Pitfalls

- While one can access the glenohumeral joint via anterior approach just lateral to the acromion process or via the rotator cuff interval, the posterior approach has a lower chance of extravasation [1].
- Avoid injection of steroid directly into the supraspinatus tendon due to risk of tendon rupture. Upon injection, visualize injectate flowing into the glenohumeral joint.
- Avoid piercing the labrum via the posterior approach. Visualize the needle tip lateral just lateral to the labrum and watch injectate flow into the glenohumeral joint.
- The teres minor muscle is located inferior to the infraspinatus muscle and must not be mistakenly identified as the injection spot.
- With anterior approach, the subscapularis muscle can spasm and pull the needle medially, increasing the risk of piercing the labrum.

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Further Reading

Ultrasound-Guided Intra-articular Injection of the Glenohumeral Joint, Comprehensive Atlas of Ultrasound-Guided Pain Management Injection Techniques, 2nd Edition, Waldman.

Part VI

Advanced Cases

Spinal Cord Stimulator Trial

37

Patrick Polsunas, Neeraj Sriram, and Alexander Varzari

Abstract

Spinal cord stimulation has been used since the 1960s originally based on the gate control theory suggested by Melzack and Wall. This theory suggested that the activation of large A-beta nerves inhibited or "closed the gate" on small pain transmitting A-delta and C fibers (Melzack and Wall, Science 150(3699): 971–979, 1965). The multifactorial mechanisms behind neuromodulation are a growing topic of research with dorsal horn suppression, A-beta inhibition, GABA activity, improved perfusion, and supraspinal action on descending inhibitory pathways all being implicated (North et al., Neurosurgery 57(5):990–996, 2005; Weigel et al., Pain Physician 18(2):185–194, 2015).

Spinal cord stimulation (SCS) systems are made up of two parts: implanted leads and a programmable pulse generator. Leads are placed at spinal cord levels corresponding to the patient's pain, and with traditional SCS systems placement can be confirmed via patient feedback in the form of paresthesias at the target site. Newer forms of SCS (burst, high-frequency, differential target multiplex, etc.) do not generally cause paresthesias and so lead implantation is based on anatomy. Pulse width, frequency, and amplitude can be programmed on the pulse generator to achieve desired results.

SCS is used to treat conditions such as complex regional pain syndrome, failed back surgery syndrome, chronic limb and trunk pain, peripheral neuropathy, diabetic neuropathy, and pain ischemic vascular disease. Patient selection is

P. Polsunas (✉)
Allied Pain and Spine Institute, San Jose, CA, USA

N. Sriram
Palmetto Pain Management, Columbia, SC, USA

A. Varzari
University of Pittsburgh Medical Center (UPMC), Pittsburgh, PA, USA
e-mail: varzaria@upmc.edu

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paramount and a thorough assessment focusing on coagulation status, infection risk, compatibility with other implanted devices such as cardiac pacemakers and defibrillators, and spinal imaging must be performed. Patients who are offered SCS have usually failed most other more conservative treatments and so the treating physician must have frank discussions with the patient regarding expectations.

Once a patient is selected the first step is a SCS trial to test pain control before permanent implantation. This is routinely done under fluoroscopic guidance in the outpatient setting. Temporary leads are placed in the epidural space percutaneous and routed to an external pulse generator. Trials typically last 3–7 days and is considered successful if resulting in ≥50% pain relief and improved activity (Deer et al., Neuromodulation 17(6):515–550, 2014). If successful, permanent leads and pulse generator are implanted after a period of observation to ensure that no infection has formed.

Complications related to hardware dysfunction such as lead migration or fracture are common and can manifest as abnormal stimulation. Less common complications include infection, spinal epidural hematoma, and dural puncture.

Keys to Procedure

- Understand the relevant thoracolumbar spine anatomy on AP and lateral views.
- Identify the appropriate entry point and approach angle to maximize chances of success.
- Understand the technique of driving the lead.
- Recognize potential pitfalls while advancing lead and corrective steps.

What You Will Need

- Sterile drape
- Chlorhexidine-based soap
- Lidocaine 1% for skin: 5 ml
- Preservative-free saline for loss
- Loss-of-resistance syringe
- 5 ml syringe for anesthetic
- 25 G 3.5″ spinal needle for anesthetizing skin entry and track for your introducer needle
- 18 G 1.5″ needle to draw up medications
- Spinal cord stimulator kit
- Radiopaque marker (hemostat, for example)
- Method of securing lead to skin (i.e. nonabsorbable suture, steri-strips, or manufacturer device)
- Sterile occlusive dressing to cover approximately 30 × 30 cm space
- Patient positioning:
  Prone, with arms placed at the side of the head or on arm boards

Pitt Pain Pearl
Ask your device company rep or supervising physician for access to a stimulator lead prior to your case to practice manipulating the lead prior to your first trial

How to Perform the Procedure

1. Sterilely prep the low back and drape with sterile drape.
2. Locate the anatomic landmarks for approach to the T12-L1 space, L1-L2 space (or best access point) in AP view (Image 37.1). Other interspace targets can be utilized based on patient anatomy, though the physician should be mindful of the conus medullaris. Skin access point (with a shallow needle entry) is approximately 1.5 vertebral levels below the interlaminar space this is desired to be accessed
3. Adjust the fluoroscope using caudal or cephalic tilt to maximize the interlaminar space. A slight ipsilateral tilt may also be beneficial
4. Identify the medial aspect of the pedicle two levels below the targeted interlaminar space, at approximately the 3 o'clock position on the pedicle, which will be the entry point at the skin
5. Anesthetize the skin at this location with lidocaine 1%, creating a wheal at the skin, and directing your 5″ 25 G needle toward the targeted interlaminar space 1.5–2 levels above which will be the path of your stimulator lead placement needle, being cautious not to access the epidural space with anesthetic
6. Insert lead introducer needle and direct toward the interlaminar space at 1.5–2 levels above. If there is difficulty getting through the skin with the lead introducer needle, dilate with the 18-gauge, 1.5 inch needle
7. The lead introducer needle should be directed at a shallow angle toward the midline of the interlaminar space
8. When the tip of the lead introducer needle is above the superior edge of the lamina at the midline, obtain contralateral oblique or lateral view to confirm depth and approach ventral interlaminar line in the CLO view or the spinolaminar line in the lateral view

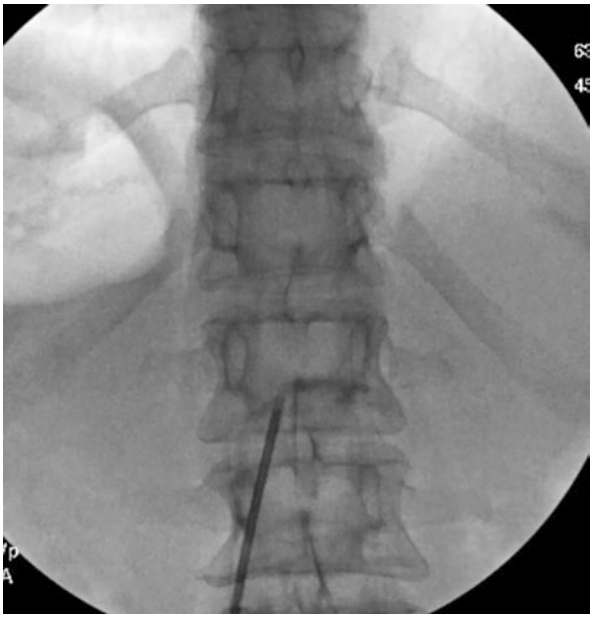

Image 37.1 Entry site at T12-L1 interlaminar space

9. Engage ligamentum flavum and perform loss of resistance technique utilizing saline, air, or guidewire in 1 to 2 mm increments with intermittent CLO views.
10. Final position of lead introducer needle tip should be just ventral to the ventral interlaminar line in the CLO view or just sublaminar in the lateral view.
11. Insert spinal cord stimulator lead into introducer needle and advance into epidural space approximately 1–2 cm or 2–4 electrode contacts, ensuring lead remains posterior (Image 37.2).
12. Return to anterior posterior view and ensure lead has remained midline and confirm level of vertebral body at entry. Confirm dorsal position in lateral view before proceeding further (Image 37.3).

13. At this time, we recommend utilizing collimation on the fluoroscope and sliding the fluoroscope toward the head such that the tip of the introducer needle is at the bottom of the image to reduce radiation exposure
14. Under live fluoroscopy, advance the lead cephalad while maintaining count of vertebral bodies, utilizing steering of the device to stay close to midline and avoid the gutter (Image 37.4)
    (a) It may be helpful to place a radiopaque marker at the targeted level before beginning lead advancement

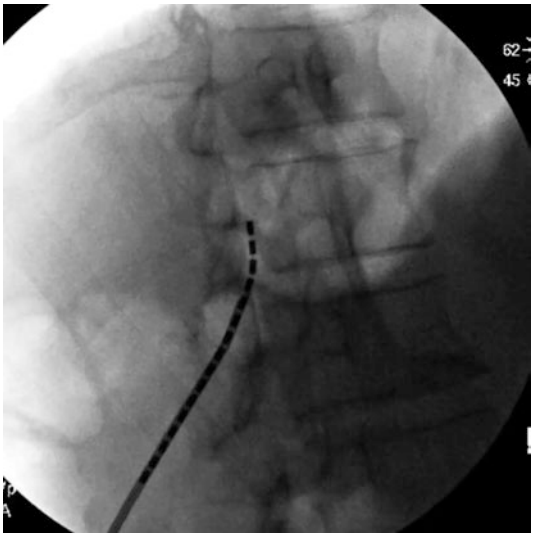

Image 37.2 CLO view of lead advancing into epidural space

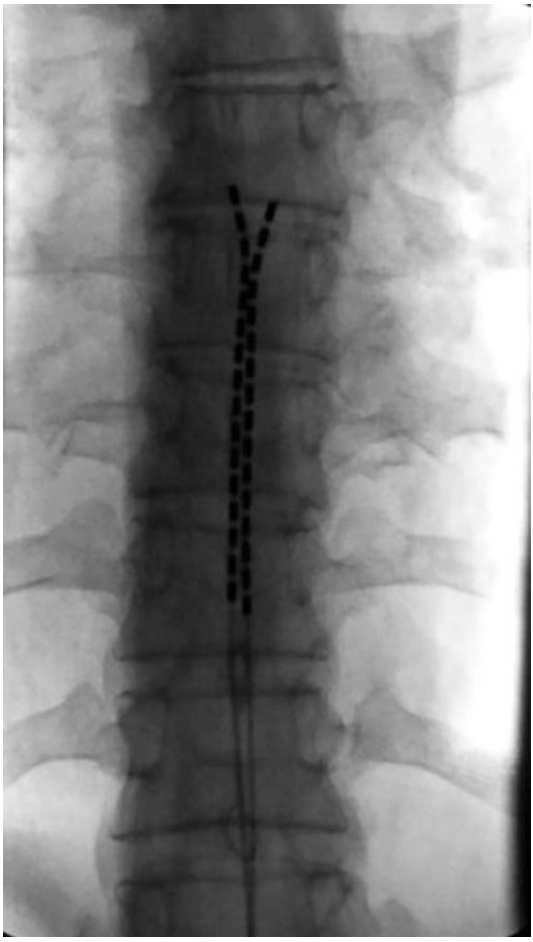

Image 37.3 AP view of leads in midline position

Image 37.4 Lateral view of leads in dorsal epidural space

(b) It may be necessary to drive the lead slightly laterally to navigate around an adhesion or other obstruction before returning to midline, though this does increase the risk for anterior/ventral lead placement

Pitt Pain Pearl: Recognize that steering can also work in reverse to allow greater redirection, similar to negotiating a tight space in an automobile

15. Advance tip of lead to the T8-T9 interspace (exact destination differs based on individual device and waveform)
16. Confirm posterior placement with contralateral oblique and lateral images
17. Connect lead to stimulation generator to confirm appropriate dermatomal distribution. At this time, it may become necessary to place a second lead

utilizing the above-mentioned steps approaching from the contralateral side. Lead placement of the second lead relative to the first will depend on dermatomal distribution and your vendor
18. When appropriate dermatomal distribution is obtained, remove the stimulation generator
19. Remove the introducer needle, taking care not to disrupt the lead by maintaining counter pressure on the lead as you pull the introducer. It may be beneficial to monitor lead under live fluoroscopy to ensure lead remains at targeted level
20. After the tip of the introducer needle leaves the skin, grasp the lead at the skin below the tip of the introducer needle and slide the introducer needle the rest of the way off of the lead, taking the stylette with it
21. Secure the lead to the skin utilizing suture with anchoring system from kit, Steri-Strip securely fastened to the lead and the skin, or device provided by manufacturer
22. Confirm final placement with AP and CLO/lateral views

Checkpoints to Mastery

Beginner

- Identify target interlaminar space, entry site, and T8-T9 interspace in AP view.
- Recognize appropriate adjustments to fluoroscope to optimize view of interlaminar entry site at appropriate angle.
- Enter skin at appropriate site and anesthetize skin as well as tract toward interlaminar space.

Intermediate

- Appropriately guide introducer needle to targeted interlaminar space at appropriate angle.
- Identify ventral interlaminar line or spinolaminar line on CLO or lateral view, respectively.
- Access epidural space using loss-of-resistance technique and confirm lead entry into epidural space.
- Understand basics of lead mechanics and manipulation of the lead.

Advanced

- Navigate epidural space while driving lead cephalad.
- Appropriately navigate adhesions or other obstacles without ventral/anterior lead placement.

- Confirm proper lead placement in A/P and CLO/lateral view, being able to identify posterior versus anterior lead.
- Removal of introducer needle without disrupting lead placement.
- Proper securing of leads to skin as well as placement of generator.

Pitt Pain Pearls and Pitfalls

- Lumbar and thoracic MRIs should be obtained prior to this procedure, and patency of epidural space should be assessed as well.
- Review MRI prior to procedure to identify the termination of the conus medullaris, as well as any potential central canal stenosis which may impede progress of the lead.
- While L1-L2 and L2-3 are common entry sites, leads can typically be placed throughout the lumbar spine provided care is taken to avoid hitting the conus medullaris at the superior levels and the lead is long enough at the inferior levels.
- Entry site may be more cephalad for low BMI patient or more caudal for high BMI patient, adjusting approximately 1 cm above or below medial aspect of pedicle 2 levels below target intralaminar space.
- Properly anesthetizing the tract before utilizing introducer needle is crucial if patient is awake or under very light sedation.
- When confirming level of placement and treated region, ensure utilization of electrodes is toward the middle of the electrode array to allow for adjustments should the lead migrate during the trial.
- Antibiotic prophylaxis should be considered on a case-by-case basis, though is not typically considered to be universally required.

References

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Further Reading

Atlas of Image-Guided Spinal Procedures, Second Edition. Furman.
Atlas of Image-Guided Intervention in Regional Anesthesia and Pain Medicine, Second Edition. Rathmell.

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